Finite element analysis of the face plate design for the beam splitter and folding mirror structures

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INTRODUCTION

This work looks at the benefit of light weighting the face plate designs for the beam splitter and folding mirror structures. The work gives an appreciation of how a beam splitter structure will behave with and without the addition of stays.

Beam splitter structure with a solid face plate design.

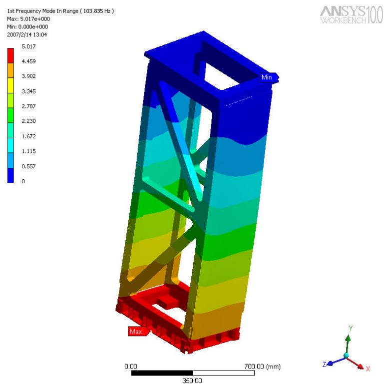

Fig 1. First modal frequency 104Hz, longitudinal mode

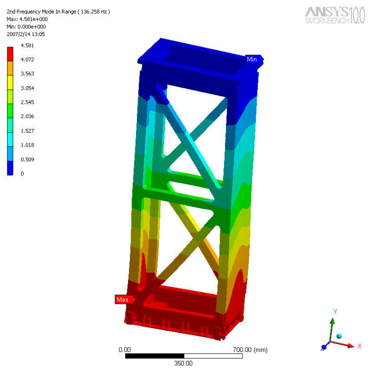

Fig 2. Second modal frequency 136Hz, traverse mode

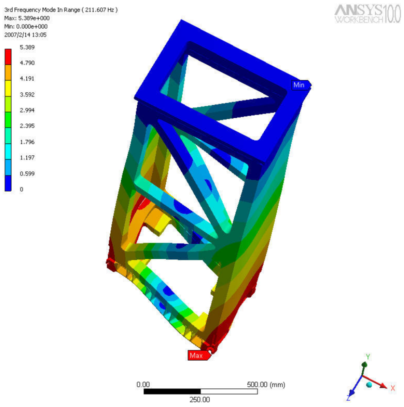

Fig 3. Third modal frequency 212Hz, torsional mode.

Beam splitter structure with a solid face plate design and extra mass.

By changing the material density of the bottom ring to 7e-6 kg/mm^3, its mass changes from 8.4Kg to 21.2Kg, an increase of 12.8Kg.

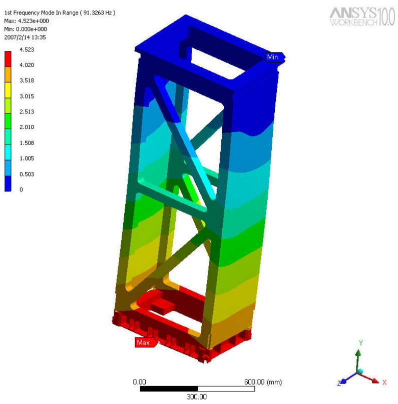

Fig 4. First modal frequency 91Hz, longitudinal mode.

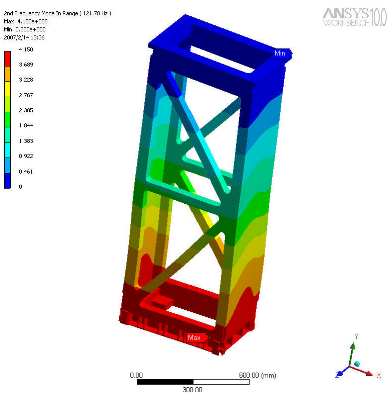

Fig 5. Second modal frequency 122Hz, traverse mode.

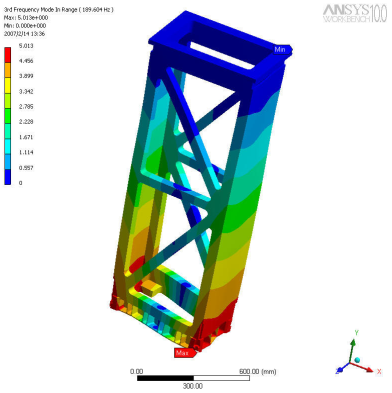

Fig 6. Third modal frequency 189Hz, torsional mode.

Beam splitter structure with a cut outs in the face plate design.

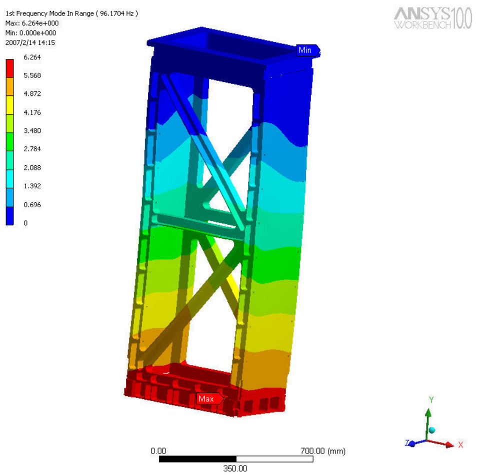

Fig 7. First frequency 96Hz, longitudinal mode.

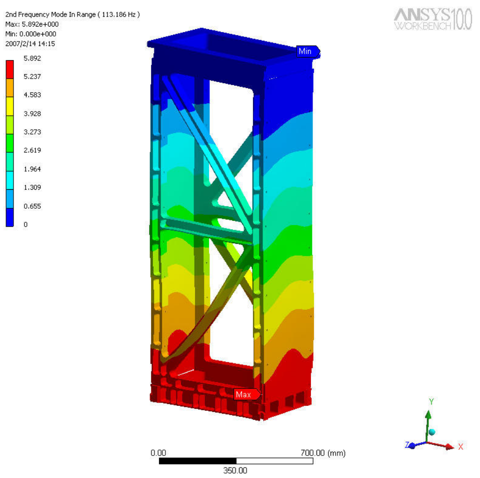

Fig 8. Second frequency 113Hz, traverse mode.

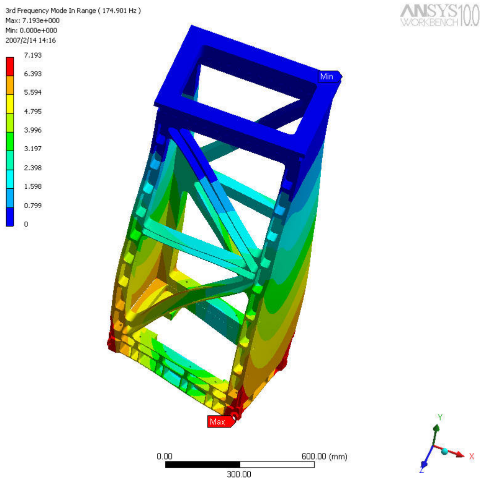

Fig 9. Third frequency 175Hz, torsional mode.

Beam splitter structure with a cut outs in the face plate design and extra mass.

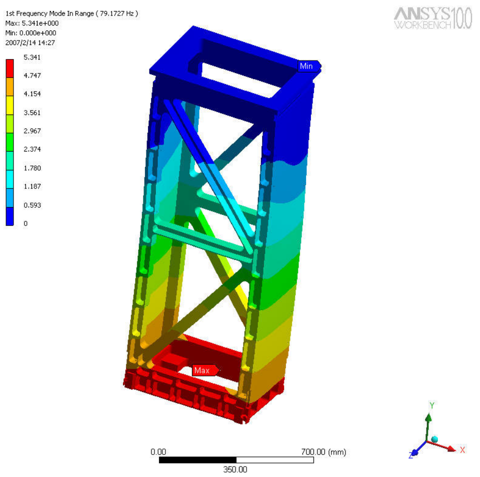

Fig 10. First frequency 79Hz, longitudinal mode.

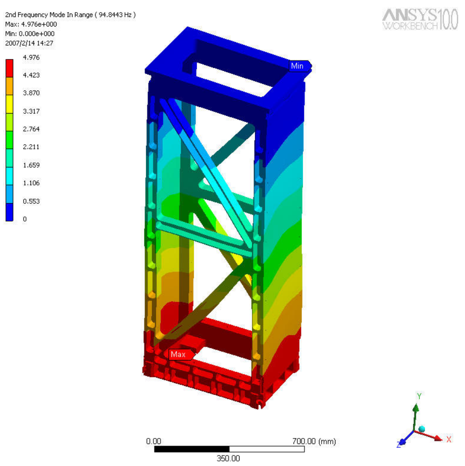

Fig 11. Second frequency 95Hz, traverse mode.

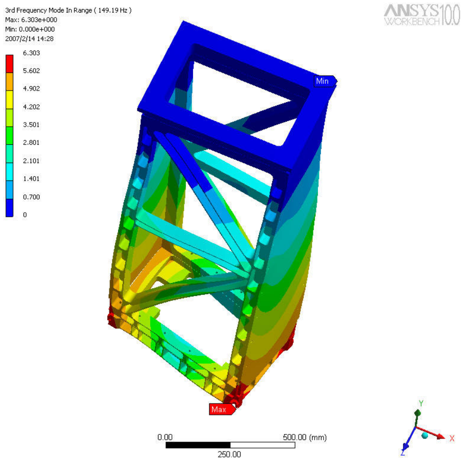

Fig 12. Third frequency 149Hz, torsional mode.

The beam splitter structure with a solid face plate design and the addition of stays.

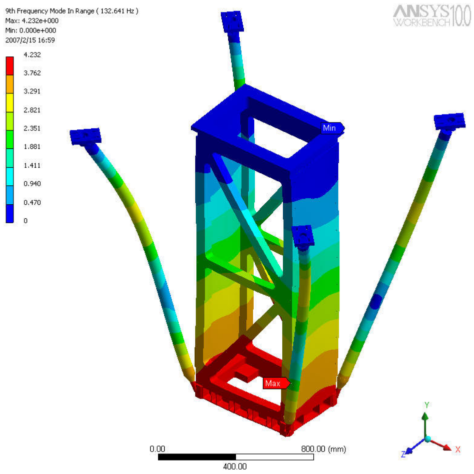

Fig 13. Ninth frequency 132Hz, predominantly longitudinal mode some traverse.

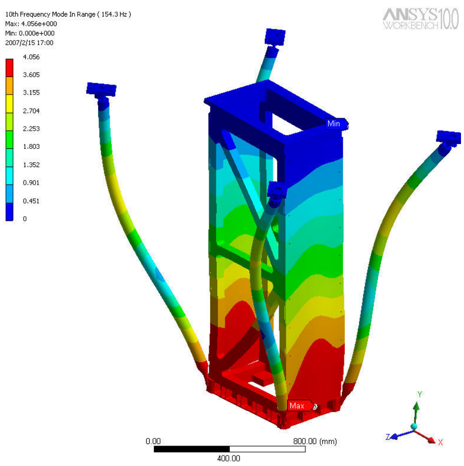

Fig 14. Tenth frequency 154Hz, predominantly traverse mode some longitudinal.

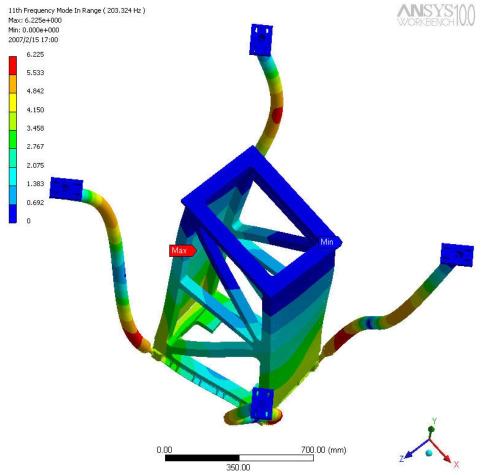

Fig 15. Eleventh frequency 203Hz, torsional mode.

The beam splitter structure with a solid face plate design, the addition of stays and with extra mass.

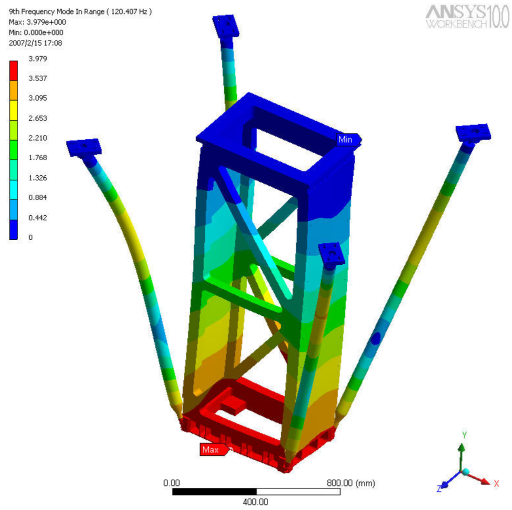

Fig 16. Ninth frequency 120Hz, predominantly longitudinal mode some traverse.

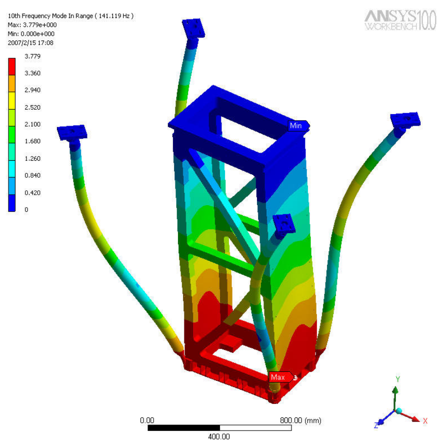

Fig 17. Tenth frequency 141Hz, predominantly traverse mode some longitudinal.

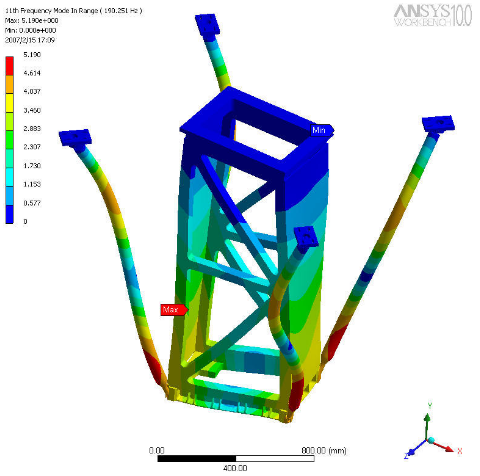

Fig 18. Eleventh frequency 190Hz, torsional mode.

The beam splitter structure with cut outs in the face plate design and the addition of stays.

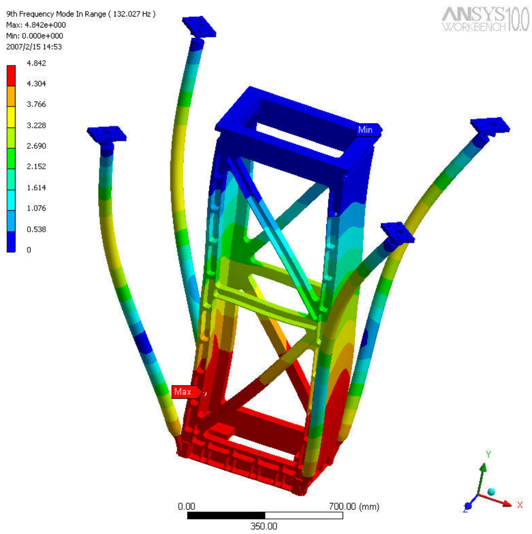

Fig 19. Ninth frequency 132Hz, predominantly traverse mode some longitudinal.

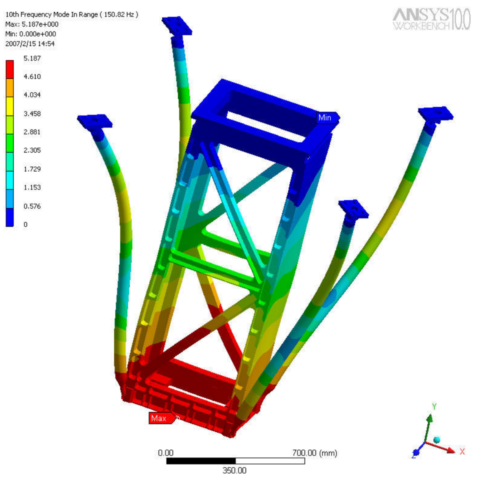

Fig 20. Tenth frequency 150Hz, predominantly longitudinal mode some traverse.

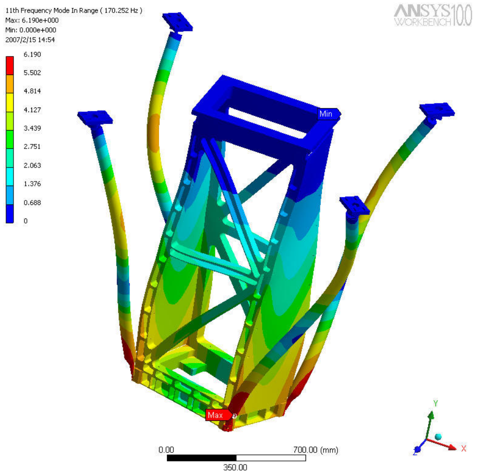

Fig 21. Eleventh frequency 170Hz, torsional mode.

The beam splitter structure with cut outs in the face plate design, the addition of stays and extra mass.

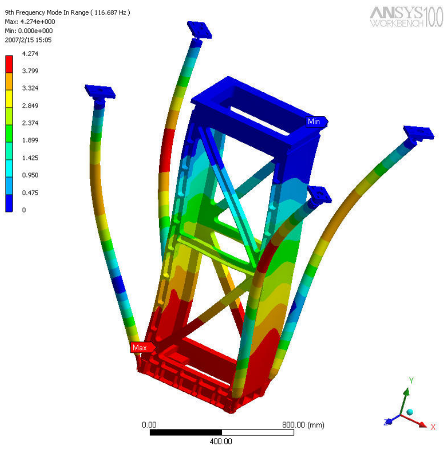

Fig 22. Ninth frequency 117Hz, predominantly traverse mode some longitudinal.

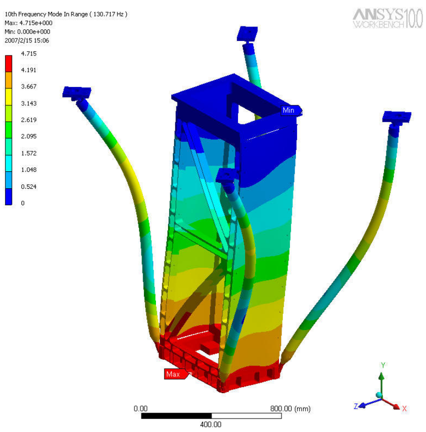

Fig 23. Tenth frequency 130Hz, predominantly longitudinal mode some traverse.

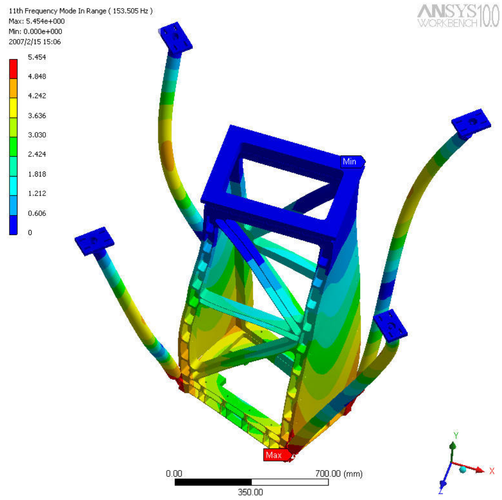

Fig 24. Eleventh frequency153Hz, rotational mode.

Summary of results

Table 1.

Modal frequency	Solid face plate	Solid face plate extra mass	Percentage reduction
1	104	91	12.5
2	136	122	10
3	212	189	11

Table 2.

Modal frequency	Cut out face plate	Cut out face plate extra mass	Percentage reduction
1	96	79	18
2	113	95	16
3	175	149	15

Table 3.

Modal frequency	Solid face plate With stays	Solid face plate with stays and extra mass	Percentage reduction
9	132	120	9
10	154	141	9
11	203	190	6

Table 4.

Modal frequency	Cut out face plate with stays	Cut out face plate with stays and extra mass	Percentage reduction
9	132	117	11
10	150	130	13
11	170	153	10

Face plates without stays

1. Solid face plate better then a face plate with cut outs.

Table 5. Percentage reduction in modal frequency from a solid face plate to a face plate with cut outs.

Modal frequency	Solid face plate	Cut out face plate	Mode shape	Percentage reduction [%]
1	104	96	longitudinal	8
2	136	113	Traverse	17
3	212	175	Torsional	17

Note the traverse mode acting in the plane of the face plates shows a 17% decrease in frequency when going from a solid face plate to a face plate with cut outs; this has implications for the folding mirror design as its first mode acts in the plane of the face plates. Possibly a solid face plate or optimised cut out design is better for the folding mirror.

2. The frequency of a face plate design with cut outs is more sensitive to the addition of mass. Again a solid face plate or optimised cut out design is better for the folding mirror.

Face plates with stays

1. The first eight modal frequencies are stay modes around 75 – 80 Hz, independent of face plate design and additional mass.

2. The Ninth and Tenth modal frequencies are independent of the face plate design, only becoming slightly more dependant with the addition of mass. The eleventh torsional mode is dependant on the face plate design, where the frequency decreases for a faceplate design with cut outs.

3. With the addition of stays, discounting stay modes, the frequency of the structure increases by approximately 30Hz for both face plate designs.

4. With the addition of stays, the ninth and tenth mode shapes switch direction when going from a solid face plate design to a cut out face plate design.

Table 6.

Modal frequency	No stays for both solid and cut out face plate designs	Solid face plate with stays	Cut out face plate with stays
1st	longitudinal	stay mode	stay mode
Ninth	NA	longitudinal	traverse
Tenth	NA	traverse	longitudinal