IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 3 Ser. V (May - June 2020), PP 18-24
www.iosrjournals.org

Evaluation of Seismic Behavior for Cheomseongdae using Ansys simulation

JeeYun Kim[1], Jun Ho Jo[2*]
[1](*Disaster Protection and Safety Engineering, HanYang University, South Korea*)
[2](*Civil and Environmental Engineering, HanYang Universitye, South Korea*)

Abstract:
Why has The Gyeongju Cheomseongdae masonry structure, been safe for more than a thousand years to this day? I wonder how Cheomseongdae, who survived the 2016 Gyeonggi Earthquake, behaves in the earthquake. So i did 3D modeling of the Cheomseongdae. And it was dynamically tested through Ansys simulation. It is hoped that it can be used as a basis for the seismic research and preservation of seismic studies and laminated cultural properties by verifying the seismic design techniques of its ancestors.
***Key Word**: Masonry Structure; Laminated Cultural Property; Seismic Performance; Ansys Simulation.*

Date of Submission: 21-06-2020 Date of Acceptance: 10-07-2020

I. Introduction

Why has The Gyeongju Cheomseongdae masonry structure, been safe for more than a thousand years to this day? According to records, the gyeongju area has experienced several earthquakes, and there are records of moderate earthquake damage in 779 a.d. and 1036 after the completion of the Cheomseongdae. Even in the event of such an earthquake, it is questioned why the Cheomseongdae, masonry building, has endured for more than a thousand years and is still safe to this day. Through this study, if you examine the characteristics of the ground based on the ground survey data for the vicinity of The Suptdae, the ground around The Shogunate is large amplification potential of the ground in the event of an earthquake, it is determined that the possibility of resonance with the Cheomseongdae structure is also large. Given the historical seismic record of the race, it is Cheomseongdae that the tidal structure, called The Suppand, has a full-of-life appearance in the modern era. Accordingly, 3D modeling for the Cheomseongdae was carried out. And the dynamic test was performed through the Ansys simulation experiment. And by performing a dynamic test through the Ansys simulation experiment, it is to experiment whether the role of the seismic performance of the seismic performance of the the Jeongja ston, binyeo ston, bottom stacked soil stone. In addition, we want to verify the "seismic design" technology of our ancestors and to awaken their superiority. Furthermore, we hope that it can be used as a basis for the study and preservation of seismic research and laminated cultural properties.

II. Evaluation of Seismic Behavior for Cheomseongdae

Review of the Cheomseongdae

On December 20, 1962, Cheomseongdae designated as National Treasure No. 31, is located at 839-1 Inwang-dong, Gyeonggi Province, Gyeongsang Province. According to the literature, the exact solidarity is unknown, as it was written in the Three Kingdoms-like Shendeok Queen Ziggy Samsajo, but it can be seen that it was constructed in 632-647. It is also our precious cultural heritage, which is recognized as the oldest astronomical observatory in the Orient, which has preserved its original shape without repairto date.

It is divided into three parts. However, Cheomseongdae has the internal roughness and filling material between each member of the supplication and filling material, and look at the member form and the remain structure form in the upper 19-stage or more position, for the dynamic horizontal load, such as earthquake supplication itself it can be seen that it is equipped with a structure system that can be a significant resistance. And until the 12 steps of the house is composed of an internal filling material that forms a stable structure.

3D Modeling of the Cheomseongdae

As shown in Figure no 1, Chemseongdae was modelled using Ansys simulation program.

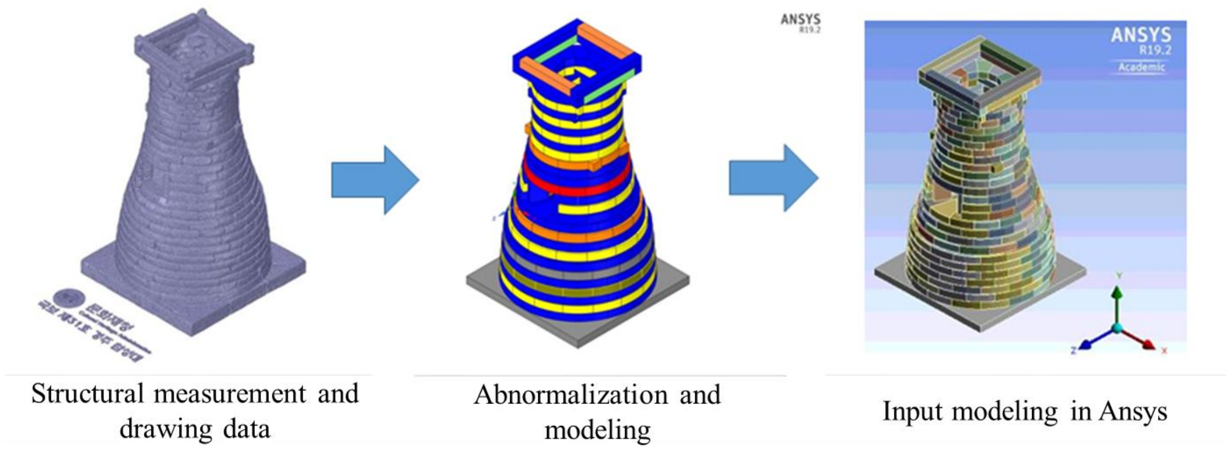


Figure no 1: Process of the structure modelling.

Valuation of Seismic Behavior

Natural Frequency of Cheomseongdae: According to the existing actual results, the measured frequency of the seismic band is 4.52Hz in the north-south direction, 4.59Hz in the east-west direction, there was little difference in direction. Therefore, the analysis was assumed to be the natural frequency of the suppnotic band in both directions 4.5Hz.

Dynamic Characteristics according to physical properties of joint: The masonry structure has a decisive effect on the behavior characteristics according to the frictional stiffness of the stacking surface. Therefore, the dynamic characteristics were analyzed while adjusting the stiffness of the line. The lower filling material was assumed to be a mixture of gravel and sediment. At this time, the stone and the line portion was modeled as a continuum, it was adjusted to the stiffness in a way to lower the shear elastic coefficient of the line. The stone was applied to the physical properties of Hwangdeungseok used in practice.

Table 3. Properties of Hwang-deung stone.

Properties	Density (ton/ m^3)	Elastic modulus (GPa)	Poisson's ratio	Shear wave velocity (m/s)
Hwang-deung stone	2.67	25	0.2	2.037

Mode	Natural frequency (Hz)
1	0
2	1.628
3	2.720
4	5.464
5	10.82
6	14.53

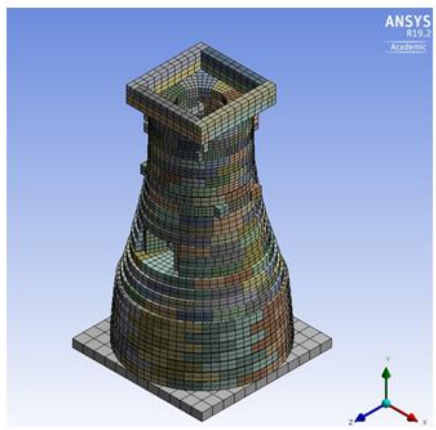


Figure no 2: Mass of Chomsungdae.

Dynamic Characteristics of Seismic Waves:

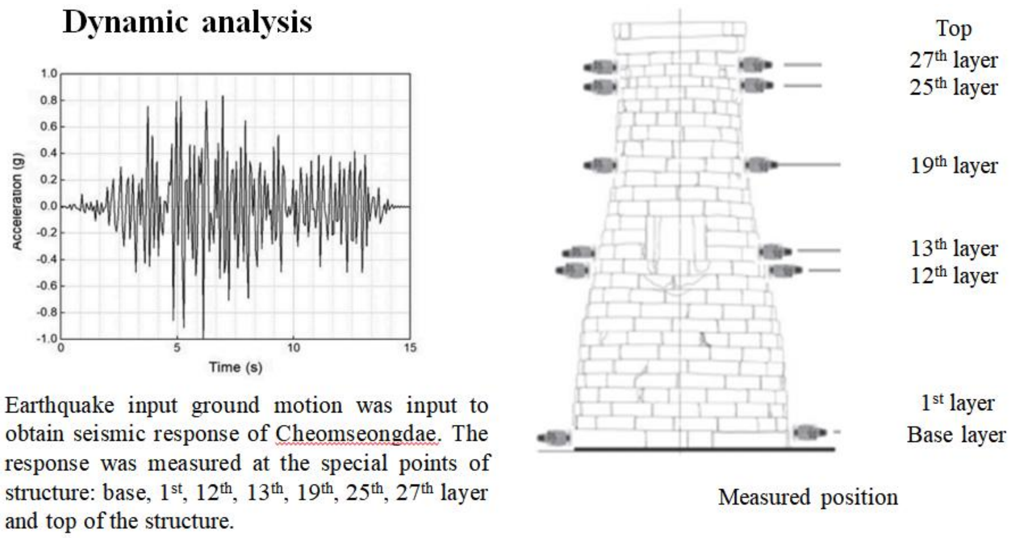


Figure no 3: Measured Position of Cheomseongdae.

Seismic acceleration was applied to the commonly used Ofunato Data stress measurement was measured in base layer, 1st layer, 12th layer, 13th layer, 19th layer, 25th layer, 27th layer. Dynamic analysis results by seismic waves show a specific result by station position. It is showing a stable structure as an effective response to earthquakes.

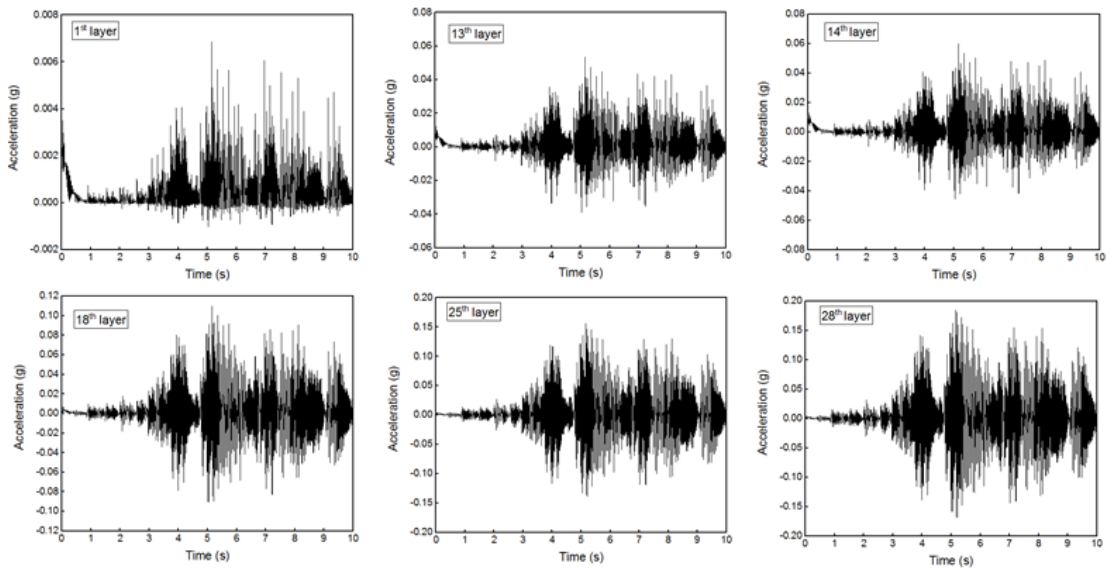


Figure no 4: Dynamic Analysis of Cheomseongdae.

* Static analysis

- The displacement at the different heights of the structures and with the change of elastic modulus and shear modulus

Layer	Height	Shear modulus G (MPa)					
		200	400	800	1200	1600	2000
Base	0	1.70	0.85	0.43	0.28	0.21	0.17
1	0.3	2.70	1.35	0.68	0.45	0.34	0.27
13	3.9	16.10	8.05	4.03	2.68	2.01	1.61
14	4.2	18.70	9.35	4.68	3.12	2.34	1.87
18	5.4	32.80	16.40	8.20	5.47	4.10	3.28
25	7.5	51.30	25.65	12.83	8.55	6.41	5.13
28	8.4	66.00	33.00	16.50	11.00	8.25	6.60
Top	9.1	103.58	51.79	25.90	17.26	12.95	10.36

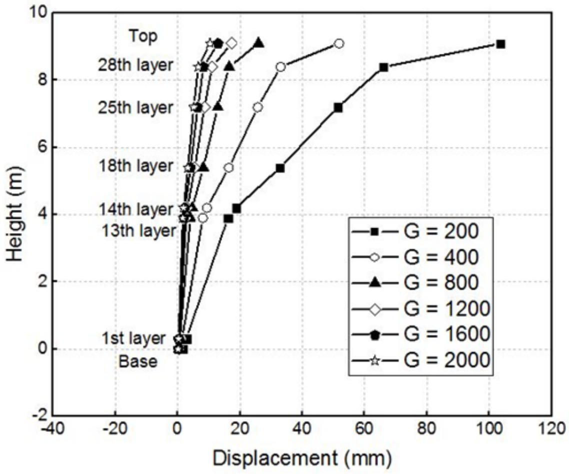


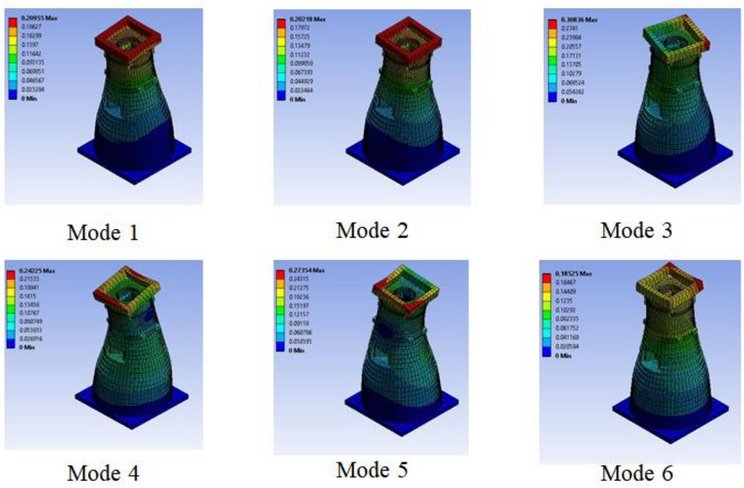
Figure no 5: Static Analysis of Cheomseongdae.

Dynamic characteristics according to the type of filling material

Depending on the type of filling material, the acceleration and displacement was interpreted by varying the fill material dynamic characteristics. The shear elastic coefficient of the experimental model was shown very low as 1Hz, which is shown to be the difference between the model and the actual peak band with the difference in frictional stiffness of the stacking line eye. Therefore, in this analysis, it was interpreted by taking into account the stiffness of the natural frequency value of the 4Hz of the actual peak band to compensate for the stiffness of the line eye and apply the elastic coefficient of 400 Mpa.

Case	Refill material	Shear Modulus (MPa)	Elastic Modulus (MPa)	Frequency (Hz)					
				Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
2.1	Sand	7.16	18.62	4.228	4.325	10.570	10.689	10.903	13.599
2.2	True Clay	76.00	197.60	4.312	4.420	10.867	11.429	11.681	14.367
2.3	Sand Gravels	320.19	832.49	4.459	4.584	11.086	12.381	12.640	15.567
2.4	Graveles	720.49	1873.27	4.593	4.730	11.319	12.915	13.162	16.367

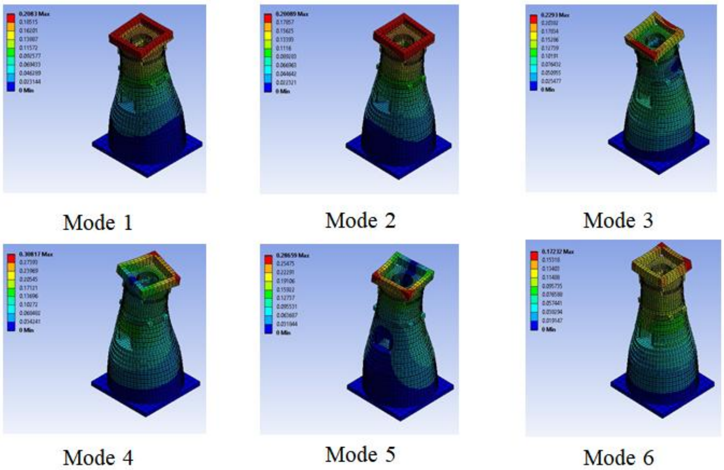
Figure no 6: Structure with Filled Part.



Mode shape and frequency

Mode	Frequency (Hz)
1	4.236
2	4.335
3	10.762
4	10.971
5	11.215
6	13.845

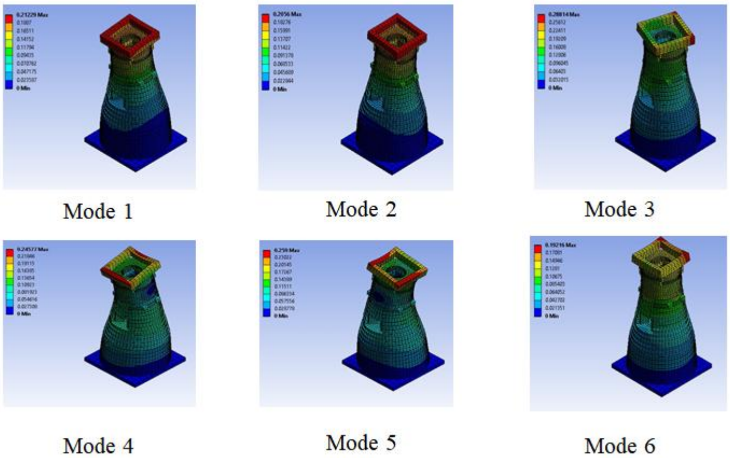
Figure no 7: Structure without Filled Part.



Mode shape and frequency

Mode	Frequency (Hz)
1	4.228
2	4.325
3	10.570
4	10.689
5	10.903
6	13.599

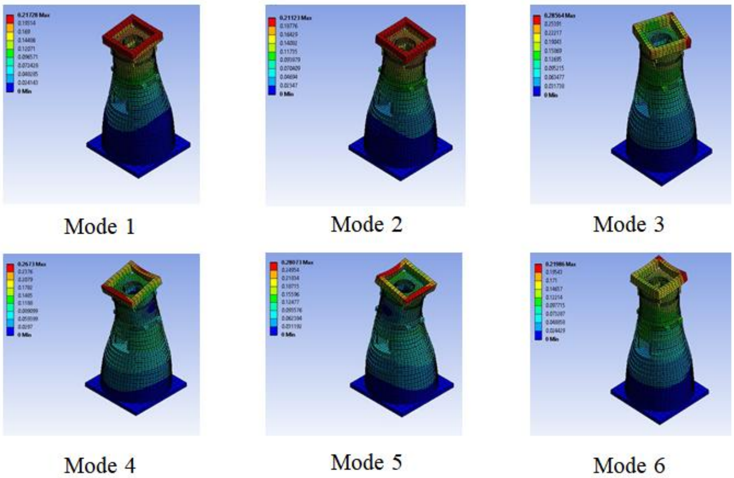
Figure no 8: Structure with Filled Part (sand).



Mode shape and frequency

Mode	Frequency (Hz)
1	4.312
2	4.420
3	10.867
4	11.429
5	11.681
6	14.367

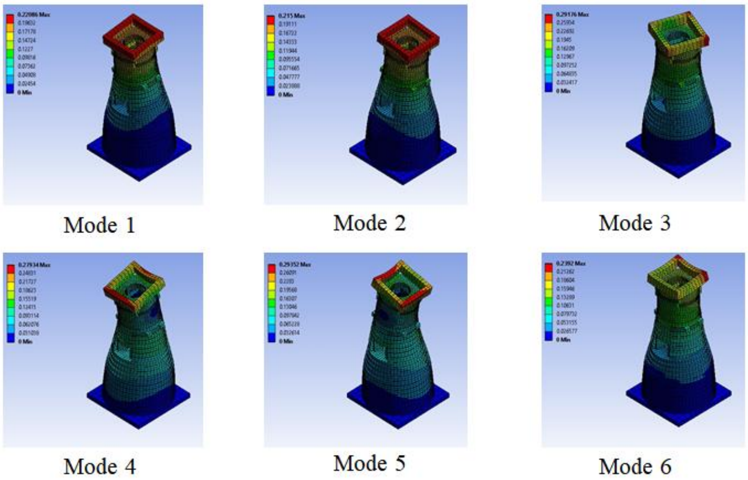
Figure no 9: Structure with Filled Part (sand clay).



Mode shape and frequency

Mode	Frequency (Hz)
1	4.459
2	4.584
3	11.086
4	12.381
5	12.640
6	15.567

Figure no 10: Structure with Filled Part (sand gravel).



Mode shape and frequency

Mode	Frequency (Hz)
1	4.593
2	4.730
3	11.319
4	12.915
5	13.162
6	16.367

Figure no 11: Structure with Filled Part (gravel).

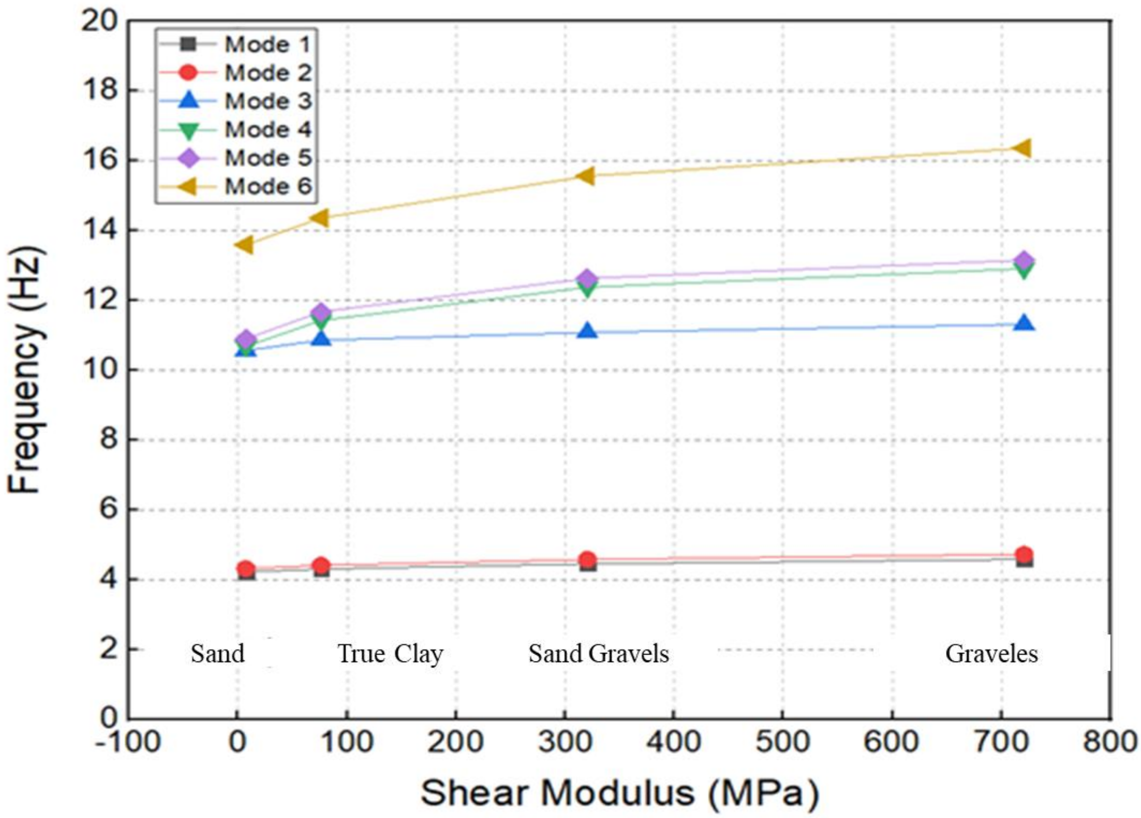


Figure no 12: Structure with Filled Part.

The graph above (figure no 12) shows the natural frequency according to each of filling material, showing the lowest natural frequency in the sand (4.228Hz) and the natural frequency in the shear stiffness large gravel (4.593Hz) it appears the largest. As the mode grows, you can see the natural frequency increases, which is determined to be due to the various influences such as torsion as the high-order mode.

III. Conclusion

The natural frequency of the modeled surface was measured almost similar to the existing results, assuming the dynamic characteristics with respect to some types according to the internal filling material state of the bottom structure and compared to the actual natural frequency. Thus, depending on the type of internal filling material, the results of studying the structural characteristics of the seismic group through dynamic characteristic experiments and comparison with the frequency of the natural frequency for the real thing and the dynamic characteristics of the 3D model of the race supptomitrinous group was able to obtain the following conclusions.

(1) When looking at the changes in the frequency of the natural frequency depending on the presence or absence of the internal filling material of Cheomseongdae, it was found that the Cheomseongdae was built to respond well to earthquakes. And it will also be an important resource for the preservation of Cheomseongdae

(2) There was no structural anxiety even if the stacked without filling soil inside the Cheomseongdae. This is analyzed to prevent the conduction of adjacent stone support and complementary relationships with each other because the cross-section of each layer is a circular cross-section.

(3) If you do not put the material of Cheomseongdae, if you put the sand in the internal filling material and put the sand gravel, it was tested for several models, such as when putting gravel. As the stiffness of the filling material increased, i could find that the natural frequency increases.

(4) The primary natural frequency of the Cheomseongdae was found to be 4.592° if gravel. This can be estimated that the texture of the current peak is very robust as a similar value when compared to the natural frequency measurement results of the real thing. Internal filling material will also mean that the shear elastic coefficient is likely to be mixed with gravel and soil, not low sediment. However, when looking at the results of the study analyzing the dynamic behavior characteristics of the ground in The Race province, the ground constant oscillations should be closely examined for the possibility of resonance to belong to the category of mainly 3.0Hz ~ 4.0Hz in the range of 2Hz to 8.8Hz, and it can be seen that the upper structure is vulnerable when analyzing the shear rate and displacement value. It is believed that attention should be paid to the management of the structure at the top.

References

[1]. Lee Su-gon, Lee Sung-min, Park Hyun-gu, Double Ho, 'Research on the Natural Frequency of The Stone Axis', Thesis of The Korean Society of Architecture, 1999

[2]. Kim Kwang-jae, Lee Sung-min' Structural Characteristics Study of Gyeongju Cheomseongdae

[3]. through Model Experiments 2002

[4]. Daniel Schiff, Dynamics Analysis and Failure Modes of Simple Structures, John Wiley & Sons, 1990

[5]. Dong-Soo Kim, etc., 'Site Assessment of Kyung-Ju for Earthquake Ground Motion Evaluation', The Thirteenth Symposium on Civil Engineering December 7-8, 2000., Taipei, Taiwan.

[6]. Emilia Juhasova, 'Seismic Effects on Structures', Elsevier, 1991.

[7]. Newmark & Rosenblueth, "Fundamentals of Earthquake Engineering, Civil Engineering and Engineering Mechanics Series", Prentice Hall, 1971

[8]. http://gcp.go.kr/sanchek/gukbo/31.htm, Data from the National Institute of Gyeongju Cultural Heritage

JeeYun Kim, et. al. "Evaluation of Seismic Behavior for Cheomseongdae using Ansys simulation." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),* 17(3), 2020, pp. 18-24.