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Analytical Study of the Composite Steel Structure under the Influence of Seismic Circumstances- A Review

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Abstract: *Reinforced concrete structures are the most often utilized structures in India, owing to their ease of construction and affordability, particularly for low-rise residential buildings. Due to variations in factors such as stiffness, an increase in dead loads, span limitation in both directions, and costly formwork, R.C.C structures are no longer convenient or cost-effective for medium and high-rise buildings. High-rise building design has grown more difficult for designers because of the difficulty in achieving an efficient and cost-effective design. Furthermore, wind and seismic characteristics must be considered while designing high-rise structures. Despite the challenges in making steel, steel's improved performance in high-rise structures helps to overcome the aforementioned issues. Because of its complexity in analysis and design, many structural engineers are reluctant to use steel. From previous studies, the use of steel structural systems makes the buildings more durable, more cost-effective, and better able to withstand earthquakes. This paper discusses the review association of execution of the unsymmetrical (Trapezoidal) model, R.C.C., and steelworks under the influence of wind and seismic circumstances.*

Keywords: Wind effect, R.C.C, steelwork, High-rise building, Earthquake effect, trapezoidal section

I. INTRODUCTION

In the latest decades, the efficiency of composite structures throughout India has grown dramatically. Composite structures and members are those that are constructed from two or more distinct types of materials. Composites have several advantages over their components, including the ability to blend different materials into a unified entity that acts ahead of a lot of its elements. Steel-concrete composites are the most ubiquitous kind of mixed element in the building works, although other types include "steel-timber, steel-concrete, timber-concrete, plastic-concrete, and so on". Formwork is a high adhesion resource, but it has a lower sensitivity to tensile stress. Steel, one on either side, is immensely powerful under strain, although when utilized in small volumes. For constructions like multi-story buildings and bridges, steel-concrete materials incorporate concrete's compressive force with steel's rigidity to stress to develop a quality feasible, and lightweight unit.

1.1 Concrete Encased Composite Column

A concrete enclosed composite column uses steel sections that are completely encased in concrete to give greater load resistance. Encased sections have a lower volume-to-strength ratio and are more fire-resistant, as well as preventing local buckling of the steel section. The compressive strength and ductility of a concrete-encased composite column make it a better building part. To optimize the concrete-encased steel composite column's advantages, recent criteria were based on the use of high-strength materials, such as higher mechanical concrete and steel [11].

As shown in Table 1 [11], structural concrete is divided into four types: "standard strength concrete (NSC), high strength concrete (HSC), very high strength concrete (VHSC), and ultra-high-strength concrete (UHSC)". As a result of its superior characteristics, such as "high strength, high abrasion resistance, low permeability, and the capacity to design smaller structural sections" while taking architectural and economic factors into account, the creation of high-strength concrete represents a significant advancement in the field of concrete technology. With such benefits, high-strength concrete has the potential to be used in a broad variety of technical applications.

The usage of "composite steel-concrete columns" combines the primary benefits of the separate elements. Advantages of composite steel-concrete structures include [26-28]: The reduction in steel consumption leads to a decline in the steel section of free-standing aspects and minimization in the number of reinforcing elements necessary. They are reinforced concrete constructions with the strength and rigidity of steel structures, and the capacity to absorb more vitality before destabilization, which is especially beneficial in segregated structures.

Table 1: Concrete strength classification

Items	NSC	HSC	VHSC	UHSC
Strength (MPa)	<50	50-100	100-150	>150
Water-cement ratio	>0.45	0.45-0.3	0.3-0.25	<0.25
Chemical admixtures	No	WRA/ HRWR *	HRWR	HRWR
Mineral admixtures	No	Fly ash	Silica fume	Silica fume
Permeability coefficient (cm/s)	$>10^{-10}$	10^{-11}	10^{-12}	$<10^{-13}$

Whereas, *WRA= water-reducing admixture; HRWR= high range water reducer

1.2 Concrete-Filled Steel Tubular (CFST) Column

The usage of "concrete-filled steel tubular (CFST) columns with circular, square, and rectangular hollow sections (CHS, SHS, and RHS)" has become more popular in a variety of engineering structures because of the superior composite actions that can be achieved between the steel tube and concrete infill. The composite behaviors of their components have been the subject of in-depth analytical and laboratory inquiry has been done [1-4].

Concrete-filled double-skin tubes of the T- and L-shape, made from stainless steel and aluminum, were utilized in the optimization of CFST specimens to improve corrosion resistance and structural response. As a result, extensive experimental and numerical research has been carried out. The structural behavior of axially loaded concrete-filled stainless steel tubular columns was reviewed [5-7]. The compressive structural response of concrete-filled aluminum tubular columns is investigated by Zhou and Young [8,9].

Axially loaded special-shaped CFST columns using finite element (FE) calculations reveal that further research is required to understand the basic structural response, "in particular interaction behaviors between special-shaped steel tubes and the concrete core", in the prior studies. Justification of composite activities amongst constituent components is required to provide sensible design suggestions. When adequate models are developed and critical parameters are precisely described, finite element analysis (FEA) may be utilized as an effective method to explore structural behavior.

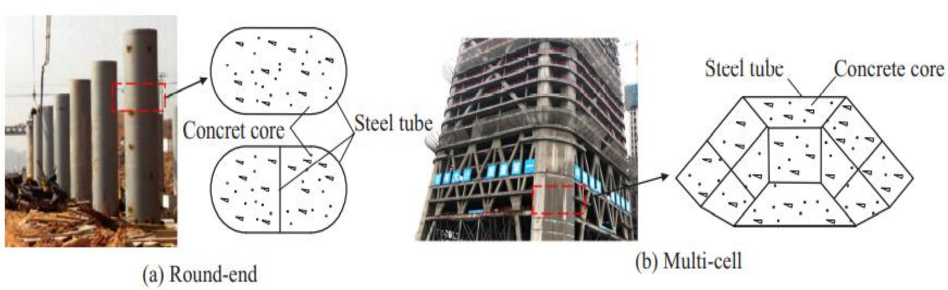

Fig. 1 Special-shaped CFST [10]

The structural behaviors of specially designed CFST members that have been utilized in practice have not been explored. "Round-end CFST columns with D-shaped or semi-circular sections are often used as bridge piers to enhance column transverse durability as shown in Figure 1(a)" [10]. To increase the quality of concrete construction in skyscrapers, multi-cell CFST columns are often employed as shown in Figure 1(b) [10]. "CFST columns with triangular, Fan, D-shaped, 1/4 circular, and semi-circular sections", as shown in Figure 2, are projected to be used increasingly often in urban projects as the need for multi-functional and symbolic architecture grows [10].

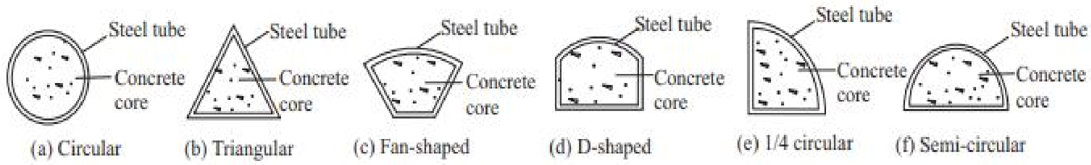

Fig. 2 CFST cross-section's schematic view [10]

1.3 Concrete-Encased Steel-Reinforced Concrete Column

Composite columns may have a high strength-to-weight ratio while targeting a specific sectional area, providing a high-level utilization of available space. In composite columns, exposed steel sections enclosed in concrete or hollow steel tubes filled with concrete are the most prevalent kinds. Concrete-encased steel-reinforced concrete columns, or CRCs, have been widely examined during the last decade. The research, on the other hand, was primarily concerned with structural behavior.

In a load-bearing application, the web typically carries the majority of the compressive stress and emits bending moment in the beam, though these flanges sustain the majority of the lateral forces. Flanges resist the majority of the bending moment received by the beam, whereas the web resists shear forces. Bending and shearing stresses may be carried extremely efficiently in the plane of the web with an I-shaped section [12-13].

1.4 Sandwich Concrete Steel Column

Sandwich composite structures (SCS) are made of steel plates on both sides and a concrete core sandwiched between them. They are held together by conventional links to build a comprehensive block that can withstand heavy loads from outside. Distinct interaction procedures at the steel-concrete substrate have been used to create several kinds of SCS sandwich composite structures. The sandwich composite structures of the SCS were constructed using epoxy-based materials.

When the SCS sandwich structure was made with "mechanical shear connectors, brittle bond failure" was more common at the steel-concrete interface because of the imperfections in the connecting material. This would make the SCS sandwich structure less stable. Tunnel liners were originally designed with a double-skinned construction that used overlapping stud connections to join concrete and steel plates [14]. The binding between the plates and the concrete, on the other hand, is highly dependent on the spacing and lapping length of the connectors. Steel panels and the cement matrix could isolate and compromise the sandwich plate's structural performance if the concrete core fails under excessive stresses.

A. Types of Columns Based on the Shape

Because column loads are mostly axial, compression is the most appropriate design for column load bearing. Bending in the columns may be caused by additional loads such as snow, wind, or other horizontal forces. As a result, column designs must take into consideration axial load, as well as twisting [15].

- **Square or Rectangular Column:** However, these particular sorts of columns are only used in rooms that have a square or rectangular layout. They are often used in the building of various constructions. Construction and casting of rectangular or square columns are far simpler than that of circular ones, for obvious reasons. When dealing with the shuttering, this is largely for the convenience of use and to prevent the shuttering from collapsing owing to pressure while the concrete is still in its flowable condition. In terms of casting, they tend to be highly equipped for square or rectangular shapes.
- **Circular column:** For piling and erecting structures, these are the most often utilized columns. This particular style of a column is used to prevent the creation of sharp corners, sit-out spaces, auditoriums, and fire-assembly zones may also benefit from the use of these columns, since they don't impede people's mobility or look awful on flat surfaces. Since there is no flushing required, circular columns may be used as the pillars of bridges.

- **L-Type column:** "They are generally used in the corners of the boundary wall and have the same features as a rectangular or square column. These kinds of columns are very less used".
- **T-Type column:** "This kind of column is used depending on design requirements and in the construction of bridges, etc. This has the same features as a rectangular or square column".
- **V-Type column:** "As a name itself, it showcases the column is in V shape and is generally used in the shape of the room is trapezoidal. As it requires more amount of concrete when compared to the other columns".
- **Hexagonal column:** "Hexagon columns are generally modified columns. It has six sides and it gives a good pictorial view generally used in elevation. It is adopted to give a good look at the column. It is generally provided in open verandas, Auditoriums, Cinema Halls, etc".
- **Arch type column:** "These types of columns are used when the room has a shape of an arch. It is adopted where there is no chance of building a square or rectangular or circular type of column. it is rarely used as it possesses very difficult in casting".

II. ANALYSIS OF DISTINCT SHAPES OF STEEL-COLUMN

The effect that a revised residual stress pattern and modified pure mathematics of cellular and crenelated sections have on the resistance of the weak axis to buckling was investigated. As a consequence, the buckling stress and resistance of nearly supported cellular and castellated components were quantified. Early observations corroborated the appearance of a new residual stress pattern in the numerical model. These simulations should be considered preliminary findings since the number of measurements was limited. In comparison to control specimens, hybrid trapezoidal sections of reinforced concrete beams had an ultimate failure load decrease ranging from 2.82 percent to 6.77 percent. This finding shows that hybrid strength trapezoidal sections reduce compression strength in the tension zone by 50%, resulting in a modest drop in strength. In contrast to the specimen with a rectangular cross-section, the homogenous specimen with a trapezoidal cross-section had a failure load increase of 2.16 percent – 6.77 percent [16].

To circumvent this, the hole metal section greatly enhances the column's weight-bearing capability. Moreover, the number of flutes available has a significant impact on the performance of hollow metallic columns. Hollow columns with five flutes performed better than those with a lower number of flutes in this study [17]. Stress and strain behavior and other associated factors may be greatly affected by the thickness of column sections. The column displayed better behavior in terms of "load vs. deflection, stress-strain values, and failure mechanisms" as the column's thickness grew.

Comprehensive finite element modeling of CFST columns with "circular, triangular, Fan-shaped, D-shaped, 1/4 circular, and semi-circular sections" are constructed to mimic experimental findings [18]. "The FE models were validated by comparing them to test data for failure mechanisms, entire load-deformation histories, and ultimate strengths. N- and P-curves and failure modes for the five specimens reveal that the CFST columns' structural behavior is quite similar to that of the RHS". A greater fy rises in strength enhancement efficiency, though parametric tests indicate that the final strengths of columns grow with increasing both material strengths.

To explore the behavior of CECFST stub columns under "uniaxial and biaxial eccentric compression in concrete-encased concrete-filled steel tubes". In the experiment, "a total of three uniaxial eccentric compression tests, eleven biaxial eccentric compression tests, and one axial compression test" were performed [19]. The impacts of loading eccentricity and end moment ratio were examined. For CECFST stub columns, eccentricity and end moment ratio have a significant impact on the ductility and failure modes under "uniaxial as well as biaxial eccentric compression". The axial load-carrying capacity of each specimen decreased when the peak load was reached because the exterior concrete crumbled and spalled. Because of this, the bending strength remained intact.

Every specimen shows varying levels among both deformation and bending stresses failure characteristics owing to the varied slenderness ratios used, and apparent local sagging of steel section might have been detected at the bottom section of both strain rate and bending sides of the test sample. It is discovered that the metal pattern and formwork have a synergistic impact [20]. SRCFST members' lateral capacity and ductility might be considerably improved by increasing the steel profile ratio. Even though the steel profile ratio is the same, the lateral capacity might change significantly amongst steel profile cross-sections of the same size. Slightly different flange-to-web thickness ratios and steel profile aspect ratios might affect the lateral capacity of members.

Based on the IdeaStatiCa package, quantitative testing of the examined link under external loads revealed that in the case of the first analysis, the connection has to be strengthened since the usage of two different materials, i.e. S235 and S355 steel, does not fulfill the safety criteria [21]. "Greater corrosion resistance, improved strength, superior toughness, and superior longevity are just a few of the benefits of ultra-high performance fiber reinforced concrete (UHPFRC) above traditional concrete" [22]. As a result, it is ideal for high-rise and large-span constructions since it may drastically reduce column size. Many investigations have shown that UHPFRC has good mechanical properties under various stress scenarios [23–25].

III. CONCLUSION

The statistic indicates that reinforced concrete columns are more cost-effective, although steel columns are desirable in terms of absolute weight, but with a steel profile that is not often accessible. When compared to reinforced concrete columns, composite columns became more beneficial due to lesser block cross-sections allowed and indeed the dramatically lower density of the sections. My future scope is to study the behavior of hollow trapezoidal sections in the various shape of columns to find the load-carrying capacity.

REFERENCES

[1]. L.H. Han, X.L. Zhao, Z. Tao, Tests and mechanics model for concrete-filled SHS stub columns, columns and beam-columns, Steel Compos. Struct. 1 (2001) 51–74.

[2]. L.H. Han, G.H. Yao, Z. Tao, Performance of concrete-filled thin-walled steel tubes under pure torsion, Thin-Walled Struct. 45 (2007) 24–36, http://dx.doi.org/10. 1016/j.tws.2007.01.008.

[3]. L.H. Han, W. Li, R. Bjorhovde, Developments and advanced applications of concrete-filled steel tubular (CFST) structures: members, J. Constr. Steel Res. 100 (2014) 211–228, http://dx.doi.org/10.1016/j.jcsr.2014.04.016.

[4]. Z. Tao, Z.-B. Wang, Q. Yu, Finite element modelling of concrete-filled steel stub columns under axial compression, J. Constr. Steel Res. 89 (2013) 121–131, http:// dx.doi.org/10.1016/j.jcsr.2013.07.001.

[5]. Z. Tao, B. Uy, F.Y. Liao, L.H. Han, Nonlinear analysis of concrete-filled square stainless steel stub columns under axial compression, J. Constr. Steel Res. 67 (2011) 1719–1732, http://dx.doi.org/10.1016/j.jcsr.2011.04.012.

[6]. D. Lam, L. Gardner, Structural design of stainless steel concrete filled columns, J. Constr. Steel Res. 64 (2008) 1275–1282, http://dx.doi.org/10.1016/j.jcsr.2008.04. 012.

[7]. B. Uy, Z. Tao, L.H. Han, Behaviour of short and slender concrete-filled stainless steel tubular columns, J. Constr. Steel Res. 67 (2011) 360–378, http://dx.doi.org/10. 1016/j.jcsr.2010.10.004.

[8]. F. Zhou, B. Young, Tests of concrete-filled aluminum stub columns, Thin-Walled Struct. 46 (2008) 573–583, http://dx.doi.org/10.1016/j.tws.2008.01.003.

[9]. F. Zhou, B. Young, Numerical analysis and design of concrete-filled aluminum circular hollow section columns, Thin-Walled Struct. 50 (2012) 45–55, http://dx. doi.org/10.1016/j.tws.2011.10.002.

[10]. Wang, Facheng and Lin-Hai Han. "Analytical behavior of special-shaped CFST stub columns under axial compression." Thin-Walled Structures (2018): n. pag.

[11]. Huang, Zhenyu, Xinxiong Huang, Weiwen Li, Yingwu Zhou, Lili Sui and J. Y. Richard Liew. "Experimental behaviour of very high-strength concrete-encased steel composite column subjected to axial compression and end moment." Proceedings 12th international conference on Advances in Steel-Concrete Composite Structures - ASCCS 2018 (2018): n. pag.

[12]. Bhadane, Prathmesh K and Manoj M. Joshi. "Review of Experimental Analysis of Trapezoidal Corrugated web beam with stiffener for its strength and modes." Journal of emerging technologies and innovative research (2019): n. pag.

[13]. Strengths of web-posts in a castellated steel beam with hexagonal web openings" Journal of Constructional Steel Research 121 (2016) 173-184 Delphine

[14]. J.Y. Richard Liew, Jia-Bao Yan, Zhen-Yu Huang, Steel-concrete-steel sandwich composite structures-recent innovations, Journal of Constructional Steel Research, Volume 130, 2017, Pages 202-221, https://doi.org/10.1016/j.jcsr.2016.12.007.

[15]. https://civilread.com/different-types-columns/

[16]. Sada, Majid & Resan, Sa'ad. (2021). Structural behavior of hybrid reinforced concrete beams of trapezoidal section. Materials Today: Proceedings. 42. 10.1016/j.matpr.2020.12.713.

[17]. C. Krishnaveni and S. Senthil Selvan, Analytical study on hollow and concrete in-filled columns with triangular and rectangular flutes under axial load, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.11.216

[18]. Wang, Facheng and Lin-Hai Han. "Analytical behavior of special-shaped CFST stub columns under axial compression." Thin-Walled Structures (2018): n. pag.

[19]. Ma, Youxin & Tan, Kang-Hai. (2021). Experimental and numerical studies of concrete-encased concrete-filled steel tube stub columns under uniaxial and biaxial eccentric compression. Engineering Structures. 232. 111796. 10.1016/j.engstruct.2020.111796.

[20]. Wang, Wen-Da & Ji, Sun-Hang & Xian, Wei & Shi, Yan-Li. (2021). Experimental and numerical investigations of steel-reinforced concrete-filled steel tubular members under compression-bending-shear loads. Journal of Constructional Steel Research. 181. 106609. 10.1016/j.jcsr.2021.106609.

[21]. Major, Maciej & Nawrot, J & Major, Izabela. (2019). Structural S235 and S355 Steels – Numerical Analysis of Selected Rods Connection. IOP Conference Series: Materials Science and Engineering. 585. 012007. 10.1088/1757-899X/585/1/012007.

[22]. C. Wu, J. Li, Y. Su, Development of Ultra-high Performance Concrete against Blasts: from Materials to Structures, Woodhead Publishing, 2018.

[23]. S. Ahmad, I. Hakeem, A.K. Azad, Effect of curing, fibre content and exposures on compressive strength and elasticity of UHPC, Adv. Cement Res. 27 (2015) 233–239.

[24]. M. Alkaysi, S. El-Tawil, Effects of variations in the mix constituents of ultra high performance concrete (UHPC) on cost and performance, Mater. Struct. 49 (2016) 4185–4200.

[25]. K. Hannawi, H. Bian, W. Prince-Agbodjan, B. Raghavan, Effect of different types of fibers on the microstructure and the mechanical behavior of Ultra-High Performance Fiber-Reinforced Concretes, Compos. B Eng. 86 (2016) 214–220.

[26]. Sonnenschein, Robert & Gajdosova, Katarina & Gramblička, Štefan. (2020). Comparison of Composite, Steel and Reinforced Concrete Columns. IOP Conference Series: Materials Science and Engineering. 960. 032093. 10.1088/1757-899X/960/3/032093.

[27]. S. Gramblicka, J. Kozak and J. Lapos: Composite and combinate steel-concrete structures. Bratislava, Jaga group, v.o.s., 2000. ISBN 80-88905-32-X (In Slovak).

[28]. S. Gramblicka and J. Lapos: 4 Design of load-bearing structures of buildings – Composite steel-concrete structures, Bratislava: STU, 2009. ISBN 978-80-227-3061-7 (In Slovak).