Kirchenburg Walldorf

Experimental Structural Dynamics

Presented by:

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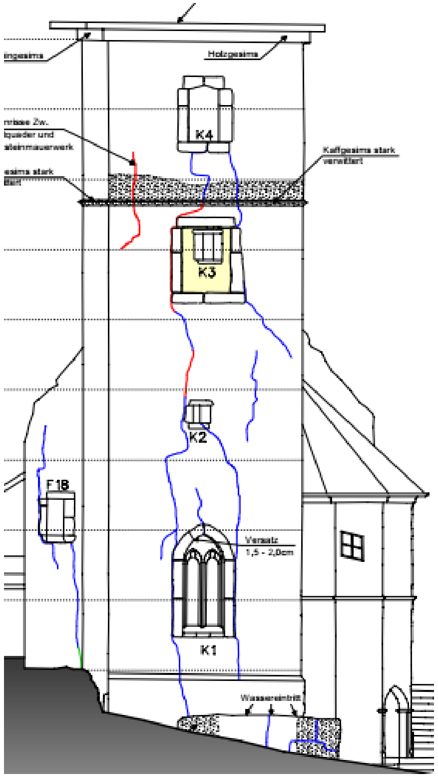
David Bonilla

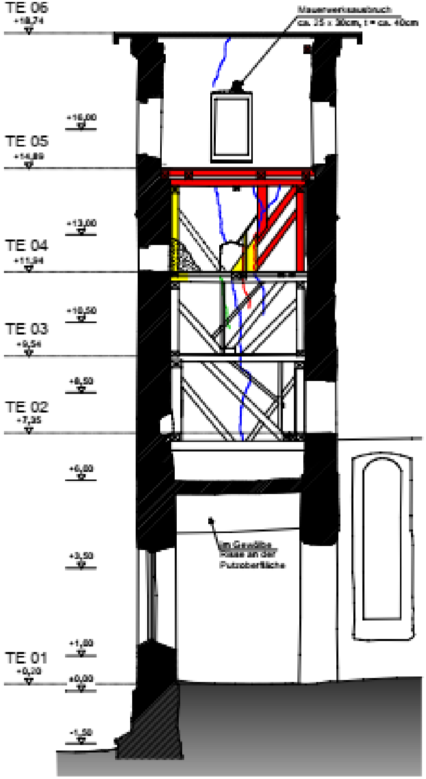
Bauhaus Universität Weimar - 17/07/2020

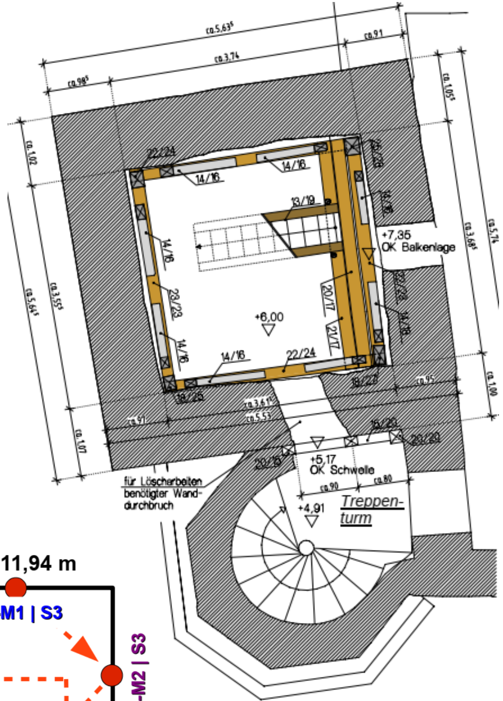
1. INTRODUCTION

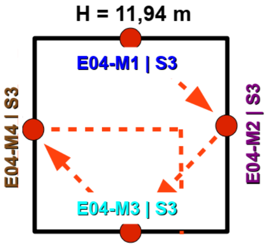
Source: (Monumente, 2012) and (Kirchenburg-Walldorf, 2013)

1. INTRODUCTION





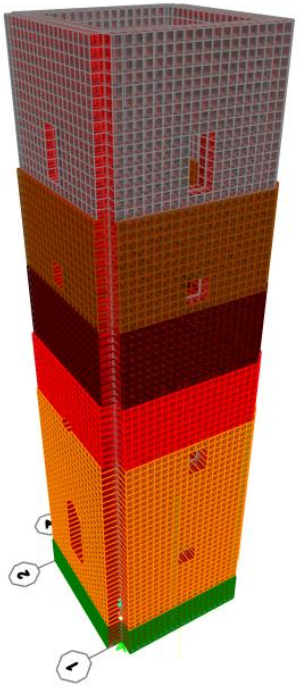




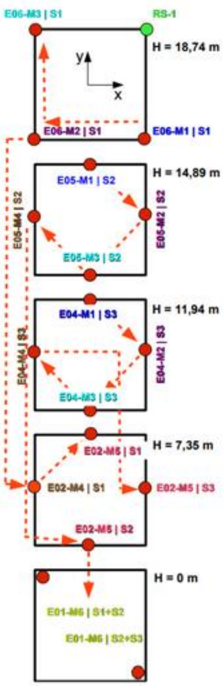
Source: (Trabert + Partner)

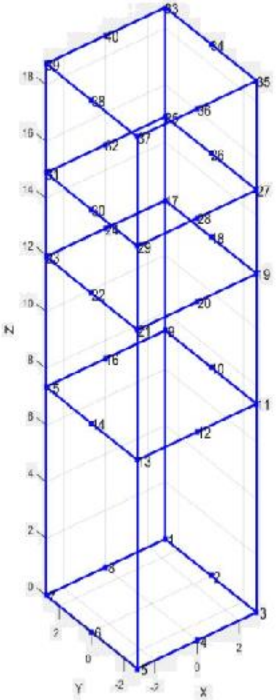
2. METHODOLOGY

Numerical Analysis

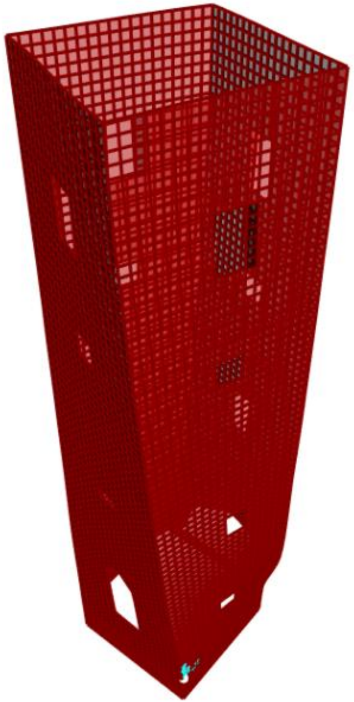


Experimental Analysis



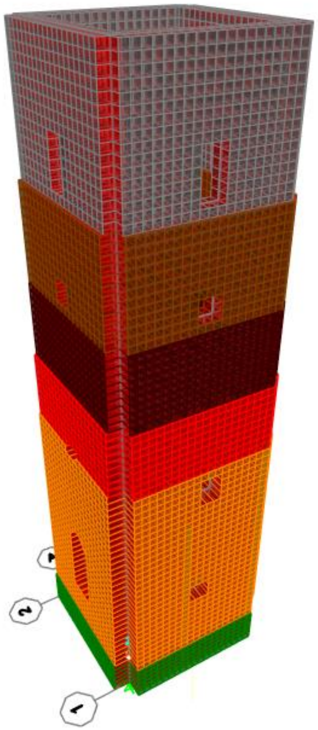


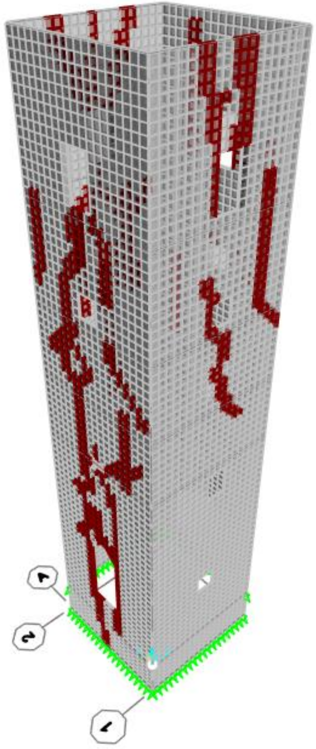
Calibration Model

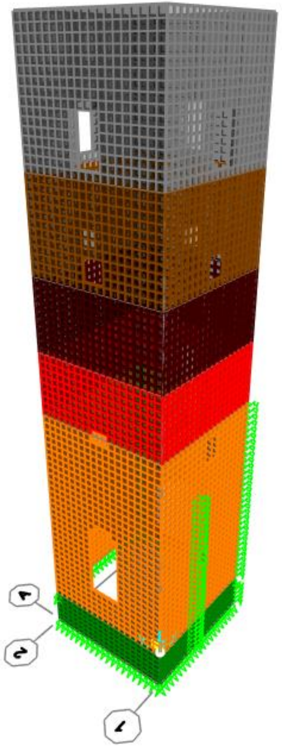


3. NUMERICAL ANALYSIS

Modelling of the structure







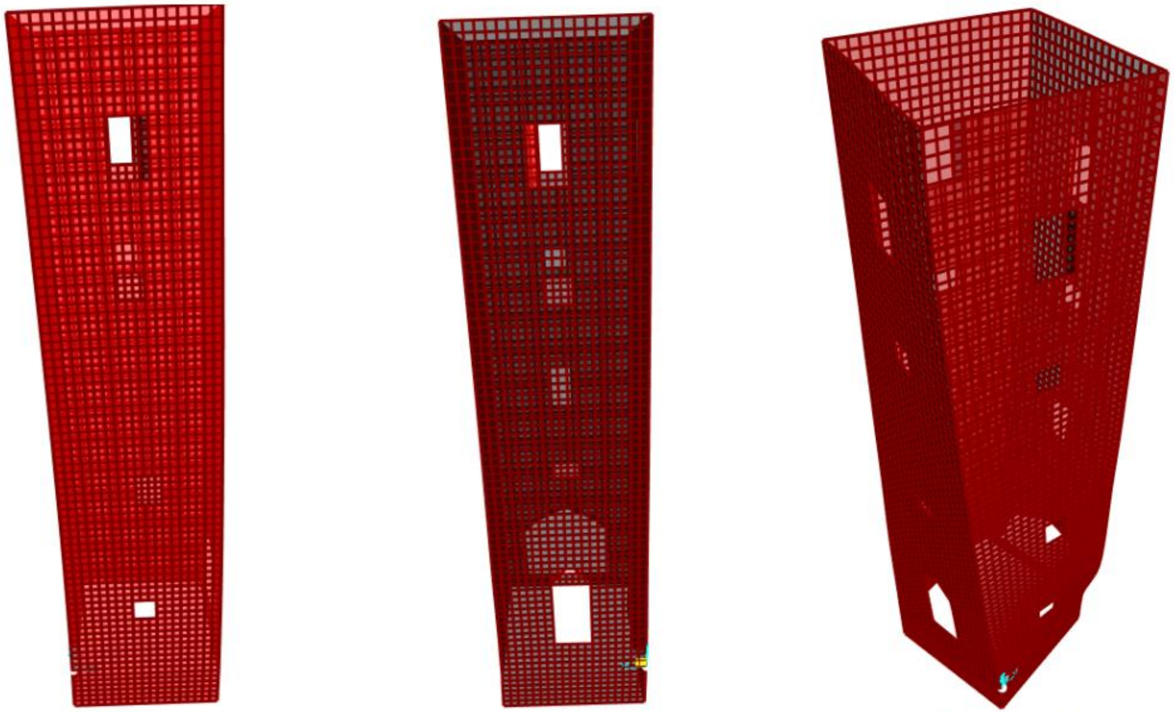
3. NUMERICAL ANALYSIS

Material Properties

Specific Weight (kN/m^3):	21
Young's Modulus (GPa):	2.55
Poisson Ratio (-) :	0.4
Cracked Region, Young's Modulus (GPa):	1
Damping ratio (%):	2

3. NUMERICAL ANALYSIS

Modal Analysis Results



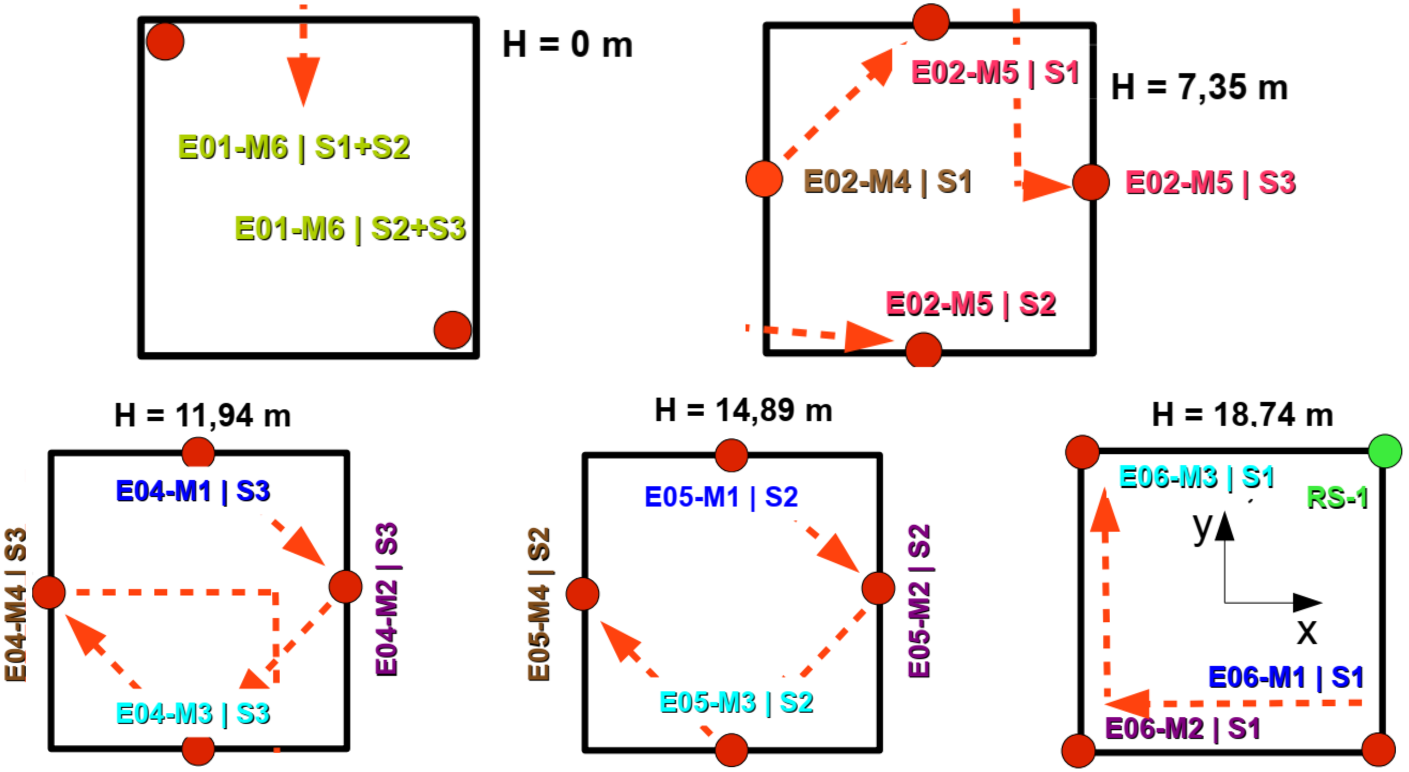
F = 2.81 Hz

F = 2.88 Hz

F = 7.02 Hz

4. EXPERIMENTAL ANALYSIS

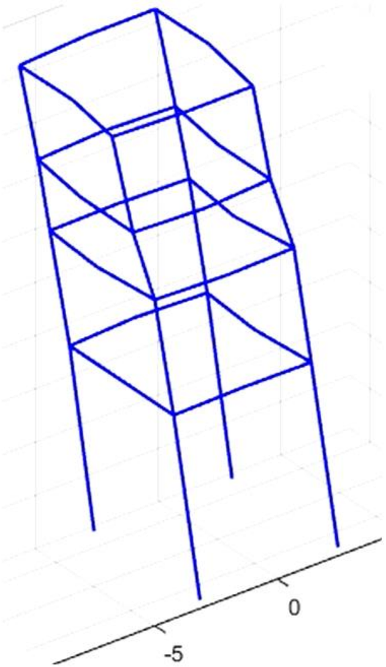
Measurements and Protocol



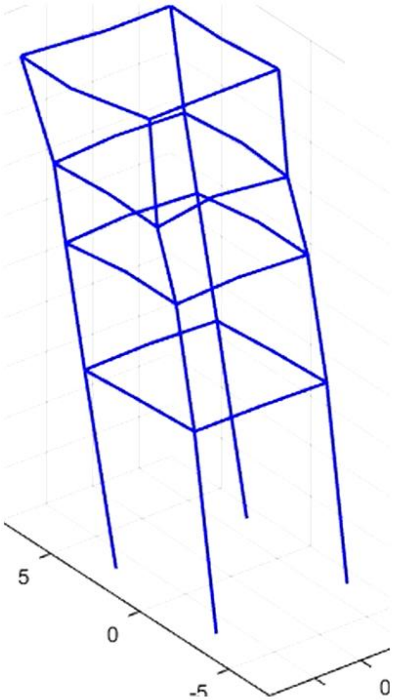
Source: (Trabert + Partner)

4. EXPERIMENTAL ANALYSIS

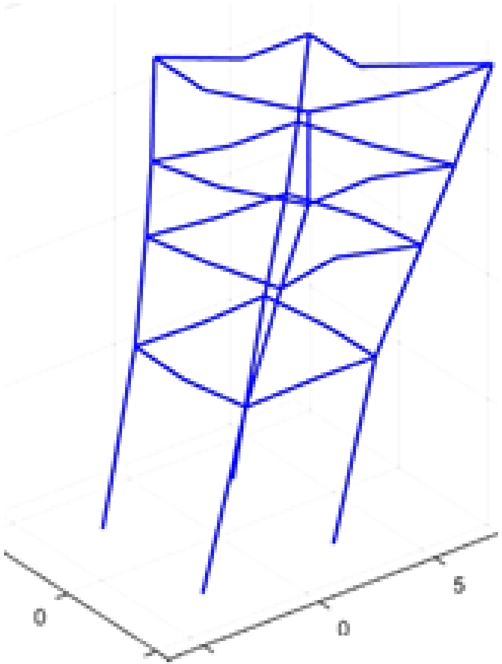
Mode Shapes



F = 2.33 Hz



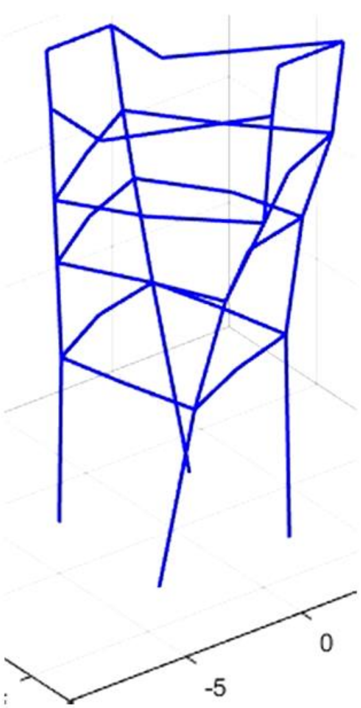
F = 2.71 Hz



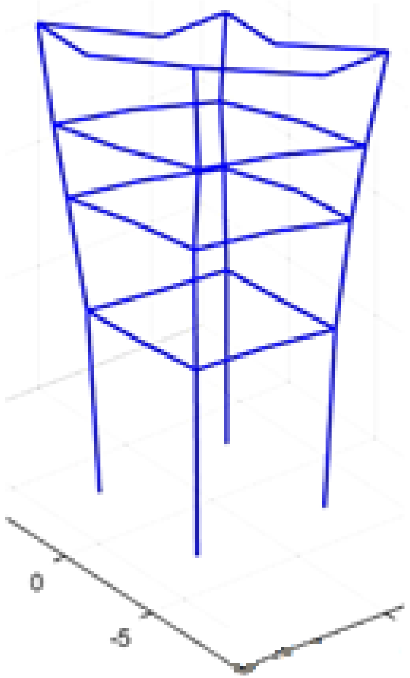
F = 4.04 Hz

4. EXPERIMENTAL ANALYSIS

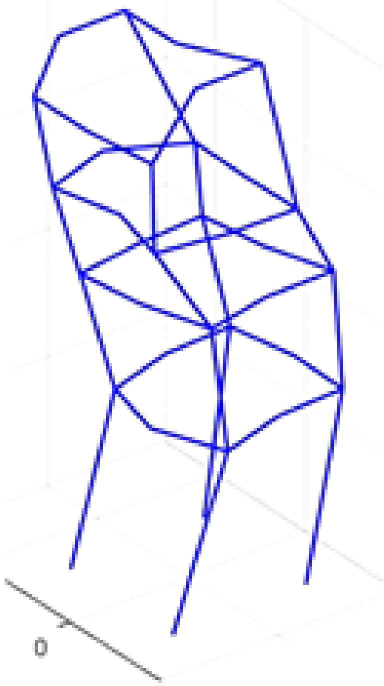
Mode Shapes



F = 5.34 Hz



F = 6.14 Hz



F = 7.66 Hz

4. EXPERIMENTAL ANALYSIS

Mode	Frequency (Hz)	Damping ratio (%)	Shape
1	2.33	1.30	1st Translation X
2	2.71	1.52	1st Translation Y
3	4.04	2.33	1st Translation XY
4	5.34	2.43	Torsion
5	6.14	3.51	Walls in-out of plane
6	7.66	2.50	2nd Translation X

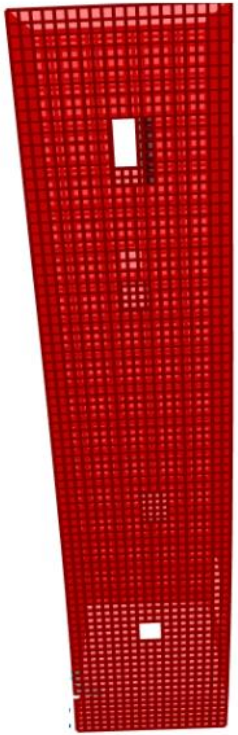
5. CALIBRATION

Material Properties

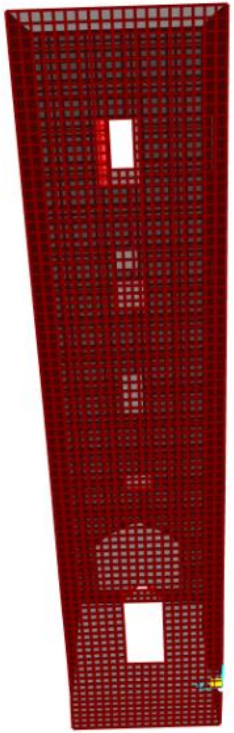
Specific Weight (kN/m^3):	21
Young's Modulus (GPa):	1.72
Poisson Ratio (-) :	0.4
Cracked Region, Young's Modulus (GPa):	0.9
Damping ratio (%):	Corresponding

5. CALIBRATION

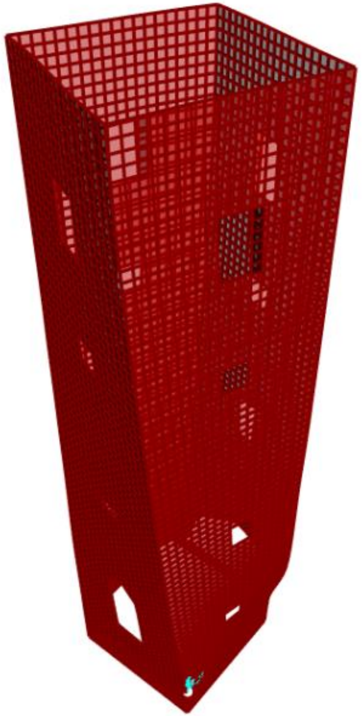
Modal Analysis Results



F = 2.33 Hz



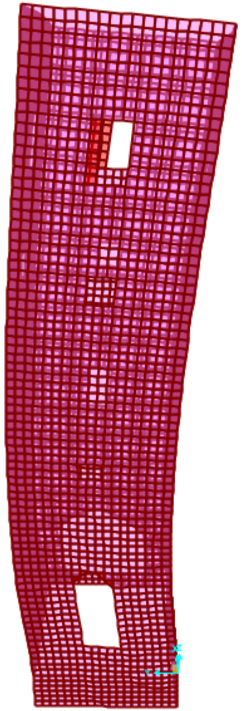
F = 2.41 Hz



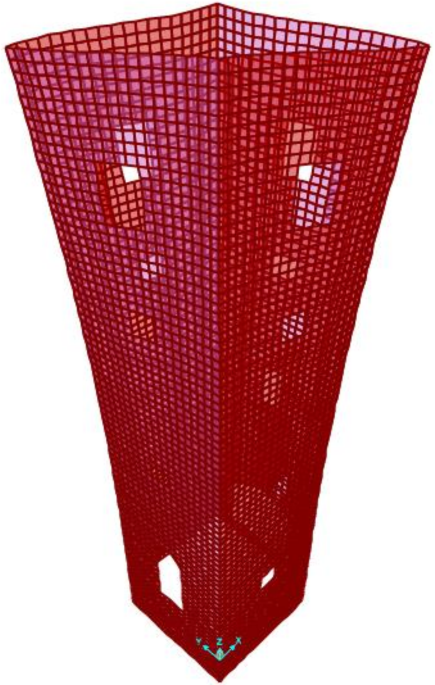
F = 5.86 Hz

5. CALIBRATION

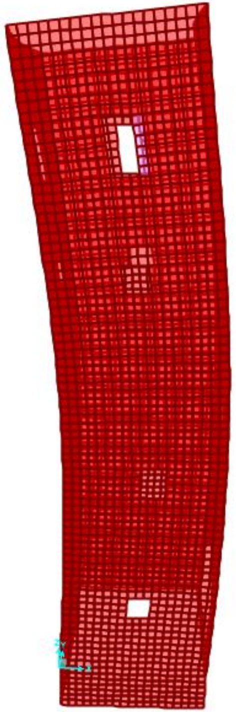
Modal Analysis Results



F = 7.13 Hz



F = 8.04 Hz



F = 8.91 Hz

5. CALIBRATION

Mode	Frequency (Hz)	Shape
1	2.33	1st Translation X
2	2.41	1st Translation Y
3	5.86	1st Torsion
4	7.13	2nd Translation Y
5	8.04	Walls in-out of plane
6	8.91	2nd Translation X

6. COMPARISONS

Results

Modes		Frequency (Hz)		Relative Error (%)
Numerical	Experimental	Numerical	Experimental	
1	1	2.33	2.33	0.1
2	2	2.41	2.71	12.5
3	4	5.86	5.34	8.9

An average relative error = 7.1 %

7. CONCLUSIONS

- The governing behaviour of the tower shows orthogonal translation along the weak and strong directions.
- The first estimation of material parameters showed that the structure was stiffer than in reality. The material stiffness was reduced for the purpose of considering the stone deterioration over time and the damage suffered.

7. CONCLUSIONS

- The comparison of numerical with experimental analysis shows accurate results in mode 1. However, for modes 2 and 3 is not the case, stiffer and more flexible behaviour is observed. In addition, the diagonal translation mode was not obtained, showing that the numerical model can still be refined.
- It can be necessary to perform site measurements in order to determine the current state of a structure. It will help develop a numerical model which can be then used for structural analysis.

References

- Monumente, “Kirchenburg in Walldorf bittet um Hilfe,” Aug. 2012. https://www.monumente-online.de/de/ausgaben/2012/4/als-christus-vom-kreuz-fiel.php#.XutrWuc6-00 (accessed Jun. 18, 2020).
- Kirchenburg-Walldorf, “Kirchenburg Walldorf,” 2013. https://www.kirchenburg-walldorf.de/m/seite/282961/der-turm.html (accessed Jun. 18, 2020).
- Trabert + Partner. n.d. “Trabert + Partner Ingeniurbüro Für Statik+Konstruktion.” Accessed July 11, 2020. http://www.trabert.de/.

THANK YOU