Analysis of Concrete Column including Central Reinforcement of different shapes to enhance the Strength of Structure

Nitish Kumar [1], Rachna Gupta[2] & Kapil Soni[3]
M. Tech Scholar[1], Asst. Professor [2] & HOD[3]
Department of Civil Engineering[1,2,3]
Rabindranath Tagore University, Bhopal, India.

Abstract — A column profile is a vertical structural member which resists higher compressive loads. For instance, a structure plays a main role for support in a ceiling, floor or roof slab or from a beam, to a floor or foundations. Structures are normally constructed from columns along with stone, brick, block, concrete, wood, steel, and so forth, that have properly compressive strength. In our analysis, experimental investigation was performed in column including central reinforcement of different size i.e. square and circular shaped with thickness of 10 mm and 12 mm, in this investigation compressive strength is analyzed in proposed central reinforcement structure with M25 grade with aggregate size of 10 mm, By performing experimental investigation the weight of sample is reduced by 4.5 % compared to column sample without central reinforcement, it could be analyzed that central reinforcement of circular shape with 12 mm thickness exhibits higher strength compared to other shaped central reinforcement, it is also predicted that by including central reinforcement the material can be saved with increase in strength of structure. The results show that by applying central reinforcement in column structure this enhances the compression strength at different loads exhibits higher compressive strength in structure.

Keywords— Central Reinforcement, Thickness, Material optimization, Compressive Strength.

I. INTRODUCTION

Reinforced concrete special second frames are used as a part of seismic force-resisting structures in buildings that are designed to withstand earthquakes. Beams, columns, and beam- column joints in moment frames are proportioned and distinctive to resist flexural, axial, and shearing movements that result as a constructing sways via more than one displacement cycles all through robust earthquake ground shaking. Special proportioning and detailing necessities bring about a body able to resisting strong earthquake shaking without sizable loss of stiffness or strength. Those moment-resisting frames are referred to as “unique moment Resisting Frames” because of those extra necessities, which enhance the seismic resistance in evaluation with much less stringently particular Intermediate and normal second Resisting Frames. In the united states, the most not unusual techniques of doing this are referred to as pre-tensioning and publish-tensioning. For a strong, ductile and robust advent the reinforcement wishes to have the following houses at the least:

- High relative strength
- High toleration of tensile strain
- Good bond to the concrete, irrespective of pH, moisture, and similar factors
- Thermal compatibility, not causing unacceptable stresses (such as expansion or contraction) in response to changing temperatures.
- Durability in the concrete environment

Previous development on reinforcement

Concrete body buildings, particularly older, non-ductile frames, have frequently experienced vast structural harm in earthquakes. Strengthened concrete special moment frame principles were added in the U.S. Starting around 1960. Their use at that time turned into basically on the discretion of the clothier, as it became no longer until 1973 that the Uniform constructing Code (ICBO 1973) first required use of the special body details in regions of maximum seismicity. In India using special second Resisting Frames started by around 1993.The proportioning and detailing of SMRF in India is according to IS 13920(1993), which later was given reaffirmed in the 12 months 2002. The earliest detailing necessities are remarkably much like those in vicinity today.

- **Materials-** Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement over time. In the past limebased cement binders were often used, such as lime putty, but sometimes with other hydraulic cements, such as a calcium aluminate cement or with Portland cement to form Portland cement concrete (named for its visual resemblance to Portland stone).Many other non-cementitious types of concrete exist with other methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder.
- When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete.
- Because concrete cures (which is not the same as drying) how concrete is handled after it is poured is just as important as before.
- Concrete is one of the most frequently used building materials. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed $600 billion in revenue by 2025.
- Concrete is distinct from mortar. Whereas concrete is itself a building material, mortar is a bonding agent that typically holds bricks, tiles and other masonry units together.

Need of Resisting Frames:

Moment frames are generally decided on because the seismic pressure-resisting system while architectural area making plans flexibility is preferred. When concrete second frames are decided on for homes assigned to Seismic layout classes III, IV or V, they are required to be special as unique strengthened concrete moment frames. Proportioning and detailing requirements for a special moment frame will allow the frame to securely go through extensive inelastic deformations which might be anticipated in those seismic design categories. Special moment frames can be utilized in Seismic design classes I or II, though this may now not cause the maximum low in cost design. Both energy and stiffness want to be taken into consideration in the design of unique second frames. In keeping with IS 13920(2002), special second frames are allowed to be designed for a force discount component of R= 5. This is, they're allowed to be designed for a base shear

same to one-5th of the cost acquired from an elastic reaction evaluation. Second frames are commonly bendy lateral systems; therefore, energy requirements may be managed with the aid of the minimal base shear equations of the code.

Corrosion

Corrosion is a natural way that converts a elegant steel to a extra chemically-strong shape, consisting of its oxide, hydroxide, or sulfide. It is the slow destruction of substances (commonly metals) by way of chemical and/or electrochemical response with their environment. Corrosion engineering is the sector committed to controlling and stopping corrosion. In the most not unusual use of the phrase, this means electrochemical oxidation of steel in reaction with an oxidant which encompass oxygen or sulfates. Rusting, the formation of iron oxides, is a well- known example of electrochemical corrosion. This shape of damage typically produces oxide(s) or salt(s) of the actual steel, and effects in a one-of-a-type orange colouration. Corrosion can also rise up in substances other than metals, inclusive of ceramics or polymers, regardless of the truth that on this context, the time period "degradation" is extra commonplace. Corrosion degrades the useful homes of materials and structures collectively with energy, look and permeability to liquids and gases. Many structural alloys corrode definitely from exposure to moisture in air, but the manner may be strongly laid low with publicity to sure substances. Corrosion can be concentrated locally to shape a pit or crack, or it can increase at some stage in a extensive vicinity extra or tons less uniformly corroding the floor. Because corrosion is an expansion- managed machine, it takes place on uncovered surfaces. As a quit result, strategies to lessen the pastime of the exposed floor, which include passivation and chromate conversion, can growth a material's corrosion resistance. However, a few corrosion mechanisms are a whole lot less visible and less predictable.

PRINCIPLES OF DESIGN FOR SPECIAL MOMENT RESISTING FRAMES

- The layout base shear equations of modern-day constructing codes include a seismic pressure- discount factor R, that reflects the diploma of inelastic response expected for design-stage ground motions, as well as the ductility capacity of the framing device. A special moment resisting body must be anticipated to sustain a couple of cycles of inelastic reaction if it reviews design-stage floor motion.
- The proportioning and detailing requirements for special moment frames are intended to ensure that inelastic reaction is ductile. Three major desires are: (1) to obtain a sturdy- column/susceptible-beam layout that spreads inelastic reaction over several tales; (2) to keep away from shear failure; and (3) to offer details that permit ductile flexural response in yielding areas.

STRONG COLUMN WEAK BEAM CONCEPT

When a building sways all through an earthquake, the distribution of damage over peak relies upon on the distribution of lateral go with the flow. If the building has weak columns, waft tends to concentrate in one or some tales, and might exceed the float capability of the columns. Then again, if columns offer a stiff and robust spine over the building height, waft will be extra uniformly disbursed, and localized damage could be decreased. The kind of failure that is proven is referred to as Beam Mechanism or Sway Mechanism. Moreover, it is crucial to apprehend that the columns in a given tale assist the weight of the entire constructing above those columns, whereas the beams simplest aid the gravity masses of the floor of which they form a part; consequently, failure of a column is of extra consequence than failure of a beam. Recognizing this behaviour, constructing codes specify that columns be more potent than the beams that frame into them. This strong-column/weak-beam precept is fundamental to achieving safe behaviour of frames during sturdy earthquake ground shaking. It is a layout precept that need to be strictly observed whilst designing unique second Resisting Frames.

Structural Designers adopts the strong-column/weak-beam precept through requiring that the sum of column strengths exceed the sum of beam strengths at each beam-column connection of a unique second body.

II. LITERATURE REVIEW

Zhen Cui et al. [1] investigates the effects of earthquake events are evaluated with no longer most effective structural damage as a result of lateral masses, however moreover the corrosion manner expedited due to residual damage. Such a holistic evaluation method paves the way to acquire practical predictions for the performance of RC columns under future earthquake occasions. To look at this vital issue, a hard and rapid of consultant conditions that consist of earthquake activities of various intensities are defined. **M. A. Hariri-Ardebili and V. E. Saouma [2]** The importance of nonlinear analyses for every of the critical load times (or stressors) or mixtures thereof, in addition to the very last safety evaluation are discussed. This large survey paper opinions an intensive frame of literature in a couple of disciplines. This article targets to provide all relevant strategies (in particular the ones not tailored for dams) in a more palpable way to block engineers. Finally due to this extensive check new multi risk ability capabilities are added. **Yijian Zhang et al. [3].** The effect of corrosion on danger is classed through sporting out fragility analyses. Results quantify the increase in failure chances of those structures, measured with the resource of increasing chances of exceeding defined harm states, with growing stages of corrosion. Corrosion is discovered to have a bigger effect on growing possibilities of exceeding extra excessive harm states. Twenty percent mass loss of reinforcement will boom the risk of exceeding the entire damage state with the aid of manner of as a whole lot as 49% and 34% for a shear-essential and lap-spliced column, respectively. **Jayadipta Ghosh and Piyush Sood [4]** paper presents Impact of column degradation mechanism on seismic response and fragility of bridge additives and gadget is assessed using nonlinear time records evaluation of 3-dimensional finite element bridge fashions reflecting the uncertainties across structural modeling parameters, deterioration parameters and floor movement. Comparisons are drawn among the proposed methodology and conventional techniques to increase growing older bridge fragility curves. **Sotirios A. Argyroudis et al. [5]** determined it fragility capabilities is provided for specific dangers. Engineering advances in the development of numerical fragility abilties for individual assets are discussed such as soil-structure interplay, deterioration, and multiple risk results. **Armin Tabandeh and Paolo Gardoni [6]** This paper proposes One deformation model corresponds to the flexural failure and the alternative considers the bond failure inside the lap- splice place. A Markov Chain Monte Carlo (MCMC) simulation technique is used to estimate unknown version parameters inside the context of a Bayesian updating technique. The results examine the column fragilities earlier than and after the software program of the retrofit diploma. **M. Fragiadakis et al. [7]** the current cutting-edge on the evaluation of systems (systems and lifelines) subjected to seismic loading. Severe earthquakes are random occasions that would have a devastating outcome. Therefore, the remedy of seismic loading and its consequences has many layers because of the random nature of the trouble and moreover its effects. **M. K. Abd-Elhamed and M. E. Owida [8]**The provided the failure load increases with the aid of the usage of growing the proportion of stirrups densification top at top and backside of column / widespread column peak. Also, the failure load decreases via growing slenderness ratio in addition to stirrups densification along duration of column is greater lively than stirrups densification at pinnacle and backside of column. Slightly effect of slenderness ratio on column wearing potential with densification of stirrups at top and bottom. However, the (FEA) models can come to be privy

to the structure conduct of examined columns and may be exceptional opportunity of detrimental laboratory check. **Xin Nie et al. [9]** provided, along with the yield strength of metallic tube, the thickness of metallic tube, the dimension of circulate-segment, the energy of concrete, the yield strength of longitudinal reinforcement, the ratio of longitudinal reinforcement, the yield power and the ratio of stirrup, to investigate the impact at the torsional capability of STRC columns with essential structural factors. It may be determined from the parametric analysis consequences that, the thickness of metallic tube, the scale of move-segment and the ratio of longitudinal reinforcement are the most critical parameters for the torsional ability of STRC. Based at the results parametric evaluation, an accurate and simplified calculation approach for the remaining torsional functionality of STRC columns beneath natural torsion became proposed. **Zhen Cui et al. [10]** Earthquake occasions are evaluated with no longer satisfactory structural damage due to lateral loads, however additionally the corrosion manner expedited due to residual harm. Such a holistic evaluation method paves the way to collect sensible predictions for the general performance of RC columns underneath future earthquake activities. To study this critical issue, a fixed of consultant situations that consist of earthquake sports of diverse intensities are defined. **Nassereddine Attari et al. [11],** This paper gives the outcomes of Strain and cracking fields have been monitored using an Aramis virtual video digital camera. The check results furnished beneficial information on the strengthening configurations adopted, on the subject of energy, ductility and energy dissipation functionality. **Hayder Alaa Hasan et al. [12]** emerge as determined that computing the contribution of the FRP longitudinal bars in concrete columns based totally at the modulus of elasticity (stiffness) of the FRP bars gives extra rational predictions than computing the contribution of the FRP longitudinal bars primarily based mostly on the closing tensile strength of the FRP bars. **Marcus Achenbach et al. [13]** The purpose of the object is to give a method to benefit, from the effects of recalculation, relevant statistical key data for the probabilistic characterization of the model uncertainties. Methods of descriptive statistics are implemented for the assessment of the results of the recalculation of laboratory test. In case of previous data from formerly published consequences, strategies of inferential statistics are also examined to adjust the statistical key statistics. In this example, using a response surface method with descriptive facts is further provided as a manner to transport test the results of the inferential method. **Haidong Wang et al. [14]** The experimental consequences display that the ductility and energy dissipation functionality of broken and undamaged reinforced concrete columns may be efficiently stepped forward the usage of the pre-tensioned metal hoops. Moreover, the size consequences of columns and the outcomes of concrete energy also are examined. Finally, based at the experimental results and discussions, numerous design issues of pre-tensioned metal hoops for broken columns are proposed. **Chang Seok Lee and Sang Whan Han [15]** Experimental assessments were performed the use of 4 complete-scale specimens. The estimates of modelling parameters and lateral power obtained from the measured cyclic curves of the specimens had been in comparison with the values calculated in keeping with ASCE forty one-17. Cyclic behaviour of lightly-reinforced columns with short lap splices modified into drastically affected by loading sorts and the tiers of axial load. The modelling parameters and lateral electricity had been moreover suffering from the tiers of axial load and via loading kinds (unidirectional and bidirectional) deviating from the normal values laid out in ASCE 41-17 for the ones parameters.

III. OBJECTIVES

1. To create samples of columns including central reinforcement in different shapes with wall thickness.
2. To perform tests for determination of compressive strength this will be obtained after optimizing the simple column.
3. To compare the results and to determine optimum strength and sample column with central reinforcement.
4. Particular test would be performed in column with central reinforcement sample whose optimum results are improved than other samples.

Testing Apparatus for column with compression tester

The below shown figure represent a column sample with different central reinforcement is configured on compression testing machine for determination of compressive strength along column structure, the compression testing machine is of Aimil compression tester 200 have ability to compress 200 mpa also configured with area calculator for calculation of stress and area digitally induced during testing of column structures sample. As shown, each column had a footing and a cap with the dimensions of 200×200×200 (length × width × height).



Figure 1 table shakers with fastening fixtures.



Figure 2 table shakers with fastening fixtures.

Test machine Specification

Product Specification	**Permissible values**
Product name	Aimil Compression Tester
Product code	AIL - C00400
Capacity(400 Mpa)	400 Mpa



Figure 4 – Sample preparation including central reinforcement.



Figure 5 Concrete filling in M25 with central reinforcement.



Figure 3 Preparation of reinforcement for M25 for column.



Fig 6 – Experimentation in Lab



Fig 7 – Experimentation in Lab

Compression Test (Without Central Reinforcement) -

Result of compression test are received by way of experimental investigation is as compared with different central reinforcement shaped and column without central reinforcement column sample value calculated by means of the enhanced digital indicator - DCTM device with with compression tester machine are demonstrated in table below.

Table- 1 Experimental Result of column sample without central reinforcement.

Column sample without central reinforcement	
Load (KN)	Stress (Mpa) (Without central reinforcement)
280	10.8
330	14.89
360	16.87
400	19.77

Above result shows the experimental results obtained of present model to determine the compressive stress which is near to the value of convergence of M25 column structures.

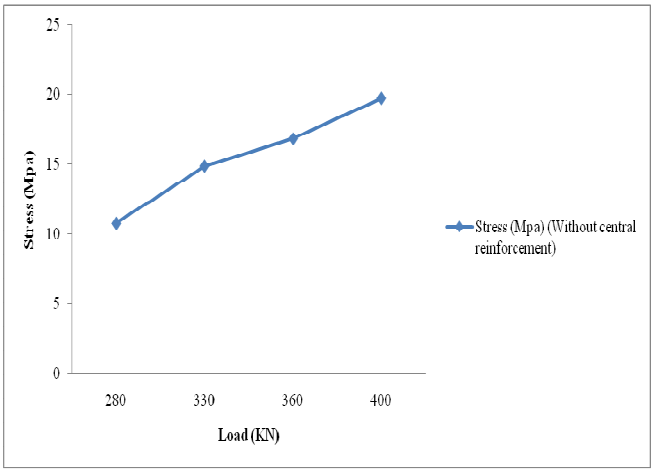

Fig 8 Experimental Result of column sample without central reinforcement.

Compression Test (Square hollow central reinforcement with 10 mm thickness) –

Table 2- Experimental results obtained of present model to determine the compressive strength of column sample with square hollow central reinforcement with 10 mm thickness.

Square hollow central reinforcement with 10 mm thickness	
Load (KN)	Stress (Mpa) (Square hollow central reinforcement 10mm thickness)
280	12.9
330	21.18
360	23.88
400	24.46

Above result shows the experimental results obtained of present model to determine the compressive strength which is near to the value of M25 grade of column structures.

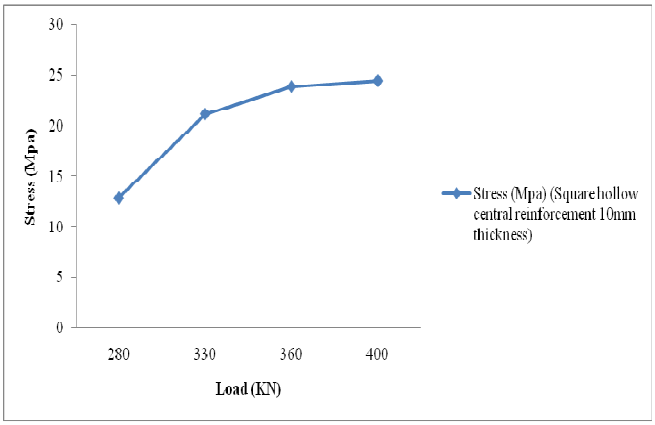

Fig 9 Experimental results obtained of present model to determine the compressive strength of column sample with square hollow central reinforcement with 10 mm thickness.

Above table and graph shows an experimental result of column structures of compressive strength and results with 10mm thickness of central reinforcement of square shaped.

Compression Test (Square hollow central reinforcement with 12 mm thickness) –

Table 3- Experimental results obtained of present model to determine the compressive strength of column sample with square hollow central reinforcement with 12 mm thickness.

Square hollow central reinforcement with 12 mm thickness	
Load (KN)	Stress (Mpa) (Square hollow central reinforcement 12mm thickness)
280	14.85
330	22.44
360	24.96
400	28.77

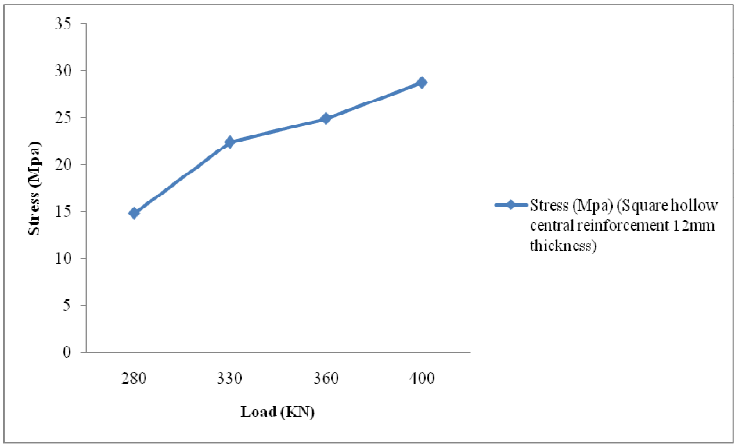

Fig 10 Experimental results obtained of present model to determine the compressive strength of column sample with square hollow central reinforcement with 12 mm thickness.

Compression Test (Circular hollow central reinforcement with 10 mm thickness) –

Table 4- Experimental results obtained of present model to determine the compressive strength of column sample with circular hollow central reinforcement with 10 mm thickness.

Circular hollow central reinforcement with 10 mm thickness	
Load (KN)	Stress (Mpa) (Circular hollow central reinforcement 10mm thickness)
280	14.67
330	22.43
360	24.47
400	25.53

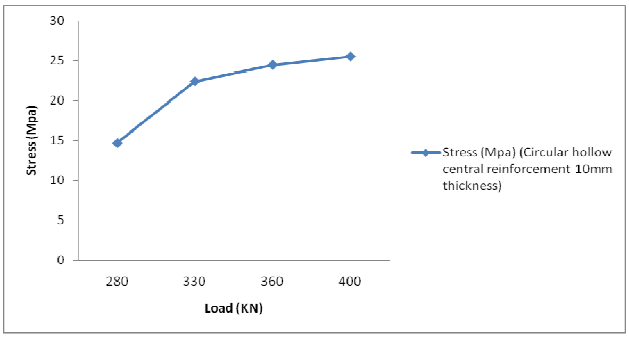

Fig 11 Experimental results obtained of present model to determine the compressive strength of column sample with circular hollow central reinforcement with 10 mm thickness.

Overall comparative result: -

Below shown result in table no. 4.7 are also investigated in STAAD PRO in column no. 4 with square hollow central reinforcement, further circular hollow central reinforcement is imposed in column no. 6, 8 and 9.

Table 5 Experimental results of compressive stress of column with different central reinforced column structures at different loads.

Load (KN)	Stress (Mpa) (Without central reinforcement)	Stress (Mpa) (Square hollow central reinforcement 10mm thickness)	Stress (Mpa) (Square hollow central reinforcement 12mm thickness)	Stress (Mpa) (Circular hollow central reinforcement 10mm thickness)	Stress (Mpa) (Circular hollow central reinforcement 12mm thickness)
280	10.8	12.9	14.85	14.67	15.42
330	14.89	21.18	22.44	22.43	23.43
360	16.87	23.88	24.96	24.47	26.56
400	19.77	24.46	28.77	25.53	28.96

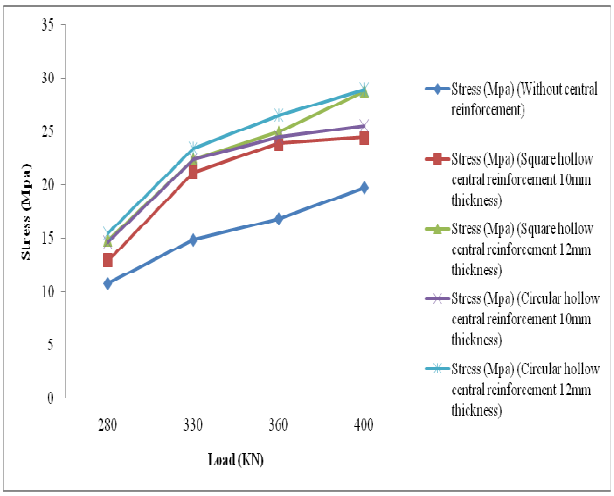

Fig 4.12 Experimental results of compressive stress of column with different central reinforced column structures at different loads.

Conclusion

The current analysis has presented a study of compressive strength characteristics of a column with different central reinforcement structures at different load of 280, 330, 360, 400 KN, compressive stress analysis with the help of Aimil compressive testing machine was carried out on a column structure of different central reinforcements of square and circular shaped with thickness of 10mm and 12mm with 10mm aggregate size. The effect of different shaped central reinforcement of the column structure with mixed aggregate size of 10mm gives optimized results on resistibility high compressive loading conditions. From the analysis of the results, following conclusions could be drawn.

Influence of central reinforcement size with different thickness at different loads in column –

- The compressive strength of column structure exhibits higher strength in 12 mm thickness.
- The magnitude of strength after indulging central reinforcement in column circular hollow shaped gives higher compressive strength.
- Including central reinforcement the weight percentage of 4.5% is reduced compared to without central reinforcement column.
- Compared to square and circular reinforcement with thickness of 10mm and 12mm the compressive strength is higher compared to without central reinforced column in M25 grade.
- By addition of central reinforcement weight and strength are optimized.

References

1. Zhen Cui Alice Alipour Behrouz Shafei, Structural performance of deteriorating reinforced concrete columns below a couple of earthquake activities, Engineering Structures Volume 191, 15 September 2019, Pages 460-468

2. M. A. Hariri-Ardebili V. E. Saouma, “Single and multi-threat capacity functions for concrete dams”, Soil Dynamics and Earthquake Engineering Volume one zero one, October 2017, Pages 234-249.

3. Yijian Zhang Reginald Des Roches IrisTien, Impact of corrosion on chance assessment of shear-crucial and short lap-spliced bridges, Engineering Structures Volume 189, 15 June 2019, Pages 260-271.

4. Jayadipta Ghosh Piyush Sood, Consideration of time-evolving ability distributions and improved degradation fashions for seismic fragility evaluation of getting old dual carriageway bridges, Reliability Engineering & System Safety Volume 154, October 2016, Pages 197-218.

5. Sotirios A. Argyroudis, Fragility of delivery assets uncovered to multiple risks: State-of-the- artwork assessment in the direction of infrastructural resilience, Reliability Engineering & System Safety Volume 191, November 2019, 106567

6. Armin Tabandeh Paolo Gardoni, “Probabilistic ability models and fragility estimates for RC columns retrofitted

with FRP composites, Engineering Structures Volume seventy four, 1 September 2014, Pages 13-22.

7. M. Fragiadakis, "Seismic assessment of structures and lifelines", Journal of Sound and Vibration Volume 334, 6 January 2015, Pages 29-56.

8. M. K. Abd-Elhamed M. E. Owida, Effect of stirrups densification on closing potential of rectangular strengthened concrete columns , Structures Volume 20, August 2019, Pages 728-764.

9. Xin Nie Wei Wang "Ultimate torsional ability of metallic tube limited bolstered concrete columns ," Journal of Constructional Steel Research Volume 160, September 2019, Pages 207- 222.

10. Zhen Cui Alice Alipour Behrouz Shafei, "Structural overall performance of deteriorating reinforced concrete columns underneath a couple of earthquake activities " Engineering Structures Volume 191, 15 September 2019, Pages 460-468.

11. Nassereddine Attari Youcef Si Youcef Sofiane Amziane., "Seismic overall performance of reinforced concrete beam–column joint strengthening by frp sheets, Structures Volume 20, August 2019, Pages 353-364

12. Hayder Alaa Hasan M. Neaz Sheikh Muhammad N. S. Hadi, "Maximum axial load carrying capacity of Fibre Reinforced-Polymer (FRP) bar strengthened concrete columns under axial compression" Structures Volume 19, June 2019, Pages 227-233

13. Marcus Achenbach, ThomasGernay "Quantification of model uncertainties for bolstered concrete columns subjected to fire," Fire Safety Journal Volume 108, September 2019, 102832

14. Haidong Wang, "Experimental investigation of broken round bolstered concrete columns with pre-tensioned metallic hoops," Engineering Structures Volume 197, 15 October 2019, 109384.

15. Chang Seok Lee Sang Whan Han, "Cyclic behaviour of gently-bolstered concrete columns with quick lap splices subjected to unidirectional and bidirectional loadings," Engineering Structures Volume 189, 15 June 2019, Pages 373-384

16. Chang-Geun Cho Byung-Chan Han, "Strengthening of reinforced concrete columns via High-Performance Fiber-Reinforced Cementitious Composite (HPFRC) sprayed mortar with strengthening bars," Composite Structures Volume 202, 15 October 2018, Pages 1078-1086

17. Xuhong Zhou Zheng Zhou Dan Gan, "Cyclic testing of rectangular tubed-strengthened- concrete column to RC beam joints," Engineering Structures Volume 176, 1 December 2018, Pages 439-454

18. Thomas Gernay, "Fire resistance and burnout resistance of reinforced concrete columns," Fire Safety Journal Volume 104, March 2019, Pages 67-78

19. MustafaMahamidaMajidHoushiar, "Direct design approach and layout diagrams for bolstered concrete columns and shear walls," Journal of Building EngineeringVolume 18, September 2018, Pages sixty six-75

20. HuangYuan Huan-Peng Hong, "Displacement ductility of staged creation-metal tube- strengthened concrete columns," Construction and Building Materials Volume 188, 10 November 2018, Pages 1137-1148.

21. Feng Yu Dongang Li Ditao Niu. A version for closing bearing ability of PVC-CFRP limited concrete column with strengthened concrete beam joint below axial compression. Construction and Building Materials Volume 214, 30 September 2019, Pages 668-676