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Modeling and finite element analysis method for the San Pedro Mártir Telescope (TSPM)

TEAM MEMBERS

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ABSTRACT

A finite element model of the current design of the TSPM is created and analyzed using the software ANSYS in order to determine the performance of the telescope when subjected to physical and environmental disturbances such as static gravity, thermal loads, seismic, and combined. The model includes fixed boundary conditions where the azimuth disk interfaces with the pier. The TSPM is still an ongoing project, so changes are still being made to the telescope structure.

OBJECTIVES

The objective of the CIDESI group is create a complete model of the San Pedro Mártir Telescope (TSPM) to be used for static structural and modal analysis by integrating the geometric model of the telescope's structure from CIDESI with the finite element model of the primary mirror cell provided by the University of Arizona.

BACKGROUND

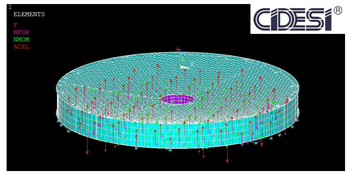
CIDESI has been working on the design of the TSPM structure since 2009. The company has conducted preliminary analysis on the main structure and the movement systems, while the University of Arizona, which has much experience designing mirrors for telescopes, are providing the structural design for the primary mirror cell. Another company, M3 Engineering, is in charge of the concrete structure that the TSPM will be stationed on.

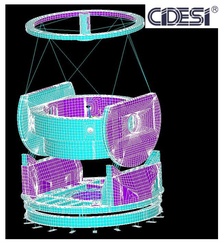
METHODS AND MATERIALS

A finite element model of the telescope is constructed in ANSYS 14.5 in order to apply all the forces and constraints needed to accurately model the structure. Material constants and real constants of element geometry is also necessary to produce accurate reaction behavior based on geometry and material type.

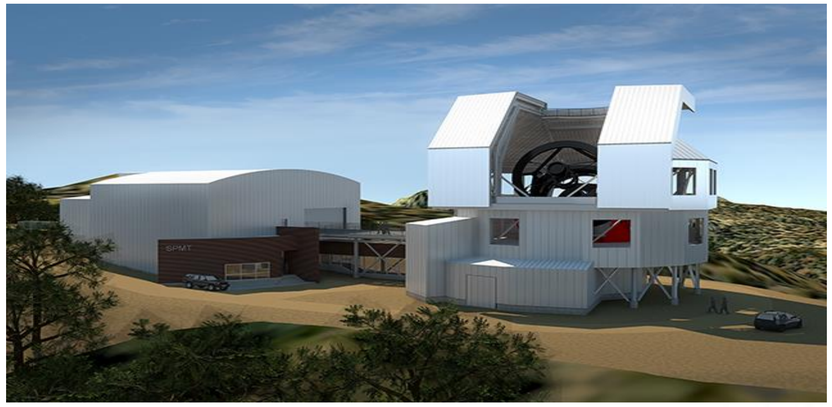
For the material modeling, steel and aluminum is used for the entire structure of the telescope, while borosilicate glass is used for modeling the optical surface of the primary mirror cell [3].

For the forces and boundary conditions used, gravitational acceleration and loads representing the forces due to the mirror actuators are used while the entire telescope base is fixed to simulate being fixed in concrete.





Finite Element images of the mirror and telescope. (From left to right).



San Pedro Mártir Telescope (artistic drawing).[1]

CONCLUSIONS

The new combined model incorporated all the needed information from CIDESI and U. of Arizona to successfully perform a static structural and modal analysis.

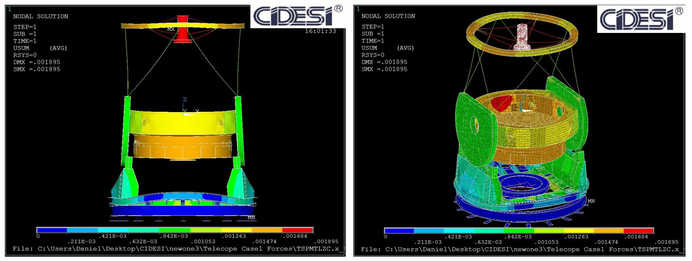
From the ANSYS analysis:

- Structure behavior is consistent with original telescope model.
- Modal Analysis results are comparable to results from other telescopes (ex. GMT) [3].
- High deformation and stress points identified.

Model is ready to incorporate further methods of analysis as well as different telescope positions (horizontal, 45 degree angle).

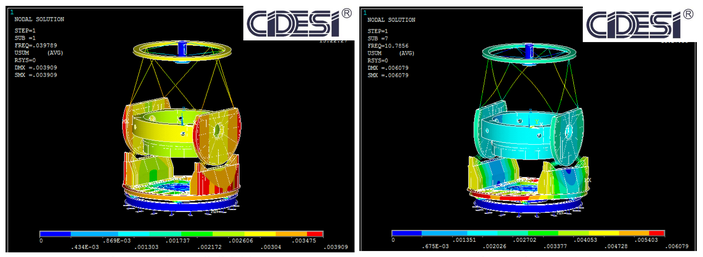
RESULTS

To validate the finite element model, the following observations were made: The nodal solution analysis shows a structure deformation consistent with the original CIDESI model. From the static structural solution, the max displacements and stresses were found to be in the allowable range for the design. The modal analysis showed the frequencies that the structure "resonates" at. The ANSYS model shows rigid body deformation for the first three mode shapes.



Combined Telescope & Mirror Deformation (two angles)

- Allowable Max Displacement: 6 mm.
- Original Max Displacement: 1.79 mm.
- New Max Displacement: 1.89 mm.
- Stress considered negligible for analysis.



1st mode at 0.04 Hz. 7th Mode at 10.8 Hz.

- Frequency range of interest for CIDESI between 0 - 10 Hz.
- Mode 1 @ 0.039 Hz, Mode 7 @ 10.79 Hz
- Rigid body deformations in base for Modes 1-3 due to spring element connections.

REFERENCES

1. M3 Engineering. http://m3eng.com/espanol/portfolio/san-pedro-martir-telescope-spmt/ (July 21st, 2016)
2. U. Arizona. http://mirrorlab.as.arizona.edu/castings (July 22nd, 2016)
3. M. Johns, et al., Telescope System Preliminary Design Report, GMT-TEL-RVW-00405, 2013.