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Structural Behaviour of RC Beam and Concrete Filled Steel Tubes Retrofitted with Natural Rubber Sheet

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***Abstract*—Concrete filled steel tube is component with good performance resulting from the confinement effect of steel with concrete and design versatility. It has become a new trend to introduce Concrete-Filled Steel Tube (CFST) members for several modern structural projects. Although, the CFST members possess similarity to other pertinent structural members that demand strengthening for various direct reasons, such as degradation due to the environment, fire, fatigue, upgrades to carry extra loads and ageing. This paper presents a detailed study on the behaviour of Concrete-Filled Steel Tube (CFST) retrofitted with natural rubber sheets. A total of 18 numbers of prism specimens of cross section 100mmx100mmx500mm (6 normal c.c,6 CFST,6 CFST wrapped by natural rubber sheet) and six numbers cylinder specimen of cross section 150mmx300mm (3normal c.c,3 CFST wrapped by natural rubber sheet) , 6 number of cube specimens of cross section 150mmx150mmx150mm.The thickness of the steel used was 1mm.natural rubber sheet of 2mm thickness was used for retrofitting beams were tested upto failure and the yield point was found out. The influence of variation of length and thickness of natural rubber sheet wrapping on ultimate load carrying capacity, deflection, load strain behaviour are studied and are compared with that of control beam. An attempt to study the variation in ductility characters before after retrofitting with natural rubber sheets are also carried out.**

***Index Terms*—concrete filled steel tube, Natural rubber sheet, wrapping, confinement effect.**

I. Introduction

Concrete-filled steel tube (CFST) have been widely used in modern structural systems. In the CFST, the inward buckling deformations of the steel tube can be prevented by the concrete core, but inelastic outward local buckling can result in the degradation of steel confinement, strength and ductility. To overcome this deficiency, additional transverse confinement outside the steel tube to constrain its outward local buckling. The additional transverse confinement can be carried out by steel tube segments or natural rubber sheet wrap. Natural rubber sheet, CFST composite materials have attracted much attention, due to the advantages of the high strength-to-weight ratio, non-corrosion and flexibility in adapting to field configurations. Their applications in strengthening or retrofitting structures have been demonstrated to be of economic and engineering advantage. As a result of the additional confinement from natural rubber sheet wrap, the outward buckling deformation of the steel tube is mitigated or even eliminated, and the concrete core is further confined. They studied the parameters of the thickness of the steel tube and the NRS layer number. The results indicated that the NRS wrap could substantially delay or even completely suppress the development of local buckling deformation in the steel tube. The behaviour of the concrete was significantly enhanced by the NRS confinement. The NRS layer number and the width and spacing of the strips were studied. The results showed that the external bonding of NRS not only provided additional confinement pressure to the concrete core, but also constrained the local buckling of the steel tube. A simple model is proposed to calculate the load capacity of CFST. The predictions are compared with the experimental results in this study and in the literature.

II. SCOPE

Concrete filled steel tube retrofitted with natural rubber sheet is the solution to resist damages of structures and want to be verified by compression strength, flexural strength and split tensile strength test and the performance of steel tube and natural rubber sheet should attain the conventional concrete strength is usually determined by its strength and durability.

III.OBJECTIVES

To reduce the outward buckling deformation of the steel tube. To increase the lifetime of the building. To reduce the cracks.

IV.MATERIALS USED

4.1. Cement

Chemical composition	Percentage
Silicon Di oxide (SiO_2)	22.40
Aluminium Oxide (Al_2O_3)	5.20
Iron Oxide (Fe_2O_3)	3.80
Magnesium Oxide (MgO)	1.70
Calcium Oxide (CaO)	61.60
Ignescent Material	1.40

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Which provide a binding medium for the discrete ingredients it is obtained by burning together, in a definite proportion. Cement can be of Ordinary Portland Cement and Portland Pozzolana Cement. The ordinary Portland cement (53 Grade as per IS: 8114-1978) was used in this investigation. The ordinary Portland cement has adequate resistance to dry shrinkage and cracking, but has less resistance to chemical attack. The Specific gravity of OPC is 3.15

TableNo.4.1 Chemical composition of Cement

Fig.No.4.1 OPC-53grade

4.2. Steel tube

Steel tubes are long, hollow tubes that are used for a variety of purposes. They are produced by two distinct methods which result in either a welded or seamless tube. In both methods, raw steel is first cast into a more workable starting form. It is then made into a tube by stretching the steel out into a seamless tube or forcing the edges together and sealing them with a weld. They have steadily evolved into the modern processes we use today. Each year, millions of tons of steel tubes are produced. Its versatility makes it the most often used product produced by the steel industry. Steel tubes are found in a variety of places. While steel tubes are strong, they can also be lightweight. This makes them perfect for use in modern construction.

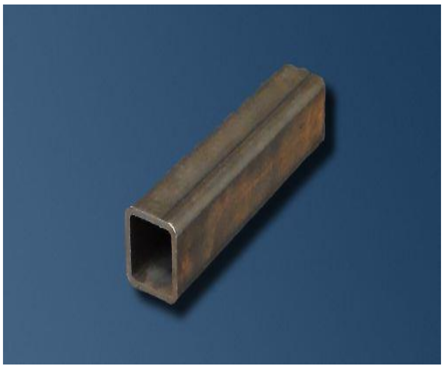


Fig.No.4.2 Steel tube

4.3 Molding sand

Molding sand is an aggregate of sand, bentonite clay, pulverized coal and water. Its principal use is in making molds for metal casting. The largest portion of the aggregate is always sand, which can be either silica. There are many recipes for the proportion of clay, but they all strike different balances between moldability, surface finish, and ability of the hot molten metal to degas. The coal, typically referred to in as sea-coal, which is present at a ratio of less than 5%, partially combusts in the surface of the molten metal leading to off gassing of organic vapours. Sand casting is one of the earliest forms of casting practiced due to the simplicity of materials involved. It still remains one of the cheapest ways to cast metals because of that same simplicity.

4.4 *Coarse aggregate*

The aggregates which are retained on the 4.75mm IS sieve are said to be coarse aggregate. The nominal sizes of coarse aggregate are 40mm, 20mm, 16mm, and 12.5mmand10mm. A 20mm size coarse aggregate has been used for this investigation.

4.5 *Water*

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The pH value of water lies between 6 and 8 that indicate the water is free from organic matters. However, the excess amount of water can cause segregation problem and the less amount can cause poor workability. The quantity and quality of water is required to be watched into carefully so that it can form the durable concrete.

4.6 *Moulds*

Here we used three types of mould to check strength at various Proportions of replacement.

Fig.No.4.6 Moulds

4.6.1 Cylinder

Cylinder mould of size 300mm height and 150mm diameter used to prepare the concrete specimen for determination of split tensile strength of concrete.

4.6.2 Prism

Prism mould of size 500mm length, 100mm width and 100m thick was used to prepare the concrete specimens for determination of flexural Strength of concrete.

4.7 Natural rubber sheet

Natural gum rubber is a popular non-marking rubber material thanks to its soft, supple nature and excellent flexibility. It is a natural product that is made from the sap of rubber trees found in South America and South Asia. Natural gum rubber is also an eco-friendly elastomer thanks to its tree-derived raw materials. The origins of this 'green' elastomer and its modern day version has a storied past and was one of the most important discoveries of the modern ect. Natural rubber material is produced by harvesting the latex from trees. This sticky, milky liquid is taken from a variety of trees through a process called tapping. Incisions are made in the trees, allowing the latex to trickle out into collection containers. It is then processed to form the material we know as natural gum rubber. More than 200 plants across the world are known to produce latex, but the majority of natural rubber products are made using latex from the Hevea brasiliens is, known as the rubber tree. This makes natural gum rubber the perfect material for environmentally-conscious consumers.

Fig.No.4.7 Natural rubber sheet

V. EXPERIMENTAL INVESTIGATION

5.1General

This chapter presents the details of experimental investigations of concrete specimens. For this experimental work Cylinders and Prisms are designed the mixing and casted the stress-strain behaviour, strength and stiffness were studied.

5.2 Mix Design

The present investigation is aimed to study about flexural strength and split tensile strength of blended concrete By using steel tube and rubber sheet for various mix Proportions.

1. Design Stipulation:

Mix design for M_{25} grade of concrete. The quantity mentioned below is for one cubic meter.

Grade designation = M_{25}
Type of cement = OPC 53 grade
Specific Gravity
(a)Cement= 3.15
(b)Coarse Aggregate =2.88
(c) molding sand =2.70

2. Target Strength

$f_{ck}' = f_{ck} + 1.65\, S$

$S = 5\ N/mm^2$

$f_{ck}' = 38.25\ N/mm^2$

3. Selection of W/C Ratio

Maximum w/c ratio = 0.45

4. Selection of Water Content

Maximum water content
For 20mm size aggregate = 186 liters

5. Calculation of cement content

W/c ratio= 0.45

Cement content=413kg/m^3

6. Volume of CA & MS Content

Coarse aggregate = 0.63
Fine aggregate = 0.37

7. mix design

- Grade of cement = 53
- Size of coarse aggregate = 20mm
- Sieve size of fine aggregate = 4.75mm
- Diameter of steel = 8mm
- Size of natural rubber sheet = 1m x 1.2m x 2mm
- Size of steel tube for cylinder = 150mm x 300mm
- Size of steel tube for prism = 100mmx 100mm x 500mm

  Characteristic compressive
- strength of concrete = 25N/mm^2
- Mix design ratio = 1:1:2

  For 0.14 cum:
- Volume of cement = 1.5 bag

- Volume of coarse aggregate = 0.11cum
- Volume of fine aggregate = 0.053 cum

VI. Casting Process

6.1 Material Preparation

The selection of aggregate, sand and cement were in proportion accordance with the mix design and current practice used in making OPC concrete.

6.2 Mixing, Placing and Compaction

For casting , all the mould were cleaned and oiled properly .These were securely tightened to correct dimensions be forecasting .Care was taken that there is no gaps left from where there is any possibility of leakage of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The concrete mixture was prepared by machine mixing. For cylinder (150mmx300mm) and Prism (100mm x 100mm x 500mm) the mixture was cast in three layers. Each layer received 25 manual strokes. Copper Slag was added to the mixture in dry condition during the mixture of cement and fine aggregate after mixing the mixture with water .The specimens were allowed to remain in their respective mould until the next day. Then the concrete was demoulded and placed in the curing tanks for the purpose of 28 days curing.

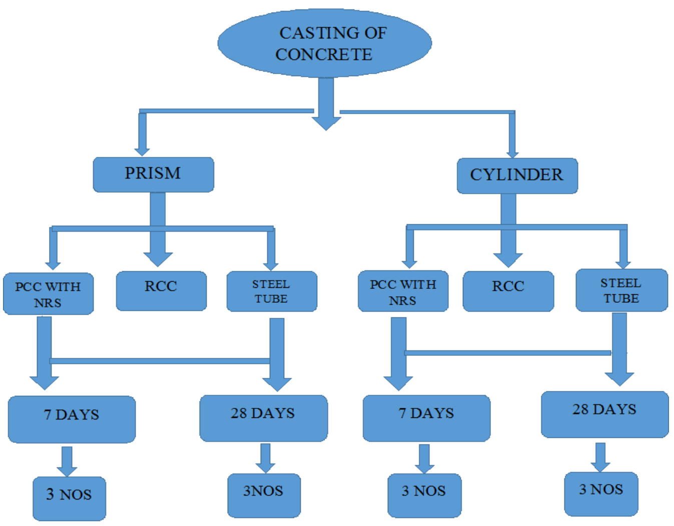


Fig.7.3 casting process

VII. TESTING OF SPECIMENS

7.1 FLEXURAL STRENGTH TEST

The maximum load applied to the specimen is recorded and the appearance of the concrete and any unusual features.

Flexural Strength = $Pl/bd2$

Fig.No.7.1. ***flexural strength test***

Table No.7.1 Test value of flexural strength test

S.NO	RCC	Steel tubes	Natural rubber sheet
flexural strength test@7days (N/mm^2)	19	60	27

7.2 SPLIT TENSILE TEST

The maximum load applied to the specimen is recorded and the appearance of the concrete and any unusual features in this type of failure are noted

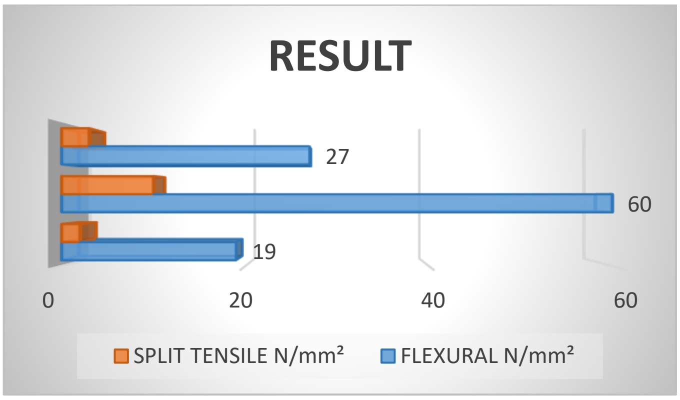
Split tensile test= $2P/\pi DL$

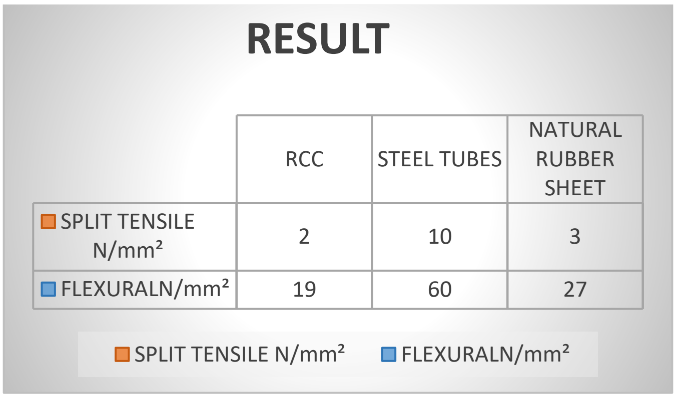
Fig.No.7.2. split tensile test

Table No.7.2 Test value split tensile strength

S.NO	RCC	Steel tubes	Natural rubber sheet
Split tensile test@7days (N/mm^2)	2	10	3

8. RESULT AND DISCUSSION





8. BENEFITS

- Used for retrofitting's works in existing buildings
- Reduces the outward buckling deformation of the concrete elements
- Increase the life time of the building

9. CONCLUSION

- Method of retrofitting's are depends upon the type of failure
- More strength to improve the durability of the structure
- Strength and estimation are directly proportional to each other

1. The load capacity and the axial deformation capacity of concrete-filled steel tube columns can be effectively improved by the NRS wrap. All specimens failed by the explosive rupture of the NRS in the mid-height region because of the lateral expansion of the concrete.

2. The NRS wrap can delay the outward local buckling deformation of the steel tube and suppress the lateral expansion of the concrete in the CFST. The strength and the strain capacity of the concrete can be enhanced by the additional confinement from the NRS wrap.

3. The NRS wrap has higher strain efficiency than the CFRP wrap. The CFRP efficiency increases with the increasing of the CFRP layer number, but decreases with the increasing of the concrete strength.

4. A simple model is proposed to predict the load capacity of the CFST The model can accurately predict the load capacity of the CFST with not too strong NRS confinement. However, it overestimates that of the CFST with strong NRS confinement. Therefore, there is further research needed to develop a more accurate design approach when strong NRS confinement is exerted on CFST. The current phase of the study was focused on the experimental study of the load capacity of short CFST. Experimental and analytical investigation is under way to examine different details for the additional confinement, particularly for slender CFST specimen subjected to eccentric loads.

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