A review on concrete filled tubular sections using self compacting concrete under eccentric loading

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Abstract: Concrete filled tubular section (CFT’s) and self-compacting concrete (SCC) is the ideal material for achieving goals like strength, durability, toughness, economic, controlling thermal cracking, plastic shrinkage, etc. for high rise buildings. The CFT’s were filled with the self-compacting concrete (SCC) and Normal Concrete (NC) with the different eccentric loading on the sections. Normal Concrete is forming the problems due to its less workability and filling concrete in the smaller cross-sections or dense reinforcement. CFT’s carries higher loads as compared to conventional reinforced concrete and steel columns. For the economic aspects, the CFT’s are mainly used for the High Rise Building (HRB) due to its properties. In earlier research show that the different ratio of the of D/t and L/D section with various types of concrete with or without using of admixture was used in the study

1. INTRODUCTION

In recent times, the construction of civil engineering plays an important and huge role in the development of a nation. So, the main focus on the stability of the structure, the safety of the structure and economic aspects of constructions. Our eyes catch the most is the modern skyscrapers, high rise building, tall structure, etc. Modern technologies and systems are used in these structures from science and engineering. For enhancement of stability, strength, durability, economic, etc. with the help of new technology that is called “composite construction”. And also to improvement in workability of concrete by using self-compacting concrete (SCC) in construction. The high volume of fly ash can be used for economical and strength purposes [5]. SCC is achieved by enhancing various viscosity superplasticizers, admixtures and paste volume by reducing the volume ratio of aggregate to cementitious materials [7]. Self-compacting concrete is produced by the use of High-Range Water Reducer (HRWR). It is also called the Supplementary Cementing Material (SCM) and superplasticizer. The durability and strength of self-compacting concrete are enhanced by Supplementary Cementing Material (SCM) and High-Range Water Reducer contributes to achieving the passing ability, segregation resistance and filling ability [4].

The self-compacting concrete (SCC) was developed by researchers at the University of Tokyo, Japan during the 1980s with the idea of overcoming the shortage of skilled labour. The first version of SSC was completed in 1988 on the name “High-Performance Concrete” and after purposed as “Self-Compacting Concrete”(Figure 1). The first paper published on the modern SCC by the University of Tokyo by Ozawa et al. in 1992 [6].
In the years of 1990s, Japan has developed the SCC and came to use in constructions to avoid mechanical vibration. It was fully compacted and give better workability, strength, and durability. Japan was famous for the production of ready-mixed concrete (RMC) and precast self-compacting concrete in 2000. The use of SCC rapidly increases day by day [10]. There is no bleeding and segregation occurs in the concrete while the placement of concrete, it remains in the plastic stage. The use of pozzolanic materials, such as GGBS, limestone powder and fly ash, helps the SCC to flow better. SCC can be pumped to longer distances due to the high resisting power and fluidity of the segregation of SCC. The use of SCC not only shortens the construction period also ensures quality and durability [8].

For fulfillment of the requirements like strength, stability and stiffness, a new type of construction technic came into introduction which is called ‘Composite construction’. The reason behind this can be expressed as steel is good in tension and concrete is good in compression. By combining these materials structurally, these will give lightweight structure and efficient. It also gives an advantage in terms of time-saving in construction. The recent decades, the Composite steel-concrete column is mostly used in the large construction for economic and strength aspects. The change in diameter of the tube, length of the tube, the strength of infill concrete i.e. effected by using metakaolin admixtures [11].

The research started in the 20th century. In 1913, Emerge of Germany gave the first design formula for composite columns. Concrete filled steel tubular (CFST) are comprised of the square, rectangular and circular with reinforced or plain concrete with high ductility, effective energy absorption capacity, high compressive strength, fire resistance, etc. Conventional RC columns are less strength, carrying capacity and durability as compare to CFST. CFST is used to the greater than 15 story structure for economic aspects of view. Euro code displays the values nearer to experimental results as compared to the Brazilian code because it provides the most conservative design [12].

The column under concentric compression, the design is not only for slender and short columns with slenderness ratio $L_k/D_{ith}$ ratio for short column is less than and equal to 4 and for slender columns is larger than and equal to 12 (Fujinaga, Doi, & Sun, 2008). The Eccentricity of the column depends upon the ratios of longitudinal and transverse reinforcement and slenderness ratio [2].

2. LITERATURE REVIEW

Fujinaga et al. [1] investigated the current design formula for concrete-filled tubular columns under the eccentric loading with a double curvature deflection. They had used the forty-three square specimens for testing and to get the results. The results show that moment radiant and concrete strength increases the concrete strength of the slender square concrete-filled tubular column with a buckling length to depth ratio of 20. The theoretically predicted results and test results are compared with each other under the current design formula which satisfies all criteria. They also studied the eccentric loading for middle-length columns and it evaluates their flexural strength with satisfactory accuracy.
Kottb et al. [2] discussed the high strength concrete (HSC) column under eccentric loading usually acknowledged by designers and contractors, particularly in high compressive stress features. The estimates of column capacities based on ACI 318-08. The authors had divided the research into two parts; in the first phase, they conduct an experimental investigation on ten square columns under eccentricity was applied and in the second part, the use of finite element program ANSYS11 for analytical analysis. The analysed column is shown a good relationship with experimental results with a normal difference of 17% and 16% for mid-height displacement and column ultimate load respectively. For the purpose of cracking patterns, results showed an excellent agreement.

Kristlawan et al. [3] discussed the compression failure of a patched reinforced concrete column under eccentric loading. The serviceability and strength of structure were performed by the poor elements and spalling of the concrete cover formed in the poor elements. The patching method is useful for the damaged RC columns and its recovery of the strength of columns. The authors investigated the comparisons between normal RC columns and patched RC columns with the compression failure of the RC columns under the eccentric loading. They had used the unsaturated polyester resin mortar (UPR mortar) for the patching. The results showed that the failure zone is not shown in the patched RC columns and the strength of the normal RC column is not enough capacity as compared to the patched RC columns, it varies from 71% - 92%.

Nail et al. [4] explained about properties, development, disadvantages, and advantages by using high-volumes fly for economical high-strength self-consolidating concrete. In this research, using the fly ash (C class) with a percentage of 35%, 45% and 55% by weight of Portland cement. The authors studied the reduction of viscosity modifying agent (VMA) and superplasticizer (HRWRA) by adding high-volumes of fly (Class C) ash for self-compacting concrete. The result showed that the maximum value of compressive strength for self-consolidating concrete was 62 MPa at 28 days with the replacement of 35% class C fly ash by the weight of cement.

Pamnani et al. [5] discussed the effect of a few waters retaining curing techniques for self-compacting concrete (SCC) of M30 grade. Water retaining curing techniques are immersion/pond, polyethylene film, compound curing, and dry curing/air curing. Self-Compacting Concrete (SCC) flows under its weight without any bleeding and segregation with high strength and by reducing the volume ratio of aggregate, using various enhancing superplasticizers and admixture. Polyethylene film curing gives 95% compressive strength and the Curing compound method gives the 92% compressive strength than the immersion method at 28 days. They concluded that the lowest value of compressive strength was achieved using dry curing and the highest value was achieved using polyethylene film curing than immersion method.

Sa et al. [6] discussed the performance of self-compacting concrete with waste plastic fibers to find magnesium chloride attack effect. The NANSU method was adopted for self-compacting concrete. The waste plastic fibers used in the Self compacting concrete mixes in various percentages like 0.0%, 0.25%, 0.5%, 0.75%, 1.00%, 1.1%, 1.2%, 1.3% and 1.4% were developed for M40 grade of concrete. The cubes and cylinders were submerged in 5% magnesium chloride solution for 30 days, 60 days and 90 days, they evaluated the reduction in a percentage loss of weight of the specimen, split tensile and compressive strength. Results show that maximum compressive strength and split tensile strength was achieved for 1% of plastic fiber when the percentage of fiber increased more than 1% in Self-Compacting Concrete than the loss in compressive strength, chloride penetration and percentage loss of weight is constantly decreased.

Lai et al. [7] investigated the behavior of the uniaxial Compression Test of CFST Columns confined by tie bars. CFST columns of varying concrete strength, dimensions and different geometric installed with tie bars tested under uniaxial compression. 24 nos. of CFST columns have been fabricated and tested under uniaxial compression. From the results, it was found that the axial load-carrying capacity of tie bars increases Maximum 16%; an average 5% of CFST columns, elastic stiffness of CFST
columns with tie bars does not affect.

Radhika et al. [8] investigated the bond strength of circular concrete-filled steel tubular (CFT) columns using metakaolin admixture. CFT with L/D ratio of 2, 3 and 4 were tested using normal concrete (NC) and concrete with 5%, 10%, 15% and 20% of metakaolin admixture. The result shows that there was an increase in ultimate strength and ductility in CFT with the addition of metakaolin in concrete, bond strength was decreased with an increase in metakaolin percentages. An experiment of the pushout test showed that the bond strength of CFT with metakaolin is higher as compared to CFT specimens.

Sulke et al. [9] studied the seismic performance of the CFST column building (G+30) using ETABS software. This study was carried out to find the comparison of normal RC frame building and CFST building under the response spectrum method (RSM). They compared RC frame building (M1), building with circular CFST columns (M2) and building having CFST columns at the periphery (M3). The result shows that there is a reduction in base shear in M2 about 20% and M3 type of building about 14% as compared to M1, maximum lateral displacement was found in M2, intermediate in M3 and lowest in M1 building. There was about 30% column size reduction in M3 and M2 as compared to M1. The author suggests the M3 type of building for construction having the advantage of resistance against seismic loadings and from the economic point of view.

3. LOADING ON THE COLUMN

A column with axial loading (Concentric loading), axial forces are the tension or compression force acting on members. If the axial forces are applied on the centroid of the sections/members is called the concentric loading. The line of action of the load is conceding with the axis of the member.

A column with uniaxial eccentric loading, the forces applied away from the axis of the section. It may be X-axis or Y-axis. In the uniaxial eccentric loading, the forces are applied only in the one axis. The line of action of the load is not conceding with the axis of the member.

A column with biaxial eccentric loading (Figure 2), the forces applied away from the axis of the section. The load is applied in both axis i.e. X-axis or Y-axis.

![Figure 2. Types of loading](https://www.google.com/url?sa=i&source=images&cd=&ved=2ahUKEwjqrjXZ2PjmAhX8_XMBH ZdpBg4QjRx6BAgt8AQ&url=https%3A%2F%2Fwww.slideshare.net%2Fshamjithkeyem%2Fsd-module4-rajesh-sir&psig=AOvVaw0_QJrq9sv0T6IaBalg0HHL&ust=1578734020234175)
4. COMPOSITE COLUMN

The main focus is to provide more ground space and accommodating more people in less space. Hence, it gives us benefits such as beautiful skyline, important landmarks, and optimum land use. The main focus has been shifted to economic aspects of the project, constructing safer buildings of residential and commercial purpose, generally, tall structures, high-rise buildings, blocks, and towers are constructed. For fulfillment of all the requirements like strength, stability, and stiffness, a new type of construction technique came into introduction which is called ‘Composite construction’. Steel with the concrete composite column is a full compression type member. Composite column has mainly two types, namely concrete-encased steel section, and concrete-filled tube steel section and is normally used as a load-bearing member in a composite structural frame. In Composite columns, steel and concrete will resist external load by joining with each other by bond or in between their friction. Because of large constructions and high-raised buildings of 10 story and above, the size of columns increases because of the revised IS Codes. Till 1970’s Composite Columns were hardly used from the second world war. The research started in the 20th century. In 1913, Emerge of Germany gave the first design formula for composite columns. The first experiment was conducted on a concrete column with strong horizontal reinforcement and a core of cast-iron outside. In the 1930s these type of columns was commonly used for tall buildings in Chicago. Many developed countries adopted composite sections to facilitate speedy construction that is the USA, Japan, Germany, Singapore, Australia, Canada, Belgium, etc.

Figure 3. Types of Concrete Filled Steel Tube
(www.steel-insdag.org/teachingmaterial/chapter25.pdf)

5. CONCLUSIONS

In recent times, the designing and construction of high rise buildings are followed the important aspects like strength, economics, durability, etc. These criteria are fulfilled only by adopting the Self-Compacting Concrete (SCC) and Concrete Filled Tubular Section (CFT’s). Self-Compacting Concrete is using the various types of admixtures for workability and strength purposes. The Normal Concrete (NC) and SSC are fill in the section and sections may be rectangular, square, and circular. In recent times, researchers have research on the Concrete Filled Tubular Section(Figure 3) with Normal Concrete or CFT’s with SSC. But they don’t have research on the comparison of CFT’s by using SSC and Normal Concrete with the eccentric loading. The many research had done on the concentric loading only with the limited L/D and D/t ratios. There is still a lot of research to be done on the use of SSC and NC with eccentric loading on the Concrete Filled Tubular column by comparing the experimentally results with simulation software for future predictions.

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