BCV
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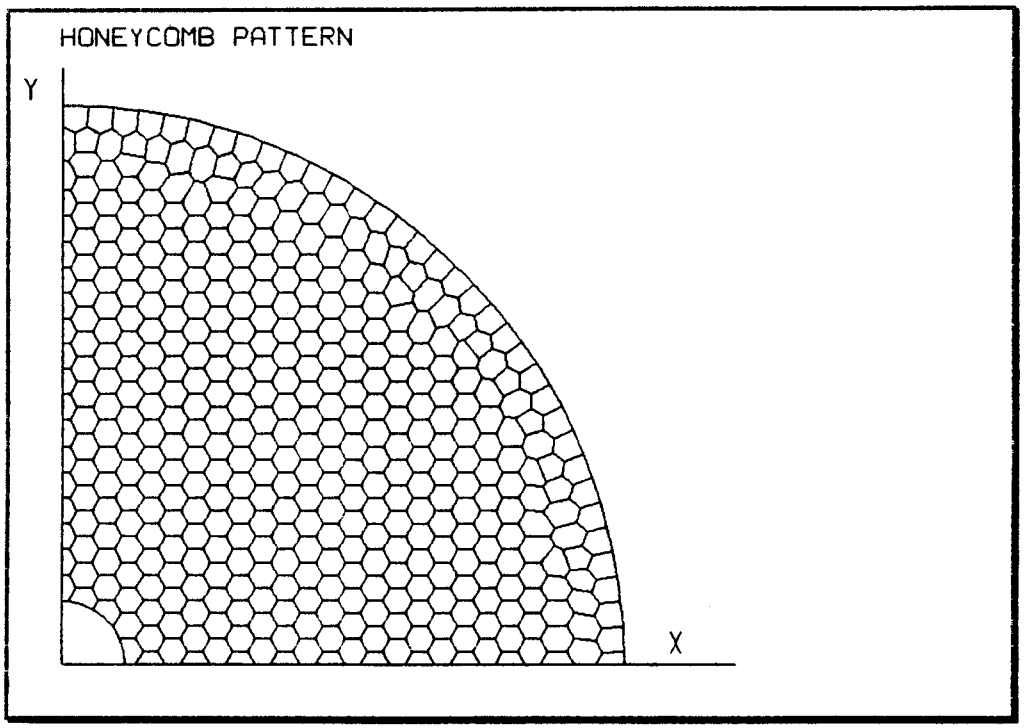
LBT Project: Primary Mirrors

NEW HONEYCOMB PATTERN: GLOBAL FE MODEL OF ONE MIRROR QUARTER



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1. INTRODUCTION

The honeycomb pattern of the primary mirrors of the LBT telescope changed. In figure 1 the new pattern is reported.
The main changes are:

- At the outer edge one ring of regular cells, having radial symmetry, has been placed. Two cell rings permit to pass from the circular symmetry to the hexagonal one. The cells belonging to these two rings are irregular.
- The diameter of the Cassegrain hole changes, the mid plane diameter has been reduced from 961 to 941 mm and the inner faceplate overhangs are now the same at the back and at the front faceplate, they are equal to 20 mm.

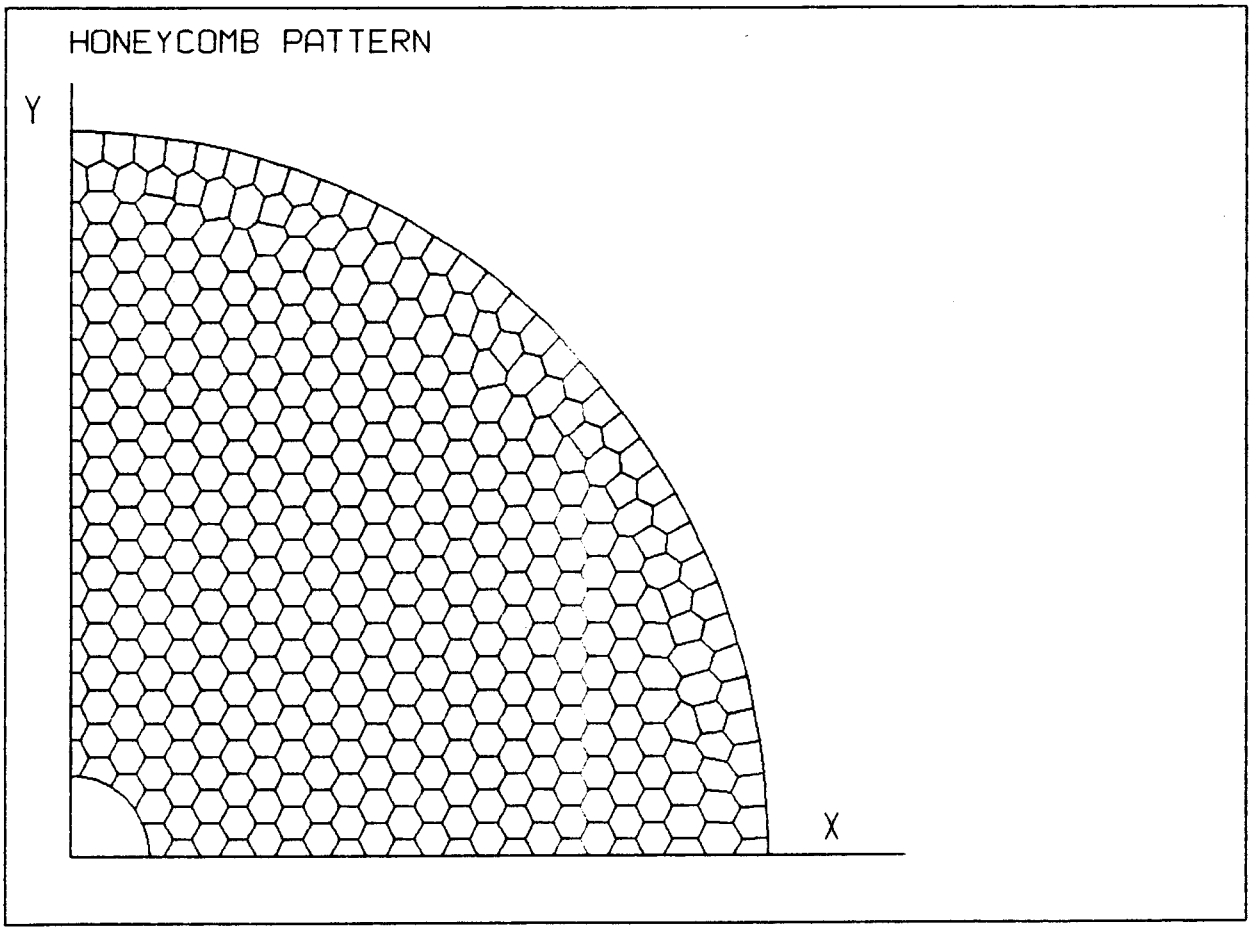

Figure 1

We desumed the data relative to the new geometry from the drawing:

- Steward Observatory, 8.4m F/1.14 MIRROR FINISH DIMENSION, drawing #5184, 3-23-94

and from the memo:

- J.M.Hill, *Dimensions for Large Borosilicate Honeycomb Mirrors*, Steward Observatory Mirror Laboratory, April 19, 1994.

2. FE MODEL FEATURES

The FE model of one mirror quarter has been realised following the usual outline used in the previous global models so:

- The general purpose structural code SAPV2 has been used, with the elements shells, beams (for the inner and outer overhangs) and boundaries for the costraints.
- Five node layers have been used in the honeycomb thickness, (four shell elements along the rib height). In figure 3 a view of the ribs is reported with the global reference system used.
- The ventilation holes in the back plate have been modelled by hexagonal, pentagonal or heptagonal holes, having the same area of the circular one, depending on the cell has six, five or seven sides. In figure 2 the mesh of the back plate is reported.
- One node has been placed at the center of the upper plate of each cell. In figure 4 the mesh of the upper plate is reported.
- Two models have been carried out respectively having symmetry and asymmetry constraints at the plane X=0. They will be used for the analyses when the mirror is zenith and horizon pointing.

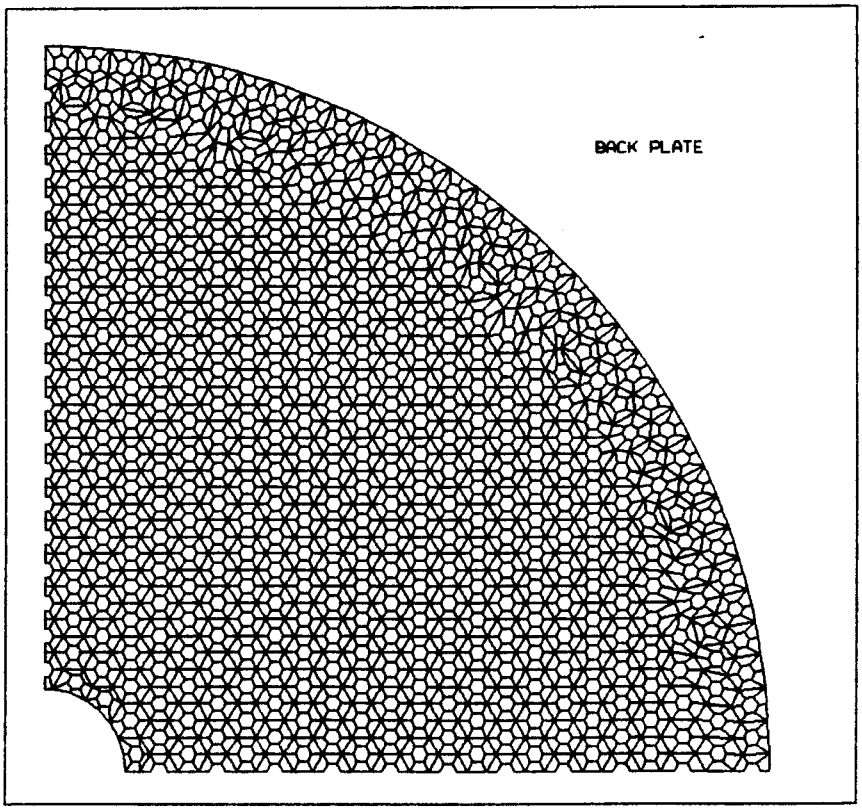

Figure 2

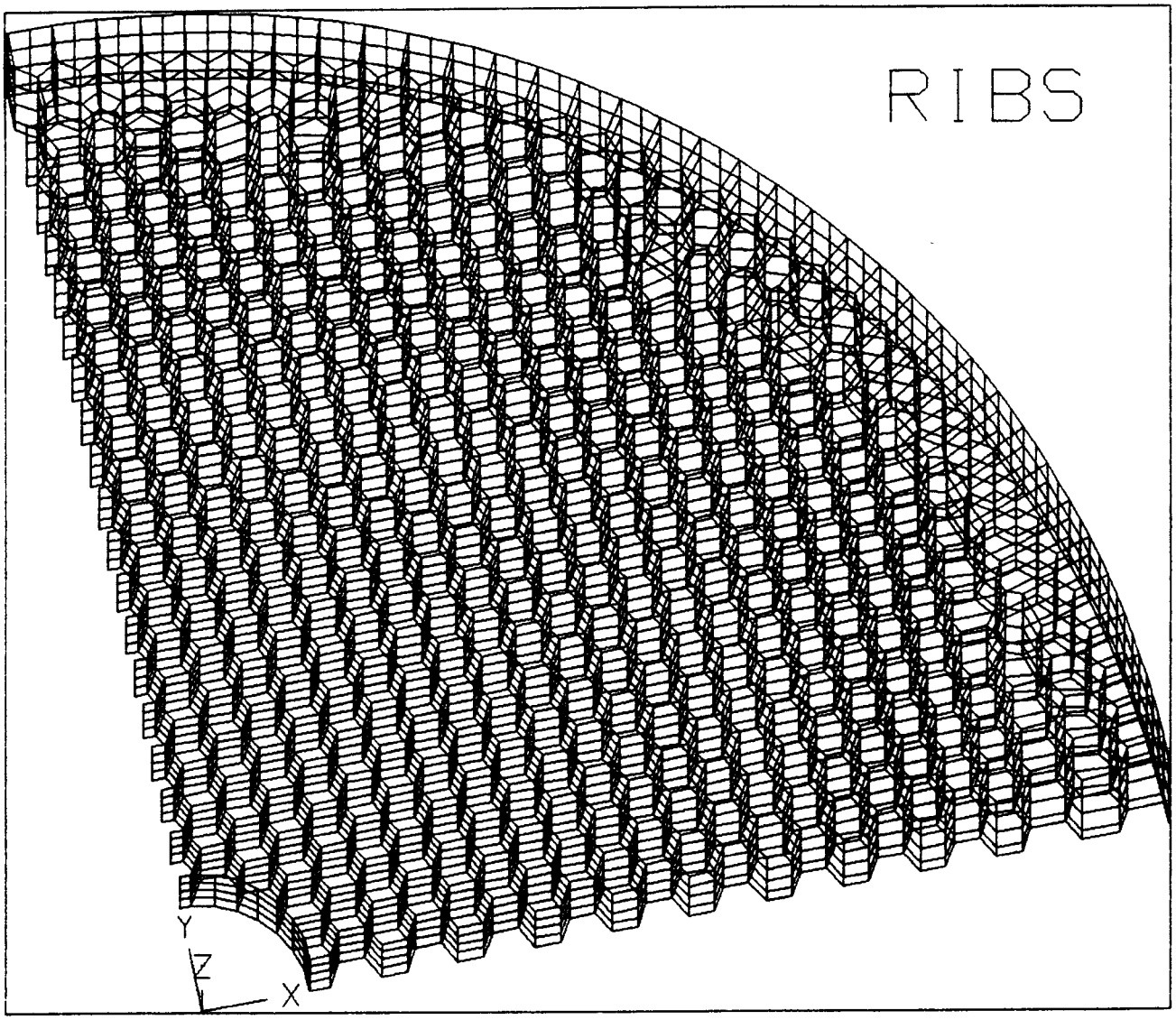

Figure 3

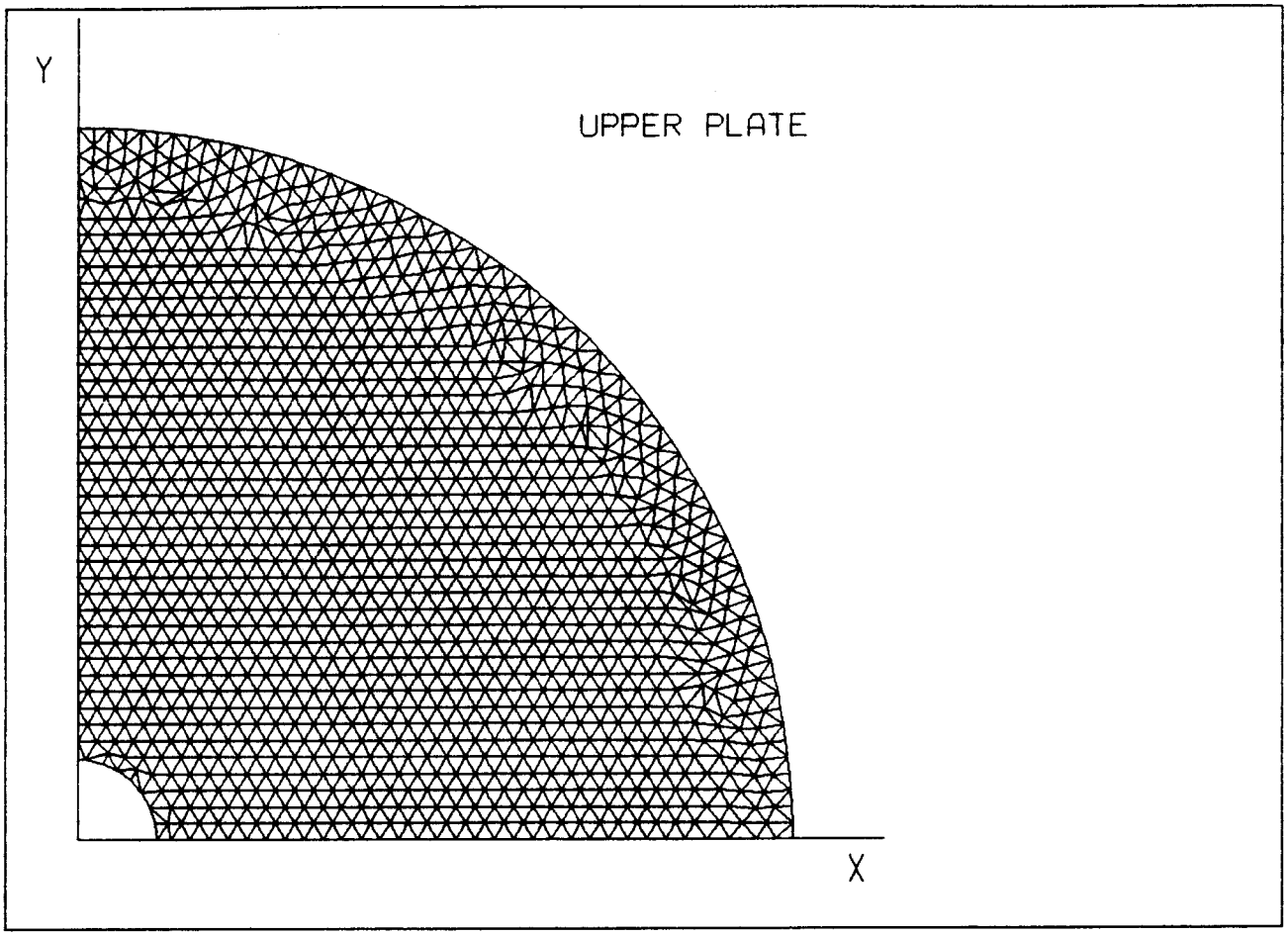

Figure 4

The mechanical characteristics of the material (E6 of OHARA) are the same used in the old models i.e.:

- Young modulus = 57487 MPa
- Poisson ratio = 0.195
- Specific gravity = 2.18
- CTE = 2.8×10^{-6} C^{-1}

The FE model gives the following values of the mirror weight:

- Upper plate = 23788.8 N
- Ribs = 96186.4 N
- Upper plate = 33207.6 N

So the whole weight obtained from the numerical model is: 153182.8 It is a value very similar (+0.2%) respect that reported in: J.M.Hill *"Dimension for Large Borosilicate Honeycomb Mirrors"* (152859.4) N.

The mesh has 11 element groups, they are respectively:

1. Back plate, it has 2510 shell elements.
2. First rib layer (from the bottom), it has 1299 shell elements.
3. Second rib layer, it has 1299 shell elements.
4. Third rib layer, it has 1299 shell elements.
5. Fourth rib layer, it has 1299 shell elements.
6. Upper plate, it has 2509 shell elements.
7. Inner overhang at the back plate, it has 8 beam elements.
8. Inner overhang at the upper plate, it has 8 beam elements.
9. Outer overhang at the back plate, it has 69 beam elements.
10. Outer overhang at the upper plate, it has 69 beam elements.
11. Boundary elements.

In the drawings enclosed to this report are reported the node and element numberings. And precisely:
Drawing 1: back plate node and element numbering.
Drawing 2: first rib layer node numbering.
Drawing 3: second rib layer node numbering.
Drawing 4: third rib layer node numbering.
Drawing 5: fourth rib layer node numbering.
Drawing 6: generic rib layer element numbering.
Drawing 7: upper plate node and element numbering.
Drawing 8: upper and lower hoverhangs node and element numbering.

3. NUMERICAL TESTS

The usual tests on the numerical reliability of the model have been performed.
For example the 6 loadings (Aj,Bj,Cj,Dj,Ej,Fj j=1,3) in figure 5 and the mirror dead weight have been considered, in each one of the six loadings in figure 5 1000 N in axial direction are applied on each of the back plate nodes marked by the same letter.
The geometry, the constraints and the loads are symmetrycal respect to the axes pointed out in figure 5, so the symmetry of the displacements of the node at the optical surface has been checked.

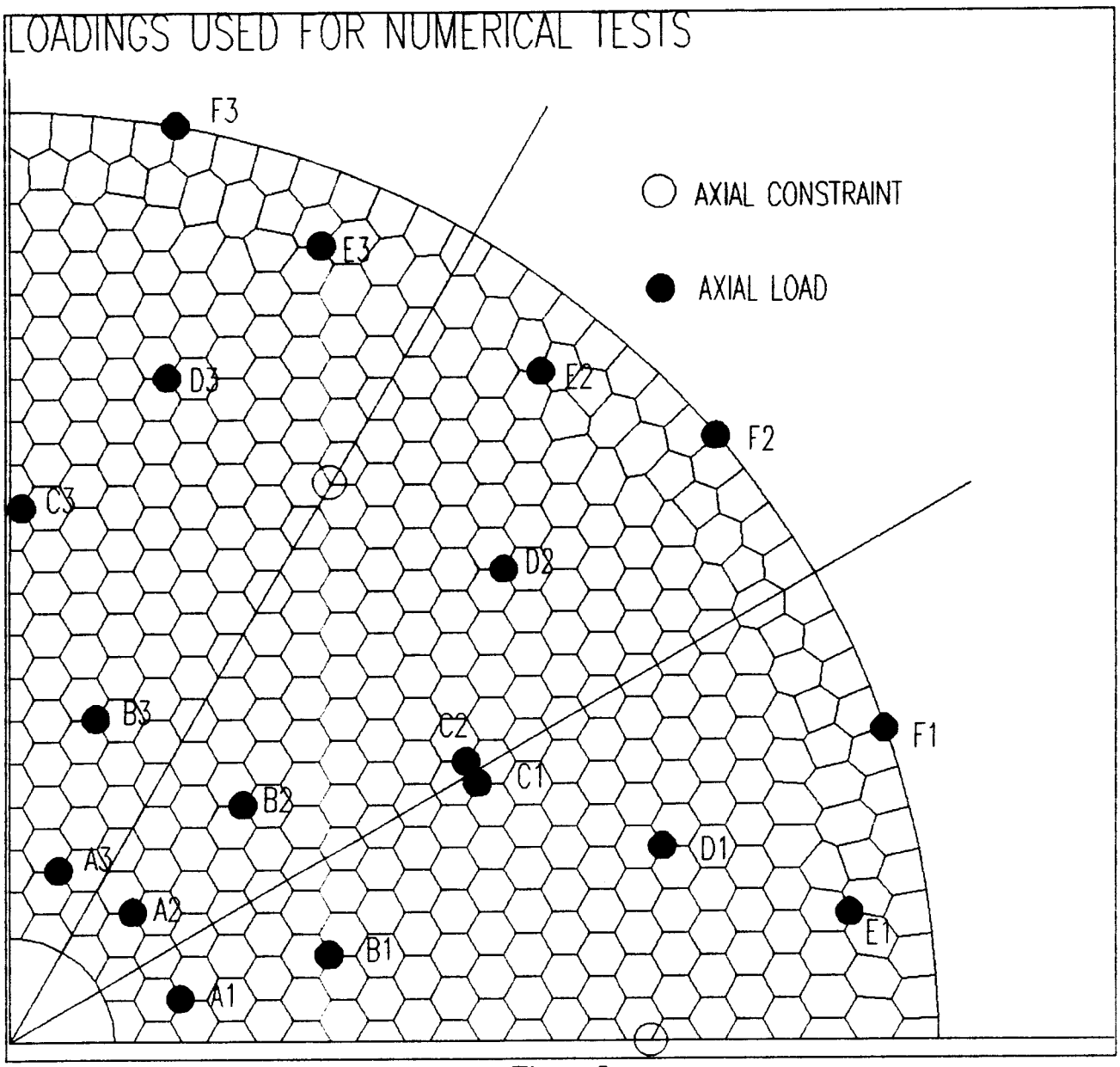

Figure 5

In the following table are reported the axial component of the displacements of the nodes at the optical surface, correspondent to the loaded nodes.

AXIAL DISPLACEMENTS [nm]

NODE	LOAD. A	LOAD. B	LOAD. C	LOAD. D	LOAD. E	LOAD. F	WEIGHT
A1	25966	17410	7586	1685	-4002	-6144	-43217
A2	25965	17410	7586	1685	-4002	-6144	-43217
A3	25962	17408	7586	1685	-4001	-6143	-43217
B1	17397	13679	6566	2031	-2300	-3865	-40071
B2	17396	13679	6566	2031	-2300	-3865	-40071
B3	17395	13678	6566	2031	-2299	-3864	-40070
C1	7579	6557	5300	2863	973	540	-39545
C2	7579	6557	5300	2863	973	540	-39545
C3	7577	6558	5301	2863	973	541	-39545
D1	1687	2032	2856	3541	3880	4376	-41577
D2	1686	2031	2856	3541	3880	4376	-41577
D3	1685	2031	2856	3541	3881	4376	-41578
E1	-3979	-2279	983	3877	7802	9038	-48002
E2	-3979	-2279	983	3877	7803	9038	-48003
E3	-3979	-2280	983	3877	7803	9039	-48004
F1	-6154	-3867	543	4378	9051	12001	-54005
F2	-6154	-3867	543	4378	9052	12001	-54005
F3	-6155	-3868	543	4378	9052	12002	-54008

The symmetry of the displacements is very well respected until the order of magnitude of the nanometer. The maximum difference between the displacements of symmetrical nodes is 3 nm for the points Fj under the dead weight. (3 nm on 54000 nm).