Cymatics as an Architectural element

CHALMERS SCHOOL OF ARCHITECTURE
Master's programme MPARC
ARKX03 Master's Thesis Direction 2021-2022
Matter Space Structure
Supervisor: Jens Olson
Examiner: Daniel Norell
Master Thesis Student: Pontus Hedstorm

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UNIVERSITY OF TECHNOLOGY

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Abstract

This thesis is an exploration of Cymatics for applying the emerging patterns as an architectural element. It is energy produced by vibration propagating in a medium harmonized and visualized by matter. From an iterative process of analyzing results to finding techniques to make a solid structure from something in motion. Focusing on the analog inherent pattern which represents physical measurements. Artists have expressed emotions and motions with soundwaves graphically and musically. In architecture, music is often referenced to describe buildings. Architecture for me is sound that is how I arrange and combine structures, forms, and textures. As a music composer, I see structures, textures, and forms when I compose music. These patterns can be seen in churches and temples as architectural constructs such as in vaults ornaments and glass windows. Understanding the chosen analog format and processing the reference material done in CAD with different scripts contributed to analyzing and finding similarities between the results. The focus on the matter is on natural materials that have a long history and are still developed. In liquid form, the patterns emerge but when density becomes higher, and the liquid solidifies the more intense the process becomes. Combining different materials and ratios to finally make a kinetic rigid functioned element is a question of increased amplitude and strength.

Keywords: Harmonizing, kinetic, form-finding, Cymatics

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Student Academic Background

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Architecture and Urban Design

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Managing Design Projects

Thesis Background

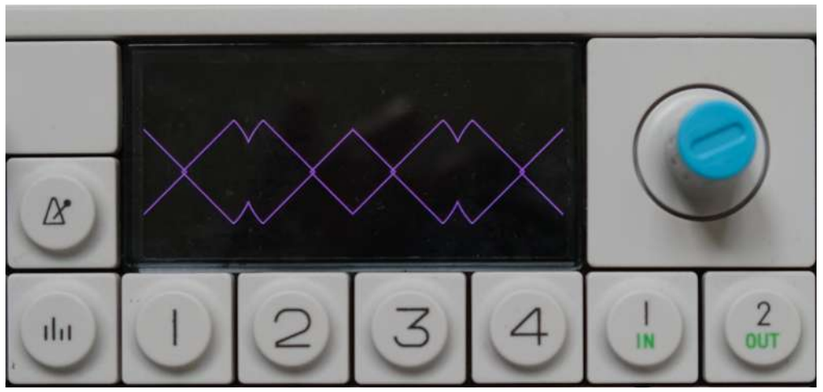
"You hear the sound, see the pattern, and feel the vibration"

-Hans Jenny

Previous in my master's investigations have been done in the importance of sound within the science of neurogastronomy where the taste is stimulated whit high- or low-pitched notes locating a dining room in an anechoic (echo-free) chamber that enhances the culinary experience. The workstation OP-1 used in the thesis experiments has a geometric pattern for all functions on display when tweaking effects on sounds. Artists have thrived in visualizing the sounds and often connect the sounds with a geometric pattern. It becomes clear when each frequency has a pattern proved thru Cymatics. It is a wonder that touches you, a form-finding way to harmonize in a certain element or a medium. Why a pattern? And what is the purpose of the pattern which you can find all over nature and in cells within the human body as in the structure of a dome. In the thesis Harmonic Form- Finding for the design of curvature stiffened shells by Cecilie Sos Brandt - Olsen (2015) she emphasizes the importance to find eigenmodes for designing a form and how to stiffen the shells depending on the function and shape of the shell.

Both Cymatics and harmonic form-finding is about vibration and geometry. Hans Jenny expressed the triadic nature of Cymatics. You hear the sound, see the pattern, and feel the vibration. But can it be kinetic, relating to or resulting from motion? Some experiments have been done with viscous paste. To explore further materials which follow us into the future. Not only for the sake of the mesmerizing geometry but to develop techniques for making a solid object and applying it as an architectural element.

Dining room in an anechoich chamber Fig. 1



OP-1 Music workstation Fig. 2

Thesis Question

How can the natural process sprung from motion become a solid form?

Can Cymatics be a tool for form-finding?

Which materials could be used?

Aim

"Architecture is frozen music"

-Goethe

The focus and the core of this thesis are to conduct experiments in wave mechanics with analog means, to study in real-time the wave mechanics of a certain medium and matter. To generate a natural pattern thru a natural process with natural materials. To make rigid objects for applying in architecture , frozen in time whit inherent primal functions. To go in-depth about the function and not just settle with the notion of the beautiful geometric pattern as a phenomena.

The liquid form of gypsum becoming a stucco implemented in the Oscar Fredrik Church or analyzed in a solid form about the possibilities of making the solid form a dome in a rendered format or as a physical model due to the chosen scale of the experiments. The glass patterns would also be rendered as a window structure as an alternative to the existing shape of the window today. If the frequency imprints a shape into the glass it would be analyzed with a polarization filter to reveal tension in the glass structure.

Site
Oscar Fredrik Church

"Ingen av konsterna står närmare mysticismen än arkitekturen

som geometrisk, abstrakt och stumt musikalisk

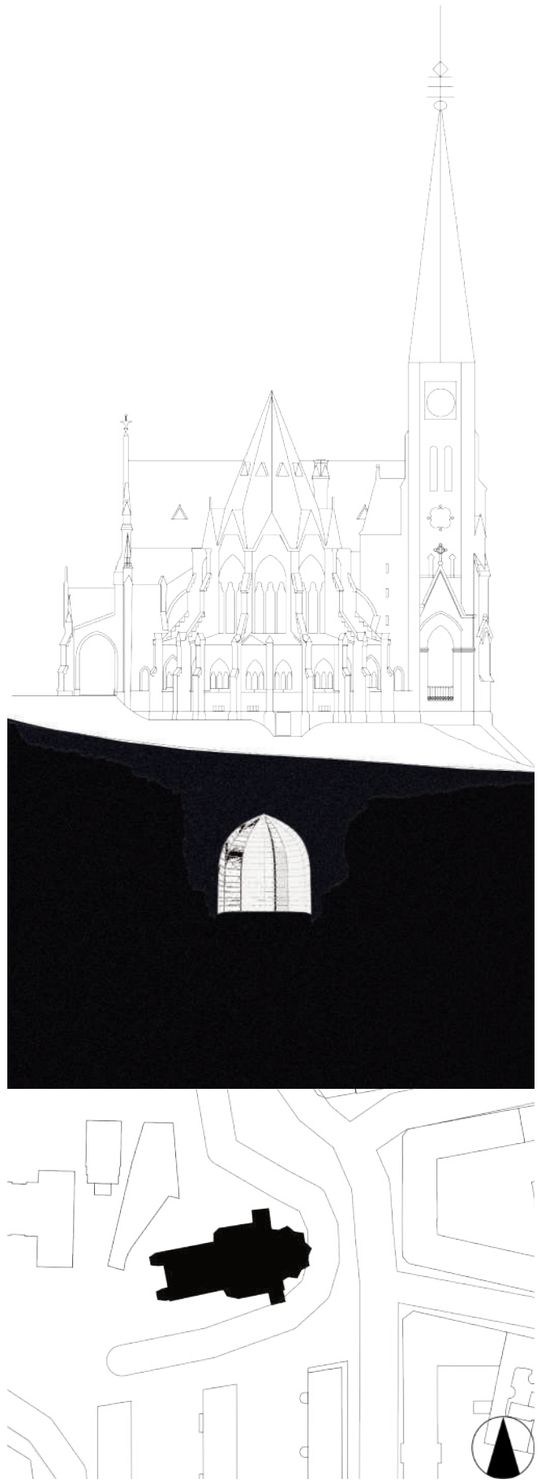
lefver i rytm och i takt" .

Helgo Zettervall- Arkitekt

The Neo-Gothic church was named after King Oscar II (1872-1907)

During the church's history, three restorations have been done. Decorations on vaults and kapitäl were painted over and brought back to existence in 1978 with the side stands and pulpit. The apse the room for the altar elements like windows and decor is made to remind you of the heavens. The church was an experimental build where the architect Helgo Zettervald (1831-1907) used new unconventional materials and methods to construct the church. Zettervall had the intention as a counterpoint to the Tegner aesthetics which stood for a more rural modest approach like a barn, implementing the romantic and mysticism from the Middle Ages churches and that the people's mind and sight should be faced upwards whit the use of vaults, the large windows located high up in the facade together with the generous space.

https://www.svenskakyrkan.se/filer/Kyrkobygganden%20125%20%c3%a5r%20s%c3%a4rtryck.pdf



Oscar Fredriks Kyrka situationsplan Scale 1:2000

Oscar Fredriks Kyrka Masthugget Göteborg

Fig. 3

Inventory church

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Method

" when finding or taking one conclusion it opens up for another because natural science is a never-ending exploration"

-Goethe (Jenny,1974)

Starting with researching the history and the origin of Cymatics and the notion that vibration propagates in mediums to find methods to adapt. The adapted methods provided the fundamental understanding of the physics behind the geometry that emerges.

An iterative process with the setup of a tone generator, an amplifier to control the strength of the vibration, and a driver as a conductor for the medium. Researching through design by the harmonizing frequency in the chosen matter.

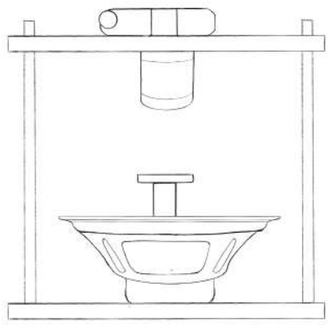
After the iterative process, the results of the materials were compared and analyzed with the referenced literature and materials.

The analysis of the results was of a similar process as Hans Jenny conducted in his experiments, to visually observe and interpret the experiments as a whole and not go in-depth into details due to the author's educational background as a trained architect and its limitations in the field of engineers.

To conduct methods of an analog approach measurements were done whit rulers and whit some digital apps measuring pitch and note frequency in the case of experiments whit the Teenage Engineering OP-1 synth/ workstation.

The different mediums and materials were documented together with the frequency for the specific experiment and the results were photographed.

The design proposal is based on the generated patterns that were chosen to conduct the different experiments both in glass and in gypsum. The outcome of the experiments is solely for analyzing further development and tweaking for future iterations whit different combinations of materials.



Set up documentation

Force

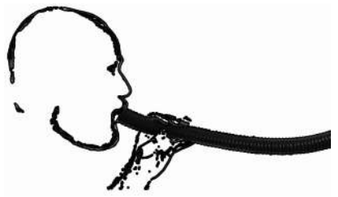


Fig. 10

Fig. 11

Frequency generator

Fig. 12

Fig. 13

Driver

Fig. 14

Fig. 15

Medium

Fig. 16

Fig. 17

Fig. 18

Delimitations

"As an architect your knowledge and insight in physics, mathematics and geometry is limited but the human creative mind is unlimited.

- The author

With my fascination of the natural process set the focus on the analog approach. The experiments is a more concrete way to see if the intended thesis did succeed or failed in the given environment and conditions. In a more computer-aided design, there would have been set parameters and variables and therefore a easier way to reflect and analyze the data, both the simulated design and the natural process have their various limitations . The computer aided design was conducted and compaired because of various similarities. As the experiments in salt and water have shown we don’t need to compute geometric beauty, but the key is in nature’s own process and way to conduct and to breed specimen. The author acknowledges the acoustic properties and environments connecting space and time with sound but hasn’t focused on the acoustics of the topic. The aspect of Cymatics as ornaments is foremost of visual quality and not structural is of course important but the focus is the rigid structural ideas behind the thesis.

Litterature Review

Wave Mechanics

If you would explain wave mechanics to a child, you can simply take the slinky demonstrating longitudinal and transverse waves. By moving the slinky at different speeds, and frequencies you can generate different harmonies starting from the fundamental first harmony. What we can see are the standing waves and we can break them down into sections marking the nodes on the centerline, equilibrium, and antinodes as the result of the combined energy of the frequency.https://ocw.mit.edu/courses/physics/8-03sc-physics-iii-vibrations-and-waves-fall-2016/syllabus/MIT8_03SCF16_Textbook.pdf

The frequency or harmonics are measured with Hertz

Unit of frequency, the number of hertz equals the number of cycles per second

On the opposite side art illustrating Frequency is painted with black acrylic with the slinky as a brush.

Anti Nodes

Nodes

Slinky
Fig. 19

Longitudonal waves

Fig. 20

Transverse waves

Third Harmonic, Eigenfrequency

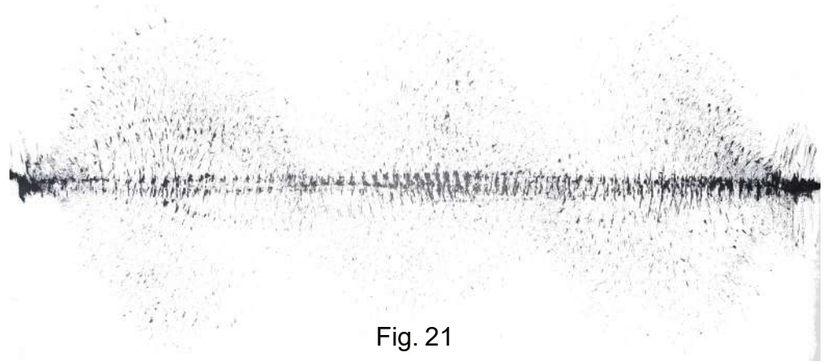


Fig. 21

Fourth Harmonic, Eigenfrequency

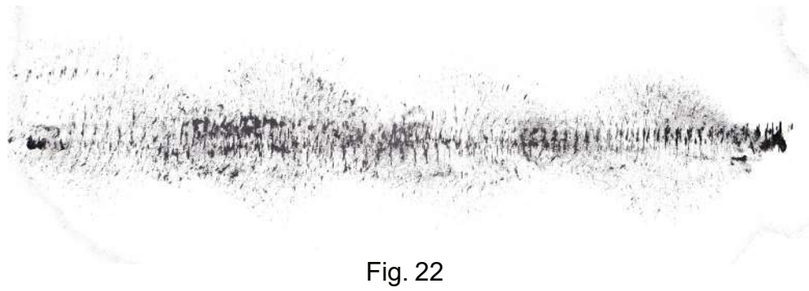


Fig. 22

Cymatics History

From the Greek language comes the word Kymat KUMA, which means waveform. (Jenny,2001) This is the origin of the science name Cymatics that Hans Jenny gave his scientific explorations in the phenomena in 1967. Before Jenny Galileo in the Enlightenment period observed dynamic waveform patterns. He discovered the phenomena when he was scraping a brass plate whit a sharp iron chisel trying to remove spots on it. He was stroking it a couple of times rapidly and it emitted a whistling sound the vibrations had formed a long row of fine streaks parallel and at equal distances from one another. (Galileo. 1939).

Pythagoras' law of harmonics and his linear geometry. (580 f.kr – 495 BC) was the first to calculate the generation of sound in a vibrating force scientifically. (Caleon, Subramaniam,2007.) Nodal patterns were observed by Robert Hooke in 1680 on glass plates (Daintith & Gjertsen, 1999). Ernst Chladni continued whit the technique whit a bow along the edge of a thin metal plate whit sand on it 1780.

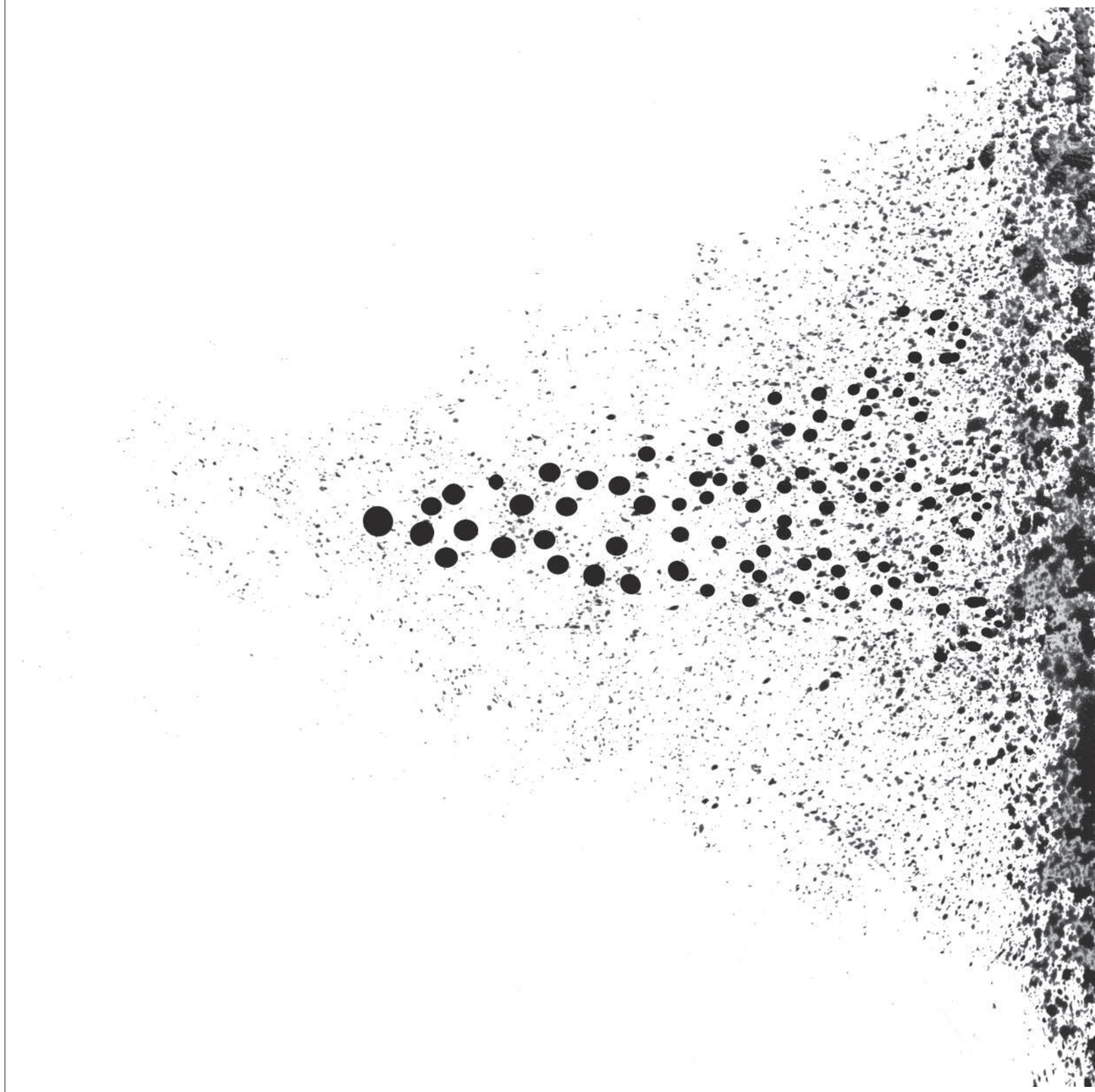


Fig. 23

Theory

Harmonic Form- Finding

Because of the chosen directory and delimitation of the analog approach of this thesis, it was of importance to scope the counterweight of the digital computed direction. A study of the thesis Harmonic Form- Finding for the design of curvature stiffened shells by Cecilie Sos Brandt - Olsen (2015) to find similarities from the digital approach and compare with the analog direction.

Cymatics Revelations

The research in Cymatics for conducting the experiments, a method from the thesis Cymatics Revelations of Carraher, T (2016) was adopted and practiced in this thesis. The results were only compared visually because the nature of the aim for Carraher was solely for a visual experience.

Stuck

To explore the possibilities with gypsum the book STUCK inspired ideas for future forms and elements to arise from the material. The book describes stucco as design elements whit almost endless creative designs from approximately 8000 years ago.

Made of

To make room for innovation it is good to search for alternatives not only in one specific field this book is a source of different materials and designs that are implemented in architecture or have the possibility to become an element. Therefore, the book opened up for implementations in mixing natural materials in the gypsum.

Shells for architecture form-finding and optimization

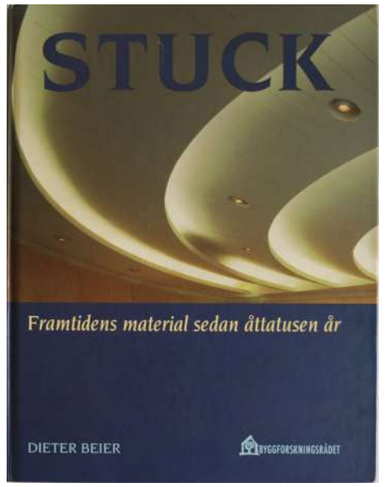


Fig. 24

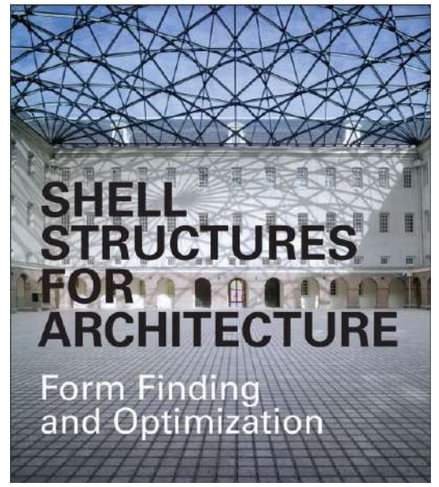


Fig. 25

Fig. 26

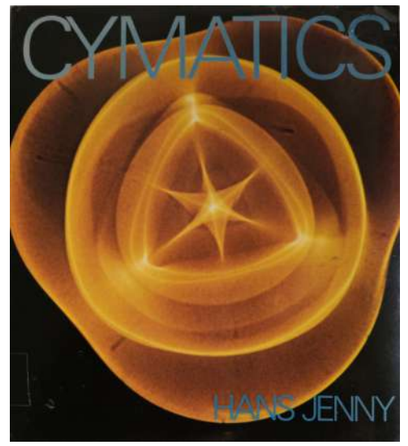


Fig. 27

Cymatics

"It is as if the "history" of the process had been recorded in transverse and longitudinal folds."

Hans Jenny physician and natural scientist experimented with plaster, and he describe the result:

It is as if the "history" of the process had been recorded in transverse and longitudinal folds.

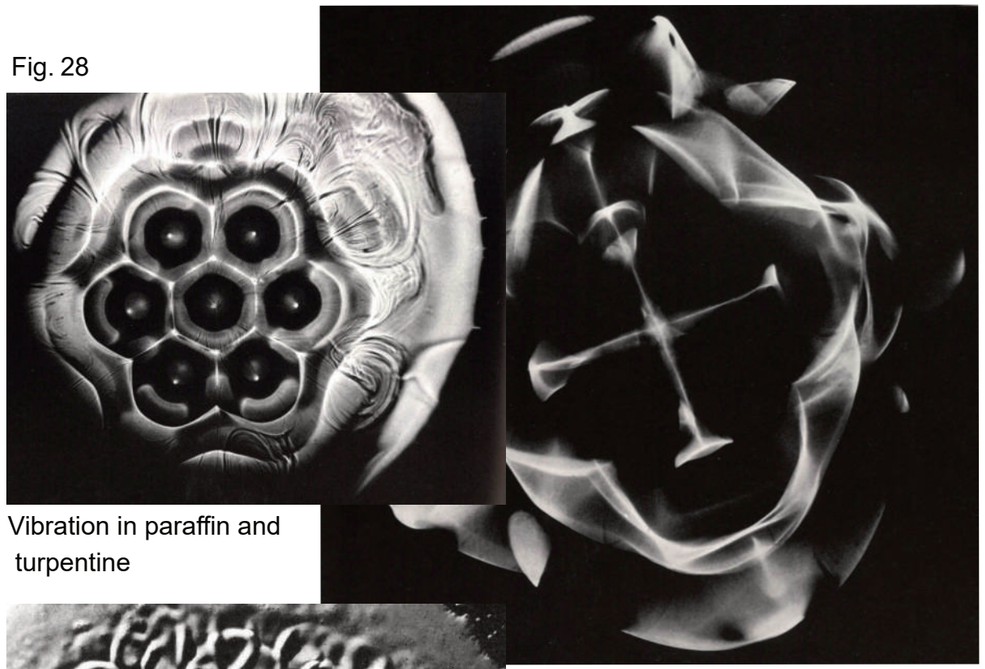
Jenny in his book Cymatics vol 2. Is examined and analyzed with observation because if you focus on one detail, it means that you miss the whole, therefore, annotations of details such as certain frequency or amplitude are only a description of what matters and the process in motion the rest is of secondary importance. To develop a sense for perceiving and observing rhythmic and periodic systems, questions asked in the book are: "How do vibrations proceed in a concrete medium? " What kind of effect do wave phenomena produce in a specific material? " Do we inject a tone, or do they originate in the liquid itself using sinusoidal tone a sinewave sent into the membrane?

When conducting experiments in various liquids such as water, alcohol, and egg white and using only audible frequencies. He references the (Aristotelian metaphysics all ten of them are present in the iterations made.) The formations he expresses is not just symmetrical diagrams or displaying mathematical order, but they are concrete reality kinetic dynamic process in symmetry.

He called the emerging patterns for primal harmonic phenomenon. In experiments where the intention was to induce two different frequencies, combine them, and morph between each other experiments were made, and it showed that it was possible. It sets precise laws that could be repeated and if you interfered with the pattern briefly the pattern formed again after the disturbance. The geometry Fig….is the result of two high-frequency patterns becoming a third pentagonal pattern and a trigonal

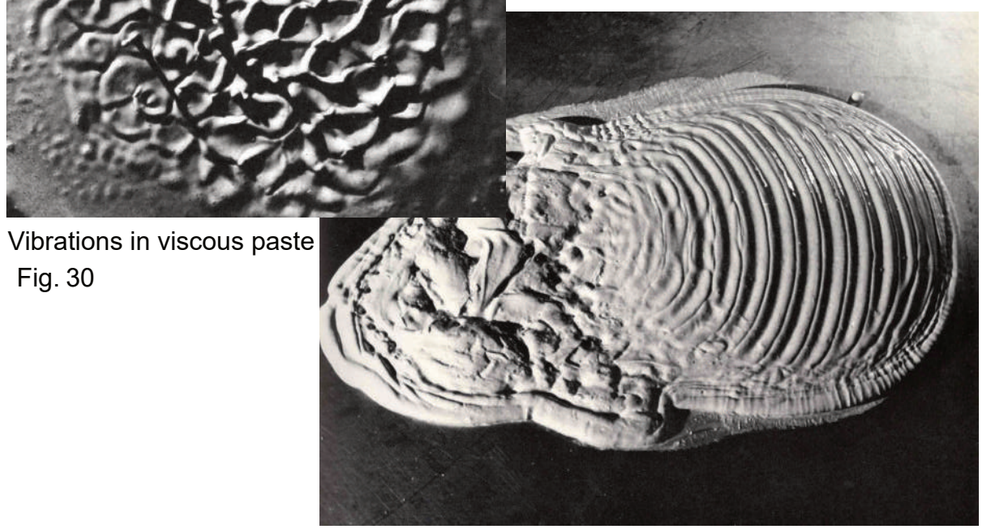
The picture on paste: the result of viscous paste which was formed out of vibration.

Fig. 28



Vibration in paraffin and turpentine

Two tones combined in a liquid
Fig. 29



Vibrations in viscous paste
Fig. 30

Experiments with viscous paste

Fig. 31

Form-Finding

-for the design of curvature stiffened shells

Cecilie Brandt- Olsen Master Thesis

Set up model of plaster gauze hanging

Fig. 32

Form-finding

To find similarities between computer aided design and the natural inherent patterns the author looks at the factual geometrical patterns and the common language and common direction in using harmonics to define limitations and forms that could harmonize in its chosen medium in a free form context. The three form aspects that Brandt-Olsen chooses to focus on in her thesis are shape, topology, and sizing using mesh. For Brandt Olsen to choose the Rhinocerous habitat is a way to take control and define the outcome of successful variables and the opposite, destruction in form of buckling of the shell. For Brandt Olsen, the function of the application was vital for the ease to use with the intention to bridge the design gap between the engineer and the architect.

Shape

In the authors, iterations in the chosen mediums are the shape of vital importance that play a part in the outcome. The architect has fredoom in design of the shape and with tools like Brandt-sos- Olsen it provides many options to form and function.

Size

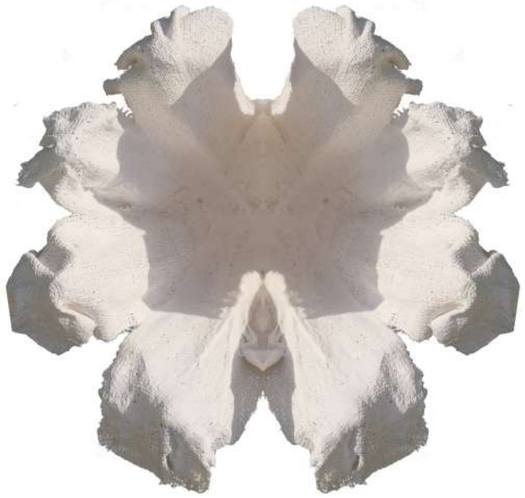
Size is certainly a factor for both environments, what combines the two is the limitations as Cecilie concludes in shape and the practical way to find and explore possibilities within the environment. To in reality manufacture and build a 1:1 scale model or finished structure is obviously time-consuming and expensive therefore the computed environment makes the design possible but of course, within given variables and limitations the software application can manage to process. When determine size the engineers knowledge is the most vital.

Topology

Is the one that is most challenging to define and see and has also have many variables depending on the intended outcome or application, a roof or a wall, flat ,curved or free form. In the wave mechanics, the frequency order itself depending on shape size, and matter. Do form follow force in this aspect in Cymatics? Topology in the sense of which material to use and the qualities that come with the capabilities of that certain material.

Model of plaster gauze flipped up side down

Fig. 33



Picture taking from below

Fig. 34

The figures is an experiment with form-finding using plaster gauze to mimic the experiments of Robert Hooke with his hanging chain model 1676 and the self weight pure compression when inverting the model. This experiment created the crypt beneath the church.

Shells for architecture

-Form-finding and optimization

To further draw conclusions of similarities in CAD the patterns of standing waves in the water experiments is a way to interpret a thrust network as investigated in Shells for architecture form-finding and optimization. The horizontal thrust work as a network that is optimized for a given set of loads for each target surface (vertice) in a self-weight complex masonry structure geometrically. Using the eigenfunctions in one of the investigations shows shapes that is connected to the geometry of the shell therefore the architect can decide on visually appealing deformations whit this set of functions that form standing waves over the shell with its spatial frequency.

The Routledge/ Taylor & Francis Group aim of the investigation is to also bridge the gap between the architects and engineers. When using the three dimensional modelling tools for the design, architects is modelling in a simulated environment that isnt depending on elements like scale, gravity or material. The simulated environment is an abstraction of reality and often made for a specific application or function but it helps the design in understanding relationships between parts and certain aspects that wouldnt exist in the common architectural use of three dimensional modelling tools.

The figures on the opposite side is several eigenmodes generated from a script my supervisor Jens Olson provided. I used it for elaborate, and to find similar patterns that emerged in the water and in the steel plates in my own experiments. What is shown is different frequencies harmonizing and their specific eigenmodes on the mesh. The patterns is similar to what Cecilie investigated in her thesis and also chosen parts in the referenced book Shells for Architecture.

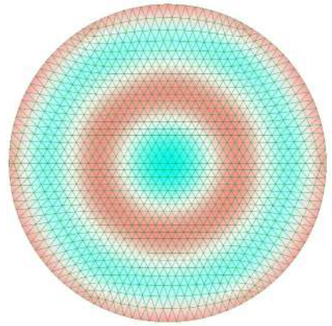


Fig. 41

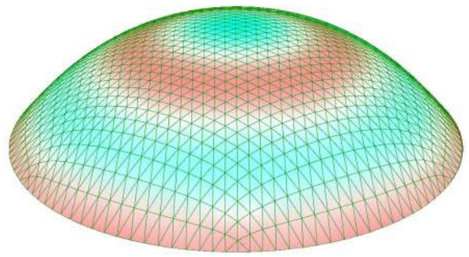


Fig. 42

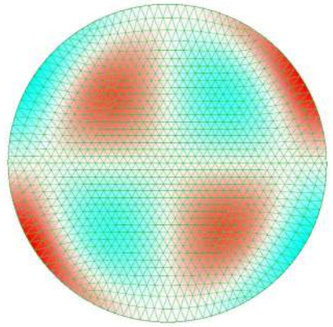


Fig. 43

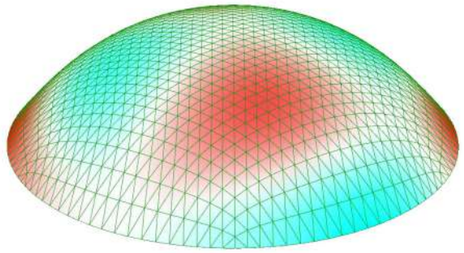


Fig. 44

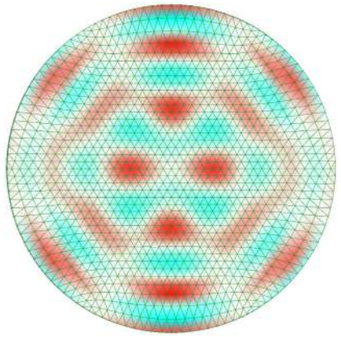


Fig. 45

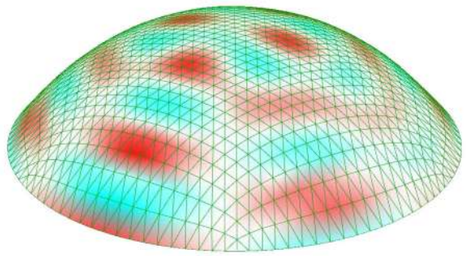


Fig. 46

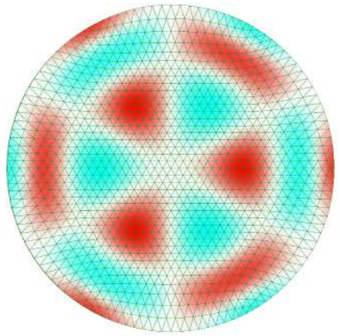


Fig. 47

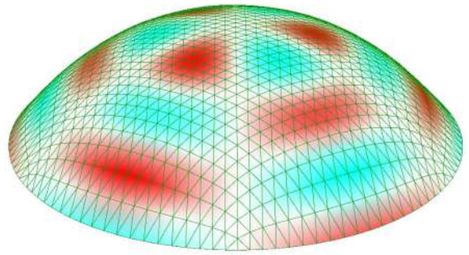


Fig. 48

Design Proposal Crypt Eigenmodes

Fig. 49

Fig. 50

Fig. 51

Fig. 52

Form-finding

The crypt beneath Oscar Fredriks Church is a fictioned structure that speaks for the mystique of the cymatics and got its form from the hanging model with plaster gauzes. The similarities lies in the eigenmodes of a shell structure and pure compression when it is harmonizing whit its shape it is more likely compared with the shapes occuring on the steel plates with the sprinkled sand on it. The form of the crypt was simplified to be able to conduct clean analyzes in Rhinoceros plug in Grasshopper. A 3-d mesh was made and analyzed in Grasshopper whit the script from the supervisor Jens Olsson to visualize eigenmodes in the shell. The most simple pattern was generated from a low frequence and the more complexed was generated with a higher frequence. The eigenmode crypt was then rendered as a exhibit model outside the Oscar Fredriks Church.

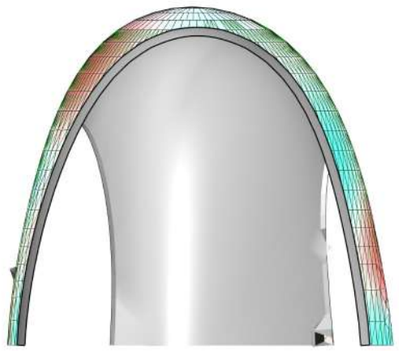
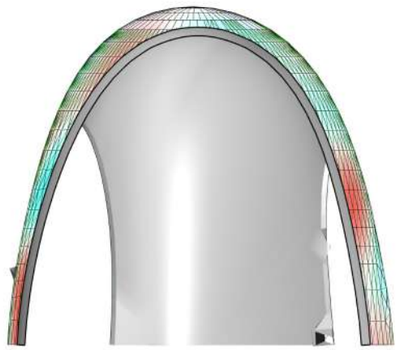


Fig. 35



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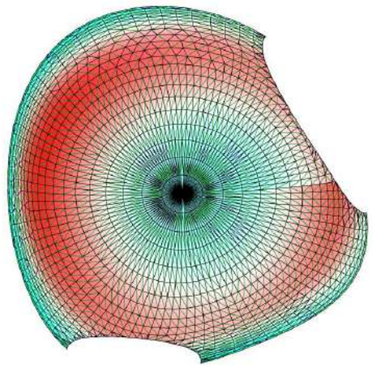


Fig. 53

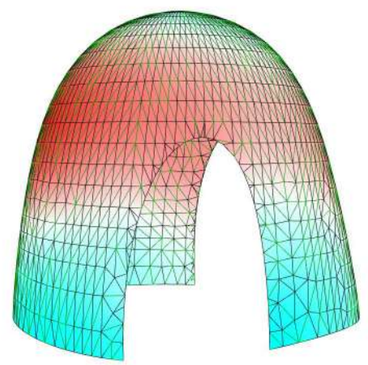


Fig. 54

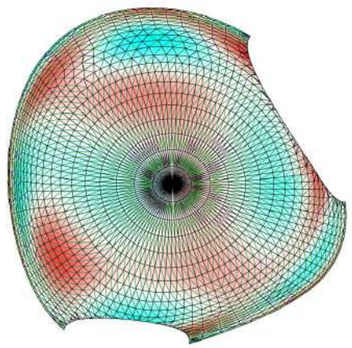


Fig. 55

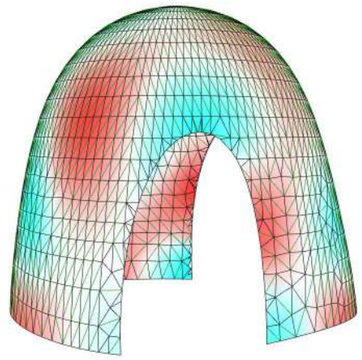


Fig. 56

Fig. 57

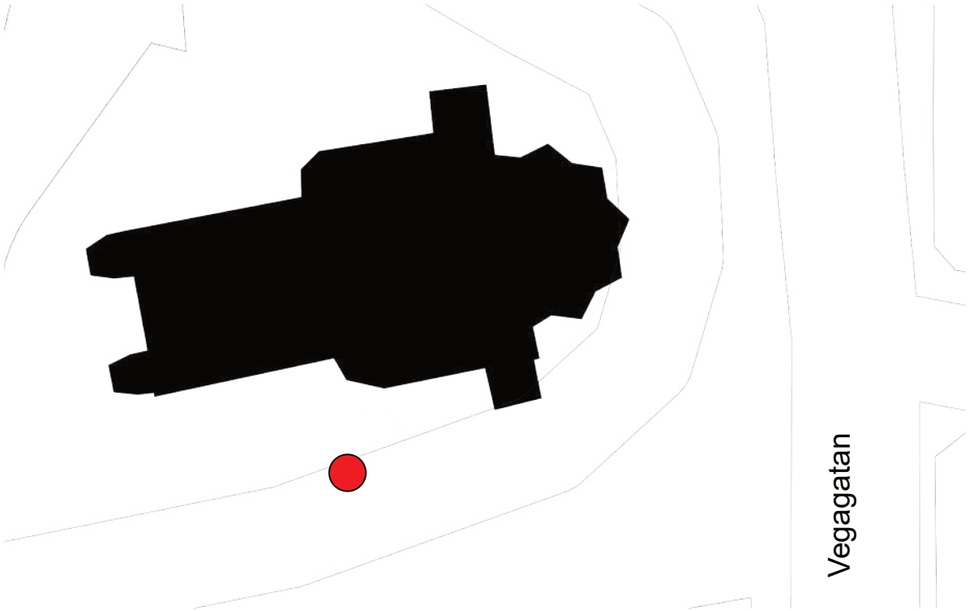


Fig. 58

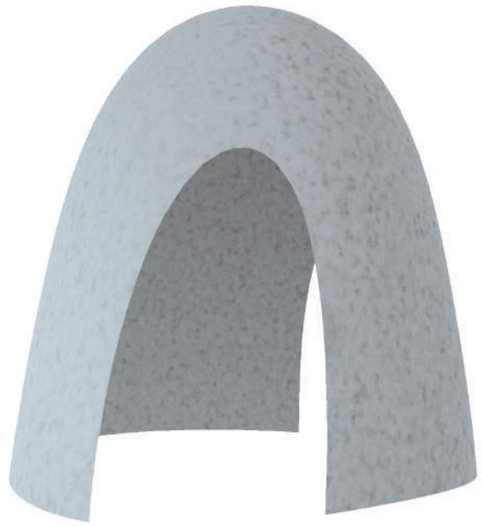


Fig. 59

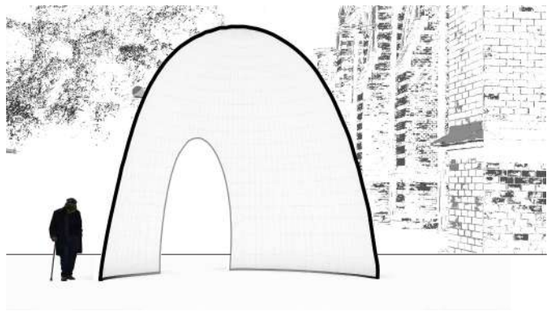


Fig. 60

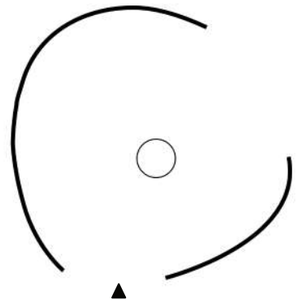


Fig. 61

Analog process and design proposals

Matter Glass

Early findings of tools made of glass obsidian, and volcanic glass was used for arrowheads and knives jewelry, and money. In Eastern Mesopotamia and Egypt around 3500BC, the first archaeological evidence was found some notion is that it could be dated back to 5000BC.https://www.archdaily.com/915760/infographic-the-evolution-of-glass

The heat that is required to melt glass was not up to today's techniques therefore the process was long and hard. The blowpipe that is still used in traditional glassblowing today was invented in the 1st century BC, by Syrian craftsmen. Stained glass in churches became a significant architectural element that marked an era and is designed to tell a story and to let light thru at the same time.

In the year 1959 Float glass was invented and incorporated into the industrial production line by Sir Alastair Pilkington by which 90% of flat glass is still manufactured today along with many different combinations of glass mixtures.https://www.theatlantic.com/technology/archive/2018/04/humankinds-most-important-material/557315/

Glassblower Studio, Stievens hytte

To make the glass experiment happen I needed an expert in the physics of glass a professional. I found one glassblower in the closest region of Gothenburg Stievens Glashytta. A real enthusiast and a warm soul of influence and positivity. Without his motivation and kindness, this experiment wouldn't even happen at all.

Fig. 62

Fig. 63

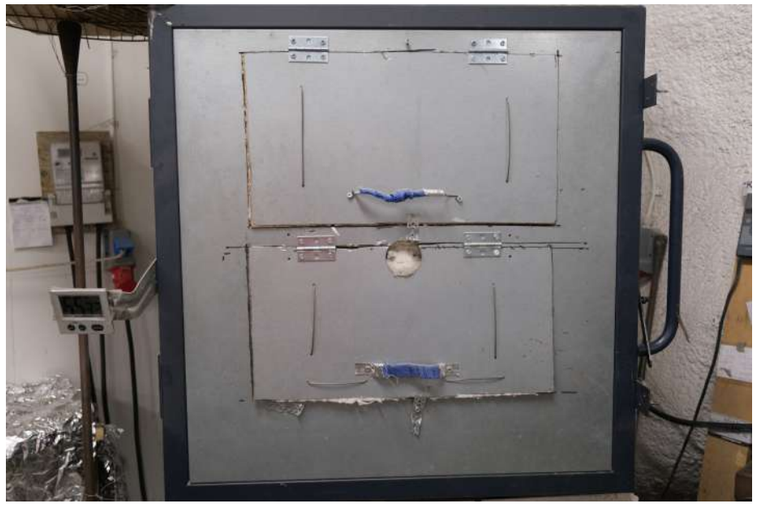


Fig. 64

Imprint

Aristotle observed the longitudinal nature of waves set in motion in air by contraction, expansion, or compression. Sound vibrates in the air molecules and the process produces energy (https://www.britannica.com/science/acoustics/Early-experimentation) Like train tracks when you can hear the train from a long distance away it propagates in solids the most than air and less in gas and not at all in a vacuum (https://www.youtube.com/watch?v=OnZCH0JfDO4). Using Chladni plates, Ernst Chladni physicist and musician who developed the Chladni Plate.

The next step was to experiment with different fluids. Water is the most visible and most common in the intent to visualize the geometry but a more challenging one to capture due to motion and its complexity.

Imprint definition? is that the best way to describe the physics behind the or the result of the modal convoluted change!? I search for the right words to describe my process and what is happening, and the direction of the sound does it matter? It reflects on Jenny's questions in his book and experiments. Is the geometry inherent or is it put into the medium and showed by matter or is the geometry in the medium /object all the time? Cecilie in her thesis doesn't emphasize the sound but the frequencies that harmonize in the shell structure.

Results

The amplitude and frequency control is by intuition.

The most basic experiment was to start with just my own voice and a tube. I was able to generate a pattern on the membrane that was fixed on the plastic bucket. The vibration coming from my mouth is limited in force and I didn't have a tool to determine the frequency or the Note. Iterations after this method I could produce the same pattern but on a steel plate so, in theory, I assumed it was the same Note frequency.

Fig. 65

Fig. 66

Generated design with Chladni plates

Ernst Chladni 1780 struck a bow along the edge of a thin metal plate whit sprinkled sand on it. In a thesis called Cymatic Revelations (Carraher, 2016) the setup used in his experiments is the most common approach to visualizing the natural patterns. This method is a good start to exploring the possibilities of wave mechanics. It is easier to explain and see the nodal patterns than cymatics generated in water.

Equipment

Tonegenerator for generating sinuswave (Ipad)

Machine oscillator

Medium: Steel Plate

Matter: Salt

Results

The results are an eyeopener and a view into the mystery and depth of nature. When frequency increases the geometrical patterns' complexity. The symmetrical shape of the medium conductor makes the pattern symmetric.

Fig. 67

Fig. 68

116Hz NOTE A2

Fig. 69

174Hz NOTE F3

Fig. 70

349Hz NOTE F4

Fig. 71

622Hz NOTE D5

Fig. 72

880Hz NOTE A5

Fig. 73

1.479Hz NOTE F6

Fig. 74

138Hz NOTE C3

Fig. 75

246Hz NOTE B3

Fig. 76

659Hz NOTE E5

Fig. 77

Process of the matter glass

Equipment

- Amplifier:

  Nauna AV2-CD508 125 rms peak 600 w

- Subwoofer:

  Aluminum woofer in die cast chassis
  8 Ohm
  Single spider suspension
  Die cast aluminum chassis
  Heat resistant voice col
  Fiberglass Cone
  Power peak
  1600W
  Power music
  800W

  Frequency response

  35Hz-4kHz

  +-6dB, 28Hz-5kHz +-12dB
  Impedance 8 Ohm
  Mounting diameter 355mm
  Mounting depth 146mm
  Dimensions Ø 394 x 163mm
  Weight net 7.6kg

Results

The setup I choose to do the experiments on is a loosely test done whit the styrofoam. The fiberglass cone is durable enough to possible glue a pod onto it for more firm connection with the medium/object. Fig... shows the pattern take form but the steel plate is just pushed into the pod the configuration is to loose.

Challenges

I realize that the setup for the titanium plate must get attached onto a steel plate in a more concrete way! The pod set up was for creating distance from the liquid glass and the 1200 degrees celcius temperature when it is taken from the oven. I was hoping that the heat did not damage the equipment when the distance is shorter with the choosen set up.

Fig. 78

Fig. 79

Fig. 80

19 Hz Frequence

The result when trying to distinguish a pattern at the time for the glass experiment was challenging because it was difficult to capture the reflections of the waves in the water for the clearest design. The first design whit the chosen frequency was an interpretation of the frequency emerging because of a lack of visible pattern. The pattern was made into a tile to make the design clear and symmetrical. Adjustments was made to make the patterns more clear on the image after captioning it in Affinity photo.

With the right light, Godox ring 72 set up and captioning it with video 4k, you can grab stills in the pattern that you find the most distinct to recognize. In water, it is much more complex and refined, comparing it to the steel plates, even with lower frequencies but the complexity increases also in water with higher frequencies.

Fig. 81

Fig. 82

Fig. 83

Fig. 84

Fig. 85

Fig. 86

Fig. 87

Fig. 88

Fig. 89

Fig. 90

Fig. 91

Glasstudio experiments

Results

Before the glassblower put the glass in the titanium plate a generated pattern was decided on through several possible frequencies harmonizing with the plate in the matter, water. The frequency of 19 Hz had the most distinguished pattern at the time of the experiment. 19 Hz is below the range of human hearing but increasing the amplitude enough for the imprint to take place the strength of the vibration could still damage the ears. The amplitude was approximately 55 % of the possible amplitude. The results hoped that a pattern would harmonize and emerge did not come true. The plate got very hot and started to deform and the double-sided adhesive started to burn. I increased the volume 10 percent more, but nothing appeared we decided to take the glass and cool it off in the cooling oven. But the glass was melted into the plate so the whole piece had to be put into the cooling oven.

After been in the coolning owen for eight hours the glass piece could be seperated from the titanium plate.

The conclusion searching for a lighter material than the classical glasscomponents!

Fig. 92

Fig. 93

Fig. 94

Design Proposal glass 19 Hz frequence

Generating, interpertating and analyzing the
19 Hz pattern.

Fig. 95

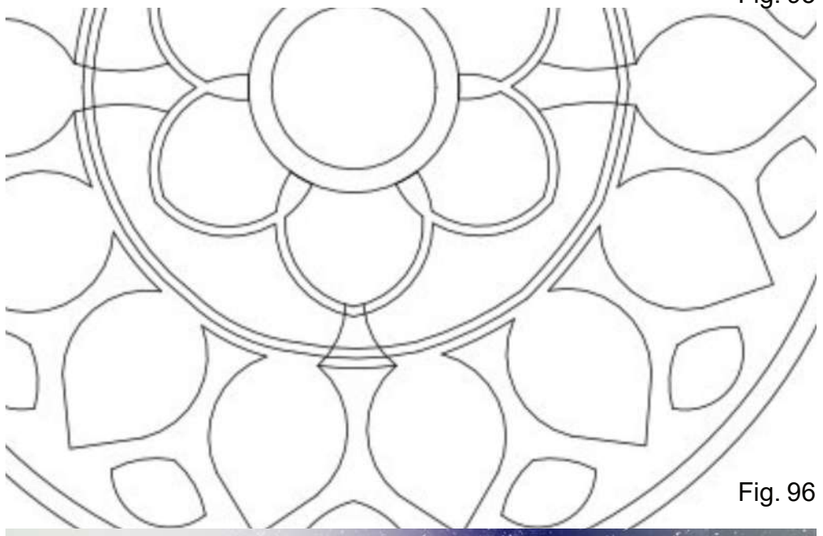


Fig. 96

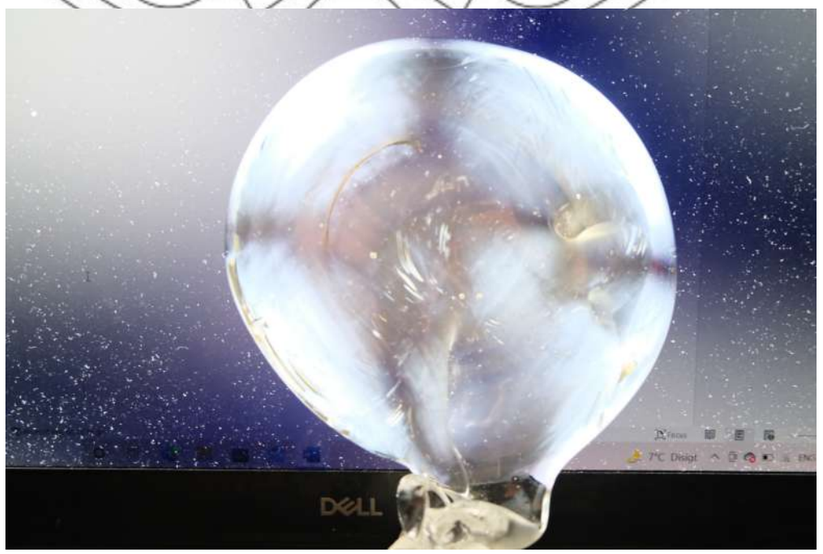


Fig. 97

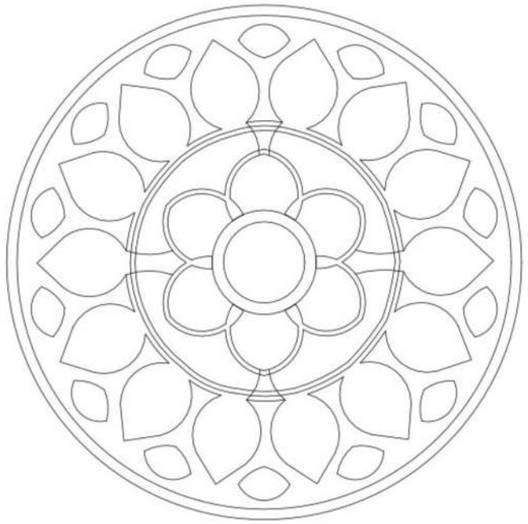


Fig. 98

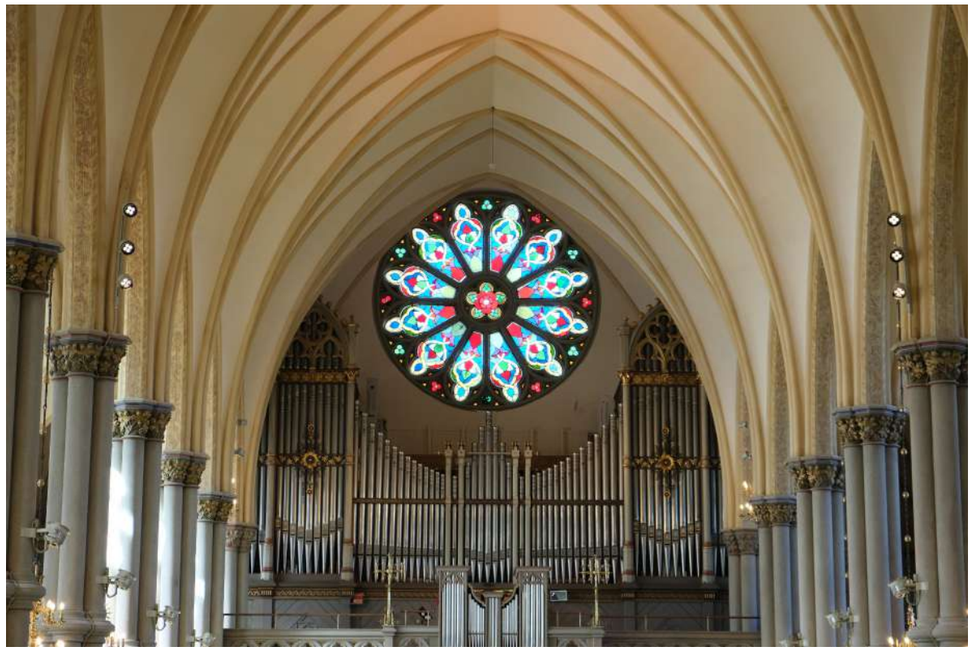
2-D Rendering: 19 Hz Pattern

Fig. 99

2-D Rendering: Existing Church Window

19Hz pattern Glasswindow rendered

Fig. 100



Oscar Fredriks Kyrka Interior

Fig. 101

Matter Gypsum Process

Stucco

Stucco has been around for approximately 9000 years in evolving in its cultural epoch.

Gypsum mixed with water becomes stucco, mainly the applications are for ornaments and figurative details. Around the world, it has simultaneously evolved without the notion of each other. An explanation for that could be the ease of use and that it easily can be demolished. In Jericho findings of stucco tells it was a functional material used for floors and as wall decorations. Pompeji is called the city of stuccos and Marcus Vitruvius Pollio is praising stucco in his book the ten books of architecture. In the ancient antique stucco was a sign of wealth and prosperity the craftmanship was widespread and used highly in the Mesoamerican cultures temples in the same era. During the 700 century, stucco craftsmanship was an own trade amongst bricklayers and stonemasons.

The bloom for stucco is during the baroque and rococo periods. Schools were established and the trade developed substantially. When the industrial boom the interest in the craft was reduced, and new materials like steel and papier mache were more commonly used. Thru the functionalism, almost all interest in stucco was gone and gypsum was mainly used for fireproofing steel structures and for ventilation channels. Today the stucco finds its place in restoration in old buildings due to nostalgia.

Gypsum is a diffusion material and proof of that as a form for supporting broken arms and legs the gypsum has the same ph. level as the human skin and gypsum has the same moist diffusion. The quality of gypsum is that it absorbs excess moisture and reduces the condensation in the room. As a fireproof material because it contains 21 percent of water crystals. Gypsum is good for the environment and contains only natural materials.

Fig. 102

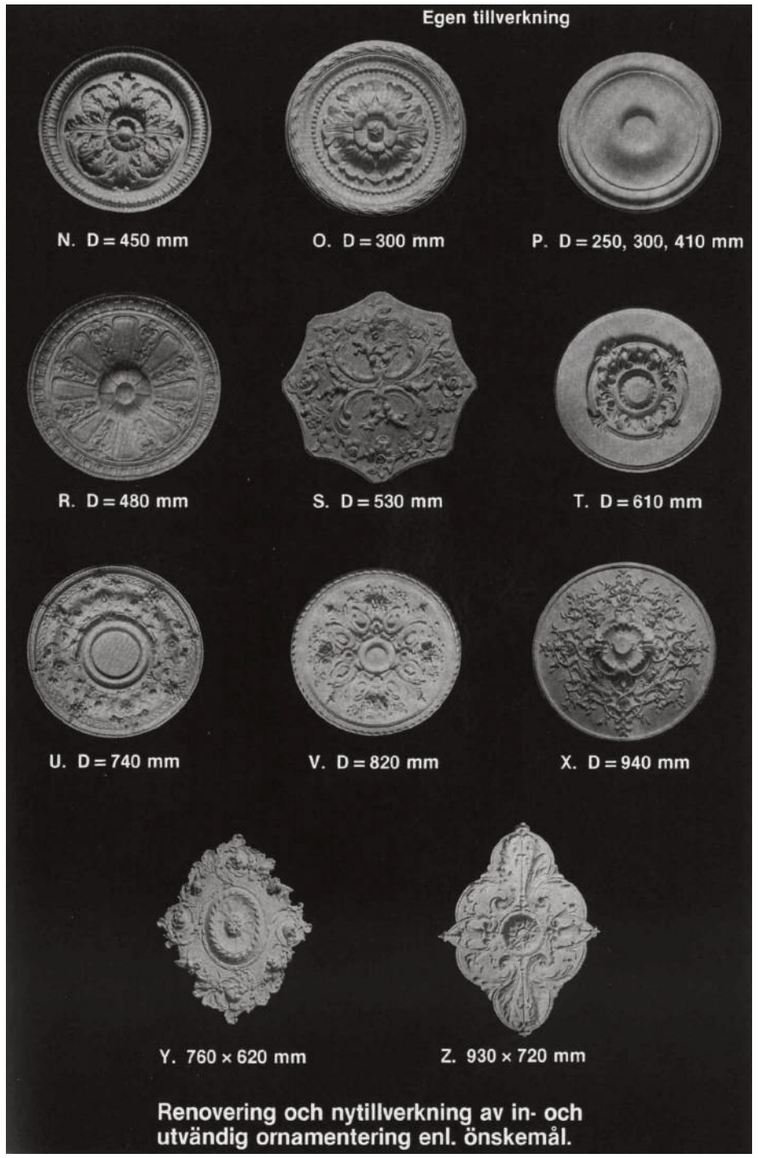
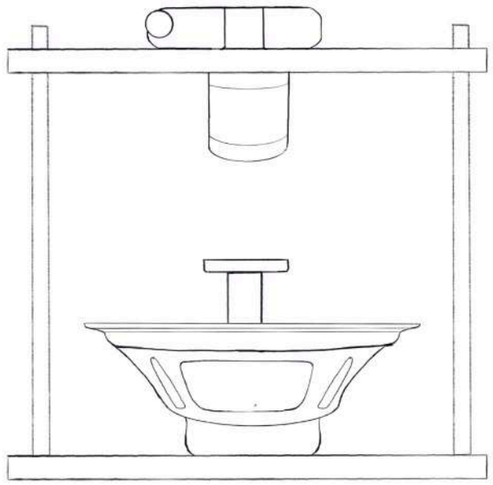


Fig. 103

Design iterations



Documentation set up
Camera
container with water
Speaker element

Frequence 41 Hz Fig. 104

Frequence 138 Hz Fig. 105

Frequence 46,249 Hz Fig. 106

Frequence 20 Hz Fig. 107

Frequence 73,416 Hz Fig. 108

Frequence Random Fig. 109

Frequence Random Fig. 110

Frequence Random Fig. 111

Frequence Random Fig. 112

Frequence Random Fig. 113

Frequence Random Fig. 114

Frequence Random Fig. 115

Frequence 41 Hz

Fig. 116

Results

In the first attempt, the gypsum was mixed with water in a ratio of one dl water and two dl gypsum.

The liquid was mixed at the recommended ratio. And the driver and amplitude were strong enough to generate a pattern. The container for the liquid was not attached properly so the container started to move when increasing the power. As the gypsum solidified the amplitude should have been increased for the pattern to still emerge but the sound the driver generated together with the tone generator was too loud.

The mass of the gypsum was too much for it to become a rigid patterned shape.

First attempt 41 Hz

Fig. 117

Frequence 41 Hz

Fig. 118

Results

Second attempt

The mix was in the same ratio as the first attempt fully mixed before pouring the gypsum into the container. This attempt used a pulsating tone, but the conclusion came fast that this wouldn’t be a solution because the lack of continuous frequency was not in motion.

Therefore, no pattern was sustained.

Frequence 41 Hz

Fig. 119

Results

Third attempt

Third attempt

Starting with water 4 dl.

The tone vibrates the water in the given frequency as in the first attempt.

Started to mix in the gypsum and stirred with a metal fork.

The pattern was generated but disappeared visually when the stirring began. The pattern emerged when the stirring stopped.

Continuing mixing gypsum and stirring it pattern was generated but after the fifth time mixing the pattern only was generated on the periphery of the container.

The process took the same result as the first attempt the amplitude had to be increased to still generate the pattern in the mix in the ratio of four dl and four dl water.

Third attempt 41 Hz

Fig. 120

Design Proposal

As a final exercize I rendered a pattern from early experiments into a part of the dome in the church to see the impact of another design element and expression. Some charachteristics of an eastern design is coming into mind.

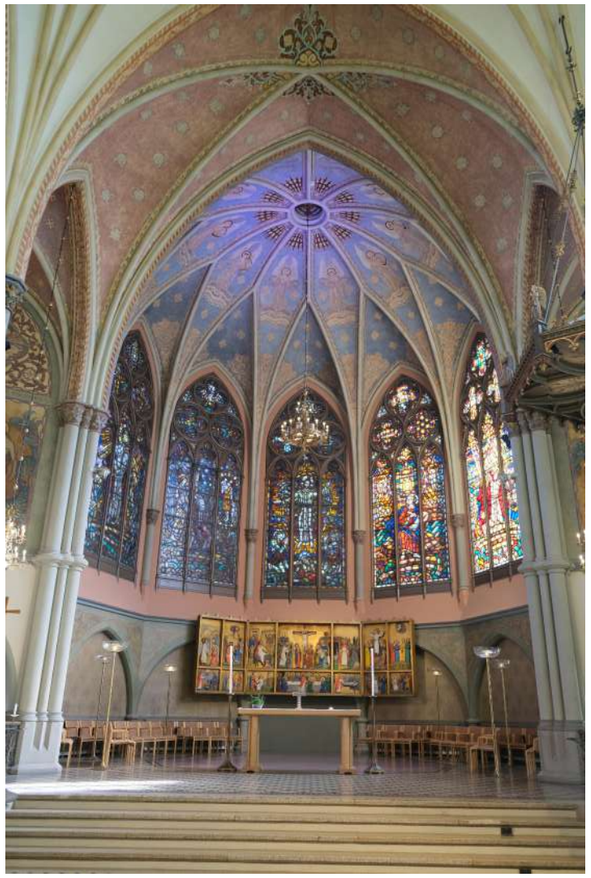


Fig. 121

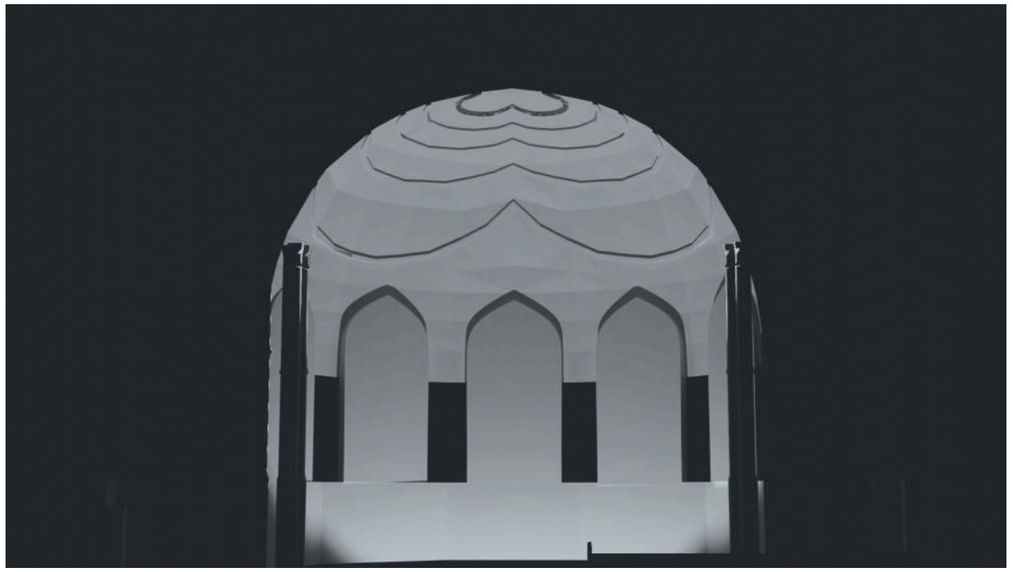


Fig. 122

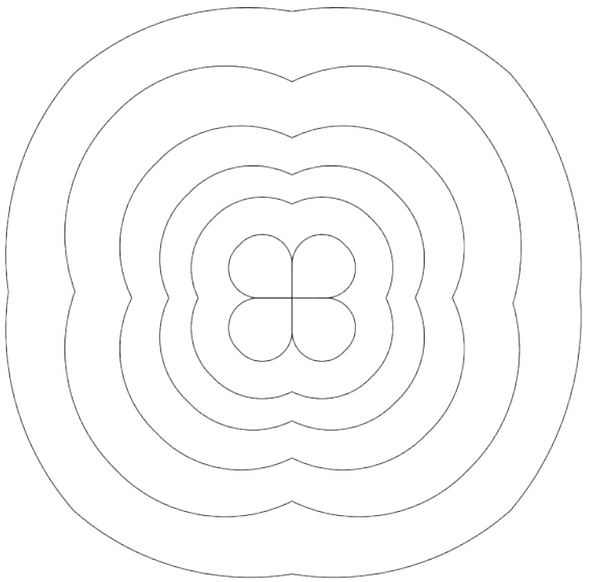


Fig. 123

Summary

In a controlled environment with the steel plates as a clear example of the natural harmonizing imprint you could breed specimen of geometrical structures easy to define and conduct. In water the mezmerizing patterns is hard to comprehend and believe, it feels like it reveals was nature is all about and the quantum mechanics of things is present. The complexity of the experiments due to the limited time made it difficult to iterate a communicative and final result both in the glass material due to just one try option. The gypsum which also needed more iterations and experimenting with different mixes and so forth. The aim was to make a kinetic object. Because of the failed experiments The design made from the frequencys both in glass and gypsum was of secondary importance.

When computing with CAD scale is not a variable that is depended on the result but shape is. The analog experiments results was depending on size because the larger the medium and matter is the more strenght/amplitude is needed, the louder it gets the sound becomes unbeareble.

Conclusion

The intention is to embrace the natural process . The motion of the vibrating cells in the body trying to fit in or make room or take place. Brandt-Olsen finds limitations in the referenced various applications which from the beginning determine certain variables to work whitin. The chosen ready existing programs determine the graphics aesthetic and the digital artifacts that can occur like time for processing, glitches, and crashes in the system play a vital role in the application.

As the research and the own conducted experiments rise questions that separates cymatics from wave mechanics because of the triadic nature you hear, see and feel the vibration, which was a contribution to the naming of Hans Jenny’s Cymatics. Jenny experiments with different solutions mixing materials and various frequencies together. Cecilie called her thesis harmonic form-finding, and It came clear that in the steel plates the eigenmode defined the patterns but there were several harmonics and frequencies generated. And not to reject the possibility to exclude chaos as a factor to generate geometry as a creator for primal screams so to speak!

To further explore materials gypsum has the most potential in comparison with glass that came out of this study. Developing a mix with optional natural materials like plant fibers and glass fibers to reinforce the objects. Letting the frequencies be the breeder and let nature do the producing of the natural primal pattern. Opus caementicium by the Romans in ancient Rome was mixed whit plant fiber or animal hair mixed with gypsum to improve its mechanical properties. An example is the Pantheon dome which is built without any steel reinforcement and is the largest and oldest standing dome (Beier, Dieter ,1995). Connecting the inherent specimen with the geometric structural possibilities, with experiments in a concrete way in a natural environment reflect and analyze the outcome in the materials possibilities to become a rigid form with an imprinted pattern and its properties. The thesis gave me more insight of the natural phenomena and ambition to continue with further experiments after the thesis is done. The investigations brought also a more personal insight of the way I see structures, forms and textures when I conduct music and vice versa.

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https://www.youtube.com/watch?v=qHhVGWj5q5Y

Cymatics: Turning Sound into Art

https://www.youtube.com/watch?v=wXRNKz0xMOU

Sound: Standing Waves and Resonance | Physics in Motion

https://www.youtube.com/watch?v=jz8IIk_bps0

Standing Waves

Thesis

Thesis

Benlloyd Goldstein's (2009) Cymatica architectural thesis investigation into the synthesis of spatial proportion and form generated from sound, formalises his approach "In Search of Cymatic Architecture". Goldstein's exploration of cymatic motion and use of code to realise images, animations and 3D printed cymatic forms presents an interesting crossover with this research.

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