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Research Paper

AXIAL BEHAVIOR OF CONCRETE-FILLED STEEL TUBULAR BEAM COLUMN JOINT

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This paper present the optimization of partial replacement of natural sand by M- sand and recycled coarse aggregate addition of manufactured sand up to 50% yielded comparable strength with that of the conventional concrete. Recycled Coarse Aggregate is obtained from the demolition of building materials. The mechanical properties for various replacements of sand by M-Sand and course aggregate by Recycled Coarse Aggregate were studied. The different concrete mixes used were 10, 20, and 30%. The cylinders were casted and tested for 28 days for all replacements and modulus of elasticity was calculated. Beam column joint in a reinforced concrete Moment Resisting Frames is the crucial zone for transfer of loads effectively between the connecting elements (i.e., beams and columns) in RC structure. But, the failure of reinforced concrete frames during many earthquakes has demonstrated heavy distress due to shear in the joints that culminated in the collapse of the structure. Hence the beam-column joints are casted for various replacements of M-Sand and Recycled Course Aggregate and tested for the seismic behaviour and compared to the model of ANSYS. Concrete Filled Steel Tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. Steel members have the advantages of high tensile strength and ductility, while concrete members have the advantages of high compressive strength and stiffness. Composite members combine steel and concrete, resulting in a member that has the beneficial qualities of both materials. In this paper, an attempt was made with steel tubular beam column joint filled with different types of concrete using M-Sand and Recycled Course aggregate. The effects of steel tubes, compressive strength of concrete and the confinement of concrete are examined.

Keywords: CFST, M-sand, Recycled coarse aggregate, Natural sand, Joints, Compressive strength

INTRODUCTION

Concrete Filled Steel Tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. They are

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widely used in high-rise and multistory buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a robust and efficient structural system is required.

Composite members consisting of square steel tubes filled with concrete are extensively used in structures involving very large applied moments, particularly in zones of high seismicity. Composite square Concrete Filled Steel Tubes (CFST) have been used increasingly as columns, beams and beam-columns in braced and un-braced frame structures. Their use worldwide has ranged from compression members in low-rise, open floor plan used in retrofitting of damages steel bridge piers after the 1995 Hyogoken-Nanbu earthquake in Japan and the Northridge earthquake in 1994 in the USA. The two main types of composite column are the steel-reinforcement concrete beam, which consists of a steel section encased in reinforced or unreinforced concrete, and the Concrete Filled Steel Tubular (CFST) beams, which consists of a steel tube filled with concrete.

CFST beams have many advantages over steel-reinforcement concrete beams. The major benefits of concrete filled beams are:

- Steel beam acts as permanent and integral formwork,
- The steel beam provides external reinforcement, and
- The steel beam support several levels of construction prior to concrete being pumped.

Although CFST beams are suitable for all tall buildings in high seismic regions, their use has been limited due to a lack of information about the true strength and the inelastic behavior of CFST members. Due to the traditional separation between structural steel and reinforced concrete design, the procedure for designing CFST beam using the American Concrete Institute's (ACI) code is quite different from the Load and Factor Resistance Design (LFRD) method suggested by the American Institute of Steel Construction's (AISC).

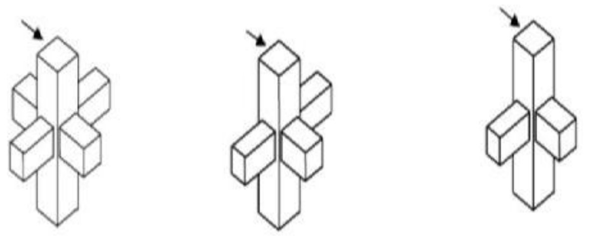
Beam Column Joint

Beam-column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to earthquake loading. Failure of beam-column joints during earthquakes is governed by bond and shear failure mechanism which are brittle in nature. Therefore, current international codes give high importance to provide adequate anchorage to longitudinal bars and confinement of core concrete in resisting shear. A review of the behavior and design of different types of beam-column joints in reinforced concrete moment resisting frame under seismic loading illustrates that design and detailing provisions for the joints in the current Indian seismic code, IS 13920:2001 are not adequate to ensure prevention of such brittle failure. Since joints are subjected to large shear force during earthquake, shear strength in this region should be adequate to carry this large amount of shear force.

The joint is defined as the portion of the column within the depth of the deepest beam that frames into the column. In a moment resisting frame, three types of joints can be identified viz. Interior Joint, Exterior Joint and Corner Joint.

The severity of forces and demands on the performance of these joints calls for greater understanding of their seismic behavior. These forces develop complex mechanisms involving bond and shear within the joint.

Figure 1: Types of Joint



Manufacturing Sand

Conventional concrete is a mixture of cement, sand and aggregate. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river sand or quarry dust. Fine and coarse aggregate constitute about 75% of total volume. When rock is crushed and sized in a quarry the main aim has generally been to produce coarse aggregates and road construction materials meeting certain specifications. Generally, this process has left over a proportion of excess fines of variable properties, generally finer than 5-mm size.

Recycled Course Aggregate

Most of the buildings materials generate solid wastes all over the world due to demolition of various buildings. It was introduced due to the growing concern about future of the planet and it applies for construction industry, a huge consumer of natural resource. The demolition of building materials can be used as a replacement for the coarse aggregate. It can reuse, recycle the waste materials from the extraction of huge waste. Rapid industrial development causes serious problems all over the world such as depletion of natural aggregates and creates enormous amount of waste materials from construction fields. Thus the recycled coarse aggregate is used as a replacement for coarse aggregate with reduction in cost and increase in strength.

EXPERIMENTAL INVESTIGATION

Cement

OPC 53 grade cement was used for this investigation and the specific gravity of cement was 3.15. The physical properties of cement are given Table 1.

Table 1: Physical Properties of Cement

Property	Values
Specific gravity	3.15
Initial setting time	30 min
Final setting time	2-3 hours
fineness	3.2%

Fine Aggregate

Locally available river sand passed through 4.75 mm IS sieve is used as fine aggregate. The specific gravity of sand is 2.45.

Coarse Aggregate

The Coarse aggregate are obtained from a local quarry is used. The coarse aggregate with a maximum size 20 mm having a specific gravity 2.84 has been taken for mixes.

Water

Water is an important ingredient of concrete as it initiates the chemical reaction with cement and the mix water was completely free from chlorides and sulfates. Ordinary potable water was used throughout the investigation as well as for curing concrete specimens.

Manufacturing Sand

The definition of the size of sand particles varies, but in general sand contains particles measuring about 0.0025-0.08 inches (0.063-2.0 mm) in diameter. Particles smaller than this size are classified as silt. Larger particles are either granules or gravel, depending on their size. In the construction business, all aggregate materials with particles smaller than 0.25 inches (6.4 mm) are classified as fine aggregates. This includes sand. Materials with particles from 0.25 inches (6.4 mm) up to about 6.0 inches (15.2 cm) are classified as coarse aggregates.

Recycled Coarse Aggregate

Recycled Concrete Aggregates have irregular and granular structure, due to the adhered mortar which can be a point of concern as it is a factor which contributes toward higher water absorption, workability and ultimately the strength characteristics of the concrete made using RCA. The structure of RCA mainly depends upon the parent source of concrete rubble. While aggregates derived from concrete cubes yields aggregates with irregular shape and better bond between mortar and aggregate.

MIX PROPORTIONING

The mix proportions of M20 concrete and mix ratio of concrete 0.5: 1: 1.74: 3.3 by weight of water, cement, fine and coarse aggregate.

RESULTS AND DISCUSSION

Control Specimen

For specimen the deformation was very small when it was loaded. When the load reached to 400 kN the extension in length and diameter is 300 mm and 153 mm respectively. The specimen had a visible yield of compressive strength of 0.023 kN/mm^2.

The load versus deflection is as shown in Figure 2.

Figure 2: Load vs Displacement Curve

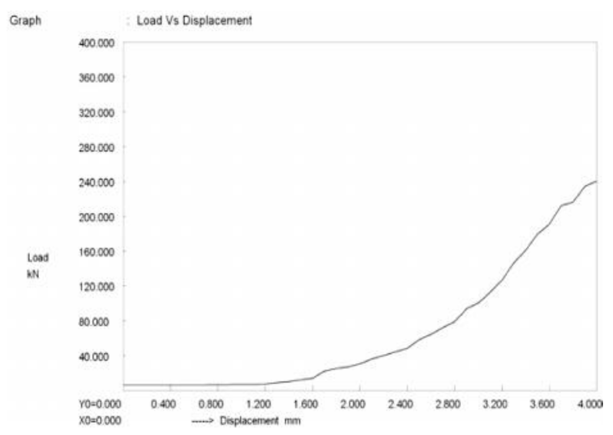
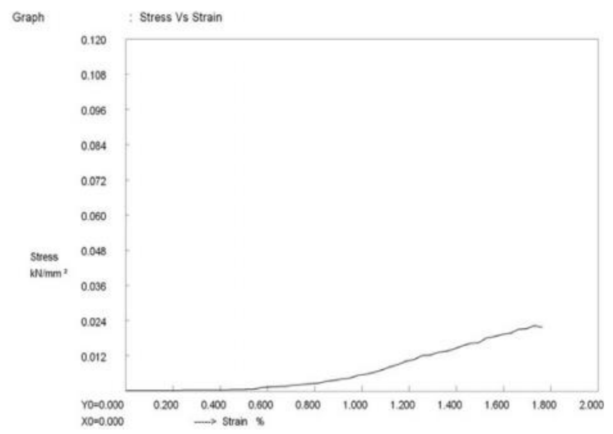


Figure 3: Stress-Strain Curve



Stress-Strain diagram is as shown in Figure 3.

10% Replacement of M-Sand and RCA

In this case the specimen had the very small deformation when it was loaded. When the load reached to 292 kN the extension in length and diameter is 293 mm and 152 mm respectively. The specimen had a visible yield of compressive strength is 0.017 kN/mm^2.

The load versus deflection is as shown in Figure 4.

Figure 4: Load vs Displacement Curve

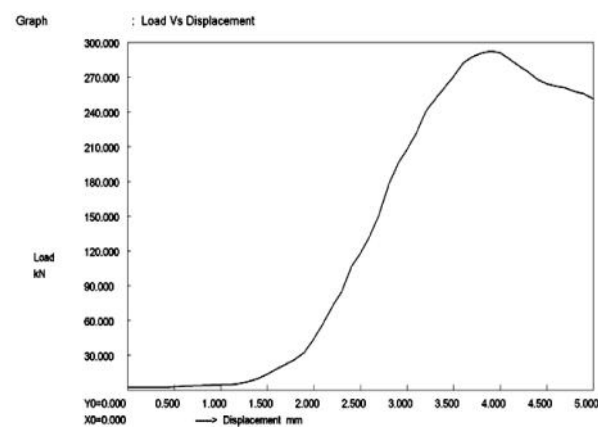
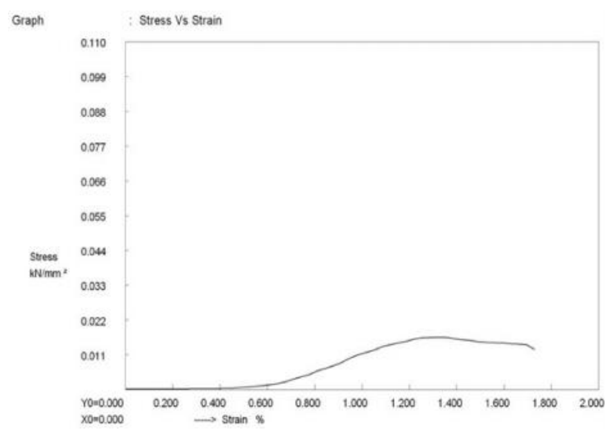


Figure 5: Stress-Strain Curve



Stress-strain diagram is as shown in Figure 5.

20% Replacement of M-Sand and RCA

For this specimen, the deformation was very small when it was loaded. When the load reached to 395 kN the extension in length and diameter is 293 mm and 152 mm respectively. The specimen yields the compressive strength of 0.022 kN/mm^2. The load versus deflection is as shown in Figure 6.

Figure 6: Load vs Displacement Curve

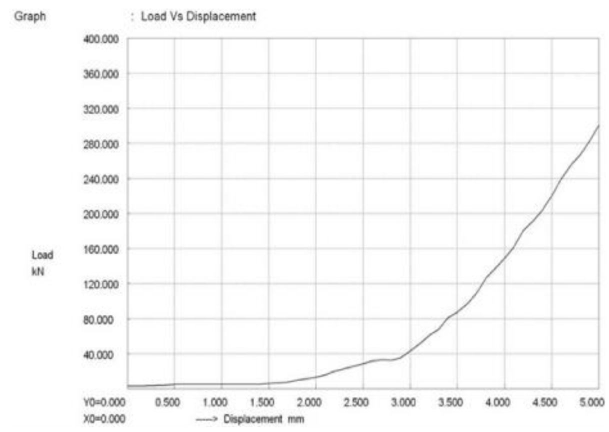
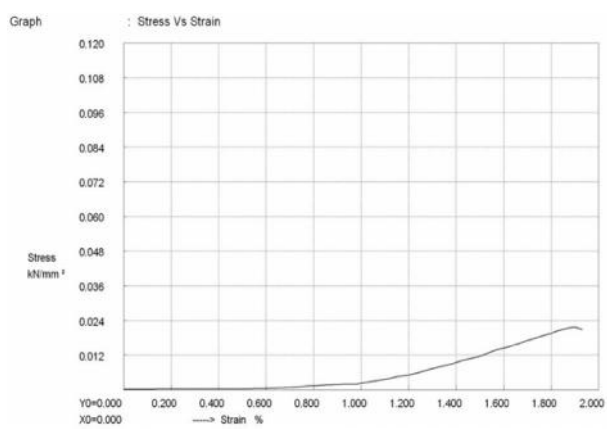


Figure 7: Stress-Strain Curve



Stress-strain diagram is as shown in Figure 7.

30% Replacement of M-Sand and RCA

For specimen the deformation was very small when it was loaded. When the load reached to 397.16 kN the extension in length and diameter is 293mm and 152 mm respectively. The specimen had a visible yield of compressive strength as 0.023 kN/mm^2.

The load versus deflection is as shown in Figure 8.

Stress-strain diagram is as shown in Figure 9.

Figure 8: Load vs Displacement Curve

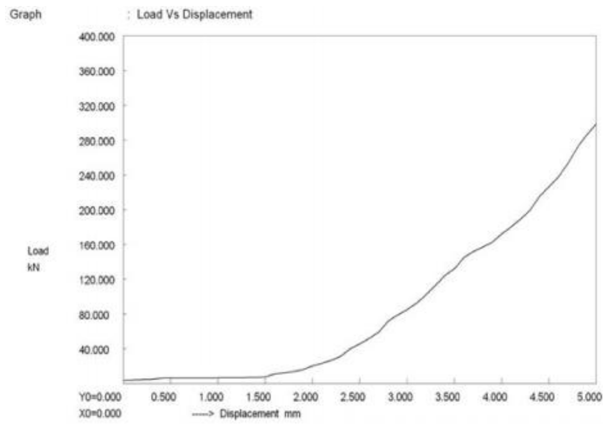
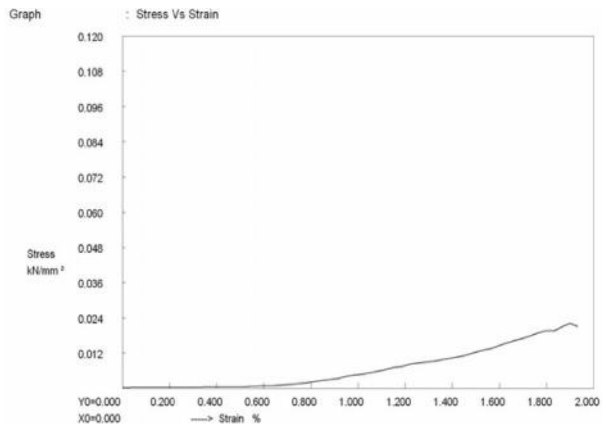


Figure 9: Stress-Strain Curve



FUTURE INVESTIGATION

The behavior of CFST beam- column joint will be studied through casting of T-Section and applying two point loads for beams and axial load for columns. The test results will be judge against with the ANSYS software.

CONCLUSION

The overall strength of concrete linearly increases from 0% to 30% in the order of 10% increase in the replacement of natural sand by manufactured sand is compared with reference mix. Also partial replacement of coarse aggregate with recycled coarse aggregate and fine aggregate with m-sand up to 30% is done and the tests shows significant improvement in results which will be used for future investigation.

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