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Original Research Paper

Engineering

AN EXPERIMENTAL INVESTIGATION ON BEHAVIOR OF TENSAIRITY BEAM SUBJECTED TO CONCENTRATED LOAD IN COMPARISON WITH RCC BEAM

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ABSTRACT

Tensairity is a new light weight structural concept. The key principle of Tensairity is to use low pressure air to stabilize compression elements against buckling. The basic Tensairity structure is a beam with the properties of a simple air beam as light weight, fast set up and compact storage volume but with the load bearing capacity of conventional steel girders. Ideal applications of the Tensairity Technology include wide span roof structures, temporary buildings and footbridges.

An experimental investigation had been carried out to understand the behavior of a Tensairity beam subjected to concentrated load in comparison with that of a RCC beam to determine its ultimate load carrying capacity and deflections. The Tensairity beam has been casted with a flex of 1m length and 30cm diameter is made into a cylindrical membrane filled with compressed air with an internal pressure of 954N/mm2 making it a very light and deployable beam.

KEYWORDS : Tensairity, Deployable beam, Light weight structures

INTRODUCTION

Tension and compression: Where there is tension, there is compression too. Tent structures need poles. And these poles have to withstand buckling. The goal of light weight structural engineering is to find the optimal interplay between tension and compression. Tension and compression are evenly balanced in the new structural concept Tensairity. In combination with the

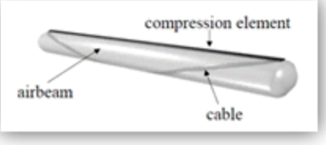

Fig 1: The Basic Elements Of A Tensairity Beam

extraordinary feature of buckling free compression, highly efficient light weight structures can be realized based on Tensairity with a tremendous potential for applications in the field of civil engineering.

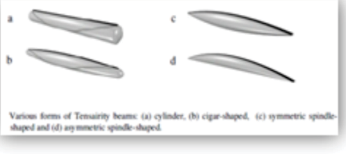

Fig 2: Various Forms Of Tensairity Beams

The new structural concept Tensairity is a synergetic combination of a pneumatic structure and a cable-strut structure. The main function of the pneumatic structure is to stabilize the cable-strut structure. Tensairity is a revolutionary light weight beam element developed by Airlight Ltd, Switzerland. Tensairity structures have a multitude of very interesting properties. Light weight, compact transport and compact storage is possible as well as fast and easy deployment. Furthermore, one of the most outstanding properties of Tensairity is that the structure is adaptable. The load-deformation response of such a Tensairity girder can be controlled by the air pressure which allows the girders to adapt to changing load conditions.

The Tensairity beam of Fig 1 has a cylindrical form. Investigation on various beam

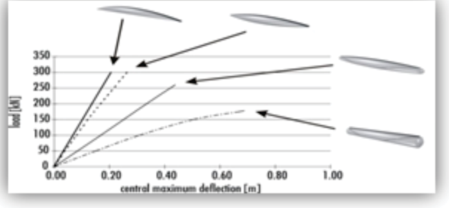

Fig 3: Load v/s Deflection of different forms

shapes by means of finite element calculations is analysed. A cigar-shaped geometry (Fig. 2b) is better adapted to the structural demands than the cylindrical form (Fig. 2a). Membrane material can be saved and the beam is stiffer. The spindle-shaped geometry (Fig. 2c-d), where the tube end converges to a point, is the stiffest configuration. In this case, the geodesic spiral of the cable degenerates to a straight line and the cable can be replaced by a tension rod. Given these advantages, many Tensairity applications will be based on cigar- or spindle-shaped tubes.

RCC beams of size 1000 x 150 x 150 mm were used for this study to test its flexural strength. A total number of 3 specimens were casted for same proportions. These beams were tested for flexural strength in Loading frame Machine of capacity 100 tonnes in BMT laboratory, DSCE, Bangalore. Simply supported RCC beams were subjected to pure flexural failure by subjecting them to three point loading test.

Two 12 mm diameter bars were used for flexural reinforcement at bottom and two 10 mm rods were provided for top reinforcement. For each beam, 8mm diameter mild steel bars are used as stirrups, spaced 100 mm c/c for shear reinforcement. All beams were cast by using M20 grade concrete with 20 mm size of CA, locally available sand and OPC 43 grade cement.

1. E xperimental Study

Casting of RCC beam

RCC beams of size 1000 x 150 x 150 mm were used for this study to test its flexural strength. A total number of 3 specimens were casted for same proportions. These beams were tested for flexural strength in Loading frame Machine of capacity 100 tonnes in BMT laboratory, DSCE, Bangalore. Simply supported RCC beams were subjected to pure flexural failure by subjecting them to three point loading test. Two 12 mm diameter bars were used for flexural reinforcement at bottom and two 10 mm rods were provided for top reinforcement. For each beam, 8mm diameter mild steel bars are used as stirrups, spaced 100 mm c/c for shear reinforcement. All beams were cast by using M20 grade concrete with 20 mm size of CA, locally available sand and OPC 43 grade cement.

Building Of Tensairity Beam

The flex of 1m length and 30cm diameter is made into a cylindrical membrane filled with compressed air with an internal pressure of 954N/mm2 making it a very light and deployable beam.

Fig 5a: Cutting of flex w.r.t. required dimensions; Fig 5b: Fixing an air vent using adhesive; Fig 5c: Filling Compressed air to the proposed Tensairity beam; Fig 5d: Winding of Tension cable to Tensairity beam

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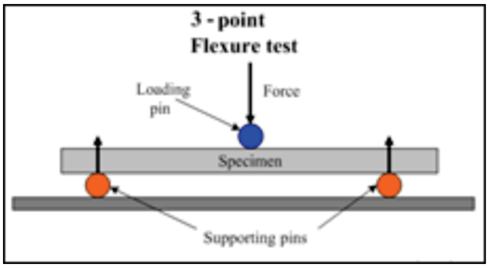
2. Results And Discussions

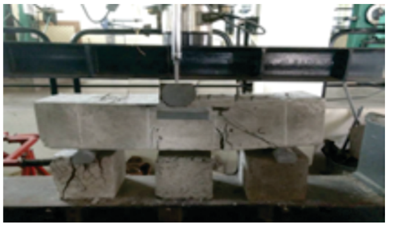
Test results of RCC beam



Sn	Deflection (mm)	Ultimate Load (kN)	Area (m2)	Flexural stress (kN/m^2)
1	2.4	98	0.0225	4355.55
2	2.3	96	0.0225	4266.67
3	2.2	87	0.0225	4222.22

The average ultimate load achieved is 93.67 kN

The average deflection is found to be 2.3 mm



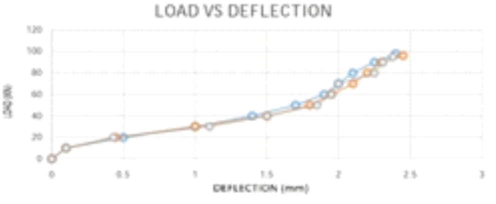
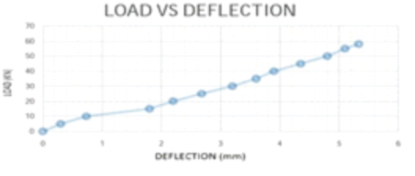


Fig 6: Testing of RCC beam

Results And Load Vs Deflection Curve Of Rcc Specimens

Fig 7: Testing of Tensairity beam



Test Results Of Tensairity Beam

Sn	Deflection (mm)	Ultimate Load (kN)	Area (m2)	Flexural stress (kN/m^2)
1	5.33	58	0.01767	3282.4

Results and Load vs deflection curve of Tensairity beam

The ultimate load achieved is 58 kN

The deflection is found to be 5.33 mm

An important feature observed from these tests was that the limit of the Tensairity structure seems to be predictable. The bending and deformation of the beam at 58kN was such that a near failure was obvious simply by looking at the structure. This good natured failure behaviour is another advantage of Tensairity structures. The Tensairity beam fulfilled all the expectations of this new technology. It clearly demonstrates that real loads can be carried by Tensairity with low structural weight and small overpressure. The basic Tensairity concept of pressure induced stabilization of compression elements has been confirmed. Theory and the experimental model are in good agreement proving the soundness of the technology. Compact storage, fast set up and good natured failure behaviour in the expected range are other important advantages demonstrated by the test. Based on these properties one can anticipate the huge potential of Tensairity for light weight civil engineering applications such as wide span structures and temporary buildings.

3.CONCLUSION

The following conclusions are drawn from the present study:

- The goal of structural engineering often structures is to find an optimal balance between tension and compression. This balance could be optimized with Tensairity.
- Tensairity is a synergic combination of an air-beam and a cable-strut structure or in other words, of fabrics, compressed air, cables and struts.
- The fabric plays an important role in Tensairity. It is pre-tensioned due to compressed air. Hence it can transfer compressive forces from the upper chord to the lower chord. The fabric stabilizes the chord under compression against buckling. Also the fabric has to take care of the shear forces. The fabric used was flex, which is the key to the outstanding properties of Tensairity such as lightweight, fast, and simple set up, compact transport and storage volume, interesting lighting options and so on.
- The deformation of a Tensairity girder for a given load can be varied simply by changing the air pressure of the structure.
- The ultimate load bearing capacity of RCC beam was found to be 38% more than that of a Tensairity beam.
- The deflection of Tensairity beam was found to be 57% higher than that of a RCC beam.
- Though RCC continues to be a dominant construction material, Tensairity concept is limited to deployable light weight temporary structures

4.FUTURE RECOMMENDATIONS

Tensairity beams can be experimented on by the following:

- Different shapes and dimensions
- Variation in thickness
- Finite element analysis using software
- Variation in internal pressure due to the compressed air
- Variation in the types used and geometrical of tensioning cables

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