

## The Column-less Stair at Loretto Chapel in Santa Fe: Strength Analysis

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### ABSTRACT

A spiral staircase in Loretto Chapel in Santa Fe, New Mexico, has no center column to provide structural strength and stability. Some estimates say that the stair should have collapsed at first use. Yet, the stair has been used daily since its genesis in 1878. Explanations of the strength of the structure varied from “basic mechanics” to “miracle”. This article presents a stress analysis of the stair using a finite element model. The loading is 16 persons on steps 1, 3, 5, ..., 31 of the stair (as shown in an old photograph), the weight of the stair, and the weight of the railing. Stress computation was performed with a finite element model built and run in Abaqus CAE (Dassault Systemme, 2016). The analysis shows that the center spiral is severely stressed. The maximum Von Mises stress, which occurs near the top of the center spiral, is 1.7MPa. The ultimate strength of strong Engelmann spruce is 2.0MPa. The absence of the center column is significant because a center column would reduce the maximum stress in the stair to about 0.3MPa.

### REFERENCES

- Angelillo, M. 2016. The Equilibrium of Helical Stairs Made of Monolithic Steps. *International Journal of Architectural Heritage*, 10(6):675-87.
- Bobbin, J. 1998. “The Staircase” Review in TV Topics. *The Buffalo News*, April 12.
- Bullock, A. 1978. *Loretto and the Miraculous Staircase*. Santa Fe, N.M.: Sunstone Press.
- Carter, T. 2010. The Loretto Chapel staircase: A lesson in physics, not miracles. *The Washington Post*. January 16.
- Dassault Systemme. 2016. *Abaqus Student Edition*. Software downloaded from <https://academy.3ds.com/en/software/abaqus-student-edition>
- Green, D.W. 2001. Wood: Strength and Stiffness. In *Encyclopedia of Materials: Science and Technology*, Forest Products Laboratory. Elsevier.
- Invernizzi, S. 2016. Numerical Modeling and Assessment of the Ebe Schooner-Brig. *International Journal of Architectural Heritage*, 6(5):453-77.
- Knight, C. 1997. Just What Kind of Wood? *Wall Street Journal*, October 22.
- Matweb. “North American Engelmann Spruce Wood”. 2017. Retrieved from <http://www.matweb.com/search/DataSheet.aspx?MatGUID=972210a797e2437982460bd800c31dc3>
- Picea engelmannii*, *Wikipedia*. 2017. Retrieved from [https://en.wikipedia.org/wiki/Picea\\_engelmannii](https://en.wikipedia.org/wiki/Picea_engelmannii)