STUDY THE DEFORMATION AND INTERNAL FORCE OF HEXAGONAL SHAPE TENSILE STRUCTURE USING FEM ANALYSIS

(SPIDER WEB CONCEPT)

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Abstract – *Spider web is one of the wonders in the field of structure engineering. The radial threads lining through support points carries all the loads and the transverse threads joining radial wires, maintain the stability of the tensile structure. In this study, the simulation of actual spider web network has been done using the steel wires. The intersection point of the radial wires has been taken as the nodal load point, at which load is applied consecutively. Hence, corresponding deflection of wires at certain nodes and internal forces at the wires are analyzed with the use of finite element modeling software named-'RFEM'.*

Key Words: Spider web, Wire, Load Point, Node, Deflection, Internal Force, RFEM.

1. INTRODUCTION

Tensile structure is a light weight structure in which only tensile force is acting. Hence, large clear spaces can be provided with the use of less number of elements i.e. the case of expo hall, auditorium etc. In our modelling, the radial wires (3mm diameter) have been taken as the main element. Similarly, the 2mm and 1.3mm diameter wires have been used as the transverse wire. Since, the main element takes all the loads of the structure, for simplicity, the weight of the transverse wires have been distributed equally along the radial wires. Thus, the distributed load and the nodal load at the intersection point forms the combination of loads.

2. PROCEDURES

The radial wires have been drawn along the six support points i.e. A, B, C, D, E, and F, giving rise to three radial wires DA, BE, and CF. These wires intersect at a point 'O', making up six segments of radial wire i.e. AO, BO, CO, DO, EO, and FO. Each segment of the radial wires has been divided into several nodes at a spacing of 10 cm each. The 3 mm diameter radial wires have been assigned as the cable elements. Two types of loads have been assigned i.e. imposed load and nodal load. The nodal load has applied at the central intersection point 'O'. The imposed line load has been applied along the radial wire segments. The springs have been introduced to the corresponding support points in order to facilitate to calculate the induced tensile force as support reaction during the experimental study.

Finally, the deflection has been measured at the distance 1m, 2m, 3m, and 3.5m respectively from the central intersection point 'O' on each wire segment. These nodes have been named with subscript 1, 5, 15, 25, 0 respectively placed with name of the support points. Similarly, the internal force has been measured at each support points at the end of radial wire segments.

Table- 1: Coordinates of Support Points on Web

Support Points	*Coordinates (X,Y,Z)*
A	*(-2.103, -3.466, 1.4)*
B	*(0, 0, 1.4)*
C	*(5.13, 0, 1.4)*
D	*(7.347, -3.466, 1.4)*
E	*(5.13, -6.780, 1.4)*
F	*(0, -7.09, 1.4)*

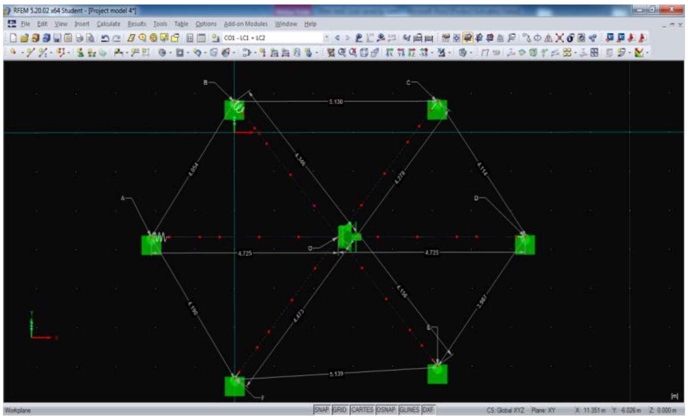

Fig- 1: Geometry of Model

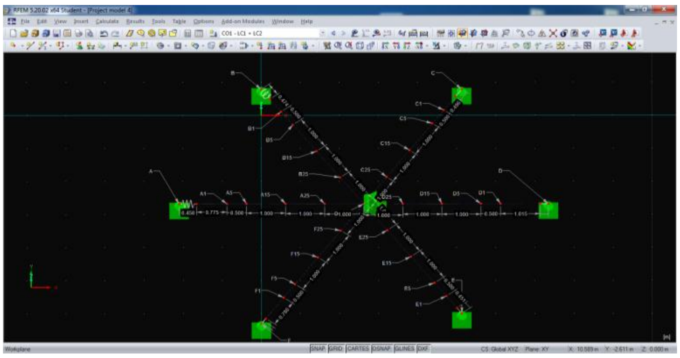

Fig- 2: Node Formation on the Tensile web structure

Table- 2: Input Values of Tensile web structure

Wire diameter	0.003 m
Density of wire	7850 kg/m3
Stiffness of spring	1564 N/m

Table- 3: Load on Each Segment of Tensile web

Segment	Load (N/m)
AO	2.2694
BO	2.4
CO	2.3896
DO	2.1775
EO	2.4106
FO	2.2673

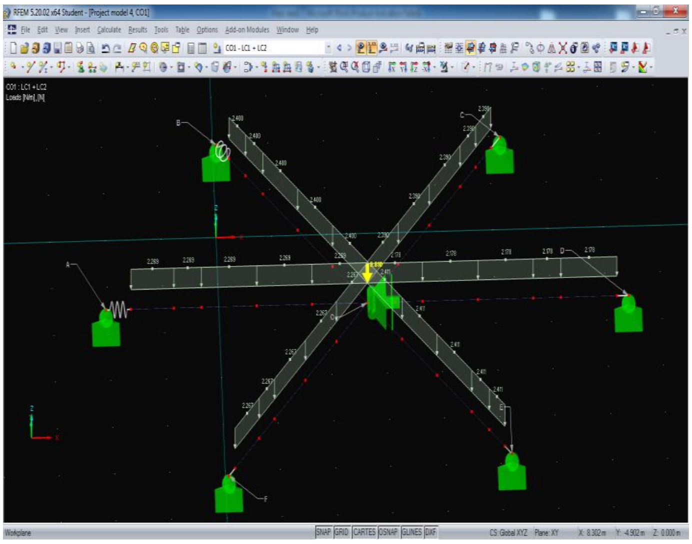

Fig- 3: Application of loads on the Tensile structure

3. RESULTS

The deflections and the reactive forces have been obtained as the output. The difference between the output obtained due to the specific load and to the output obtained without any load, (under the effect of its own weight) gives the effect of the specific load. Similar effects were obtained during the experimental study for the verification of its behavior.

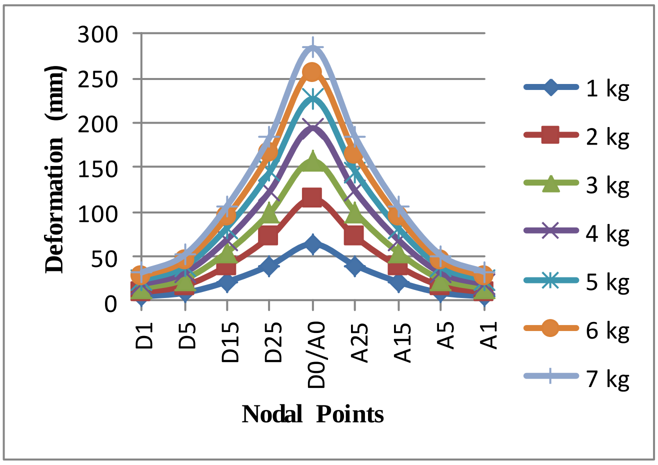

Fig- 4: Actual Deformation Due To Nodal Load (mm) along the radial line – DA

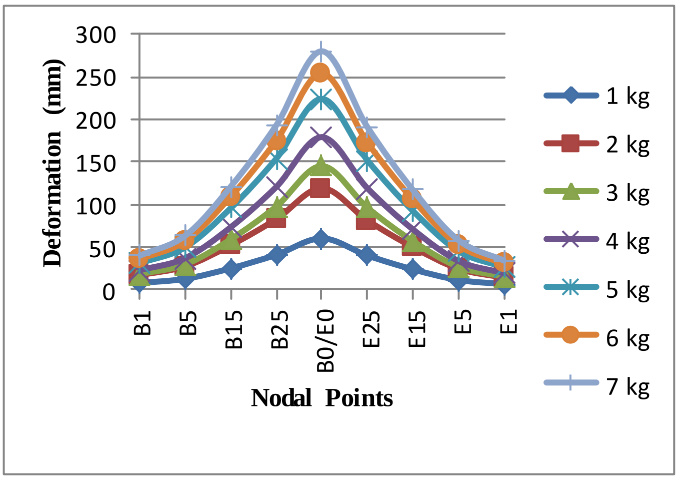

Fig- 5: Actual Deformation Due To Nodal Load (mm) along the radial line- BE

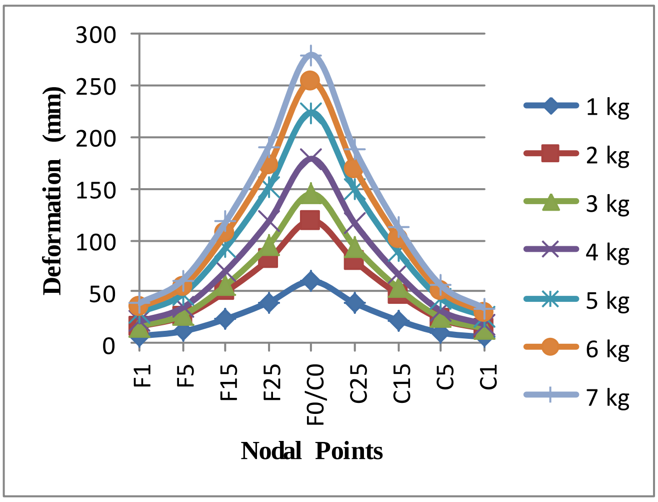

Fig- 6: Actual Deformation Due To Nodal Load (mm) along the radial line- CF

Table- 4: Internal Force

Load on Point 'O'	Internal Force (N)					
Nodal Load	AO	BO	CO	DO	EO	FO
1 kg	7.1	8.2	8.4	7.2	8.9	7.8
2 kg	14.1	16.2	16.6	14.2	17.5	15.5
3 kg	20.8	23.9	24.5	21	25.8	22.9
4 kg	27.4	31.3	32.1	27.6	33.7	30
5 kg	33.8	38.4	39.4	34	41.3	36.9
6 kg	40	45.3	46.5	40.2	48.6	43.6
7 kg	46	52	53.3	46.2	55.7	50.1

4. CONCLUSIONS

- The maximum deflection occurs at the central intersection point and remains same for each wire.
- This load test is conducted on the web to simulate the deformation of the net due to wind action.
- The deflection of the wire increases along the line from the support points to the central intersection point 'O'.
- The internal force developed on each wire is about average 76% of the magnitude of load applied to the intersection point and the proportionate of the internal force developed with respect to applied load gets decreased with increase in load applied.

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