MASTER

Dis-tance
rhythm and architecture

Serowiec, E.

Award date:
2013

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DISTANCE
RHYTHM AND ARCHITECTURE

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The Naked Architect 2.0

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September 5th, 2013
The Naked Architect was not only a graduation atelier where one investigated a certain chosen aspect in the field of architecture. It was, most of all, an experience into getting to know oneself as an architect. While gaining awareness by looking into and questioning the process of making my designs, my interest in proportion crystallised. Proportion, particularly in distance, is the main subject and focus of this thesis.

While working on the thesis I have received a lot of help from my fellow students: Toon Rooijmans, Elisabetta Bono, Fariba Joveini, Filip Pietens and Nick Matulessy. I appreciate your feedback and inspiration that helped me finalise my design. I would also like to give special thanks to my parents, especially my father, who contributed greatly to my thesis and early stages of the design. I would also like to express my thanks towards Anna Olejniczak and Klaudia Weglarz for their help on this essay.
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The Naked Architect Assignments

Research-M3

The Naked Architect atelier had a clear vision of a specific research method. During the atelier each of the students takes a specific concept, such as Kunst und Kernform, Hylomorphism, Mass Tectonics, Ornament and space, Ambiguity and spatial hierarchy, The Body and Perception, The notion of Craftsmanship. The research done on these concepts is materialized in the M3 (preliminary) design. Each of the students builds their own philosophical table. The philosophical table becomes a designed and realized product of an intellectual struggle with the chosen concept as well as the object of focus and discussion. The experience of making the table contributed to the reflection of the chosen concept. That reflection was taken a step further in the M4 fazes of the studio.

Design-M4

During this phases the design and research still come to stand hand in hand to produce a larger scale architecture. The choice of function, location or the materialization of the design is guided by the research subject. The chosen concept form M3 stage is now being questioned by a full scale design.
The research subject

Attitude towards proportion

In the course of working on the design, I paid close attention to the way I approach the concept of the table. The early stages of the design resulted in many different concepts for the table. The common ground that embraced all the design was the attitude to the proportion of the archetypical table (4 legs and a table top). Without changing the shape of the archetypical table, but merely changing its proportion, the table shifted through a wide range of functions and appearances. Putting so much emphasis on the way in which the design proportions corresponded to each other led my research into investigating the nature of proportion.

Looking at architects and designers, it would be possible to point out two totally distinct attitudes towards the subject of proportion. Some may claim that they are not concerned with using proportion in their design instead being guided by their intuition and sense of beauty. However, it is not possible to materialise a design without coming at a certain proportional arrangement. It is quite intriguing that not only design but the whole human activity which has to do with ordering always uses some kind of proportion. We give minutes certain proportion of the hour. We divide pitches and scales in music into certain tones, or we use a certain part of your body to relate to quantity or distance (foot, yard). All these are activities which require thinking about or using proportion.

Another point of view on the matter of proportion is when we attempt to mystify the function of proportion. Since ancient times, some were looking at proportions as a cure for beauty. The right proportions of buildings were believed to produce beauty. Such an attitude created certain limitations on the art of building. It led to copying the whole buildings or special arrangements in order to reach the divine beauty. This, in turn, has placed the variety of possibilities of different measurements and systems in stiff position.
The investigation of the nature of proportion as a system and its application on the experience of distance in one-dimensional and two-dimensional space.

My investigation into the nature of proportion disclaims both of the radical points of view towards proportion. Focusing on the meaning of the word proportion and simplifying it, led me to redefine it: Proportion is a system. The new stance towards proportion provides the flexible space for creating new spatial arrangements. An application of such a new system was tested in the design of the Philosophical Table, as well as in the design of two residential buildings. Each of the building explores the system with a different approach, by applying it on distances between different design elements such as construction or function. Consequently, each house is a case study of one-dimensional and two-dimensional representation of the same system of proportion.
Through over twenty two hundred years many architects and artists believed in The Great Theory of Beauty. It has been rightly assigned it the name ‘The Great’, as there was no other more popular and influential theory in aesthetics (Tatarkiewicz, 1975). The theory stated that: ‘Beauty is a form of sympathy and consonance of the parts within a body...’ (Alberti, 1991). Beauty and proportions were as if grown together. Many architects found the recipe for beauty in proportions. Combining proportions with beauty so closely created limitations in the development of understanding of these two ideas. Having defined the objective beauty, it was believed that proportions cannot vary from the set ideal, as it would result in something uglier. However, through the centuries there were several theories opposing to the Great Theory of Beauty. One of the first influential architects to bring out his opinion was Claude Perrault. He claimed that we find certain system of proportions beautiful, because we got used to them. He explained that the reason why we would find an object beautiful, in the first place, is due to the fact that it manifests other characteristics like richness of material or precision of workmanship, which we might find beautiful. Eventually, the proportions of this certain object are being appreciated as a part of the entire reception (1993). An object with the same proportions done in two different manners can be perceived as utterly beautiful in one case and extremely ugly in another. Consequently, if we find an object beautiful, it doesn’t have to do with its proportions. This point of view is also conveyed in Edward Burke’s ‘A philosophical Inquiry into the Origin of Our Ideas of the Sublime and Beautiful’ (1958). Burke claims that the idea of proportion is neutral to the mind; ‘All proportions, every arrangement of quantity, is alike to the understanding’. If we assign it a value, it is merely our judgment on certain calculation or geometry, which for Burke has to do with our imagination. Wouldn’t it be reasonable to state that the imagination can be used to any kind of geometry? What if we could switch off our imagination for a while and have a look at a completely new object, which we haven’t seen before? The object would be then unaffected by our subjective taste and we could consider its proportional arrangement as
nothing more or less than just a system of relationships that was applied to the shape. This system, in many cases, might have a very strong connection with the subjective value that some may assign to it. However, the history of proportion in music discloses the fact that those values are only temporary. Since ancient times many musicians had a clear idea about the consonances and dissonances occurring between two certain sound frequencies. Those relationships between frequencies were discovered by Pythagoras: the octave (from do to do) that was formed by the ratio 2:1, the perfect fifth (do to sol) by 3:2. Those ratios, together with the perfect fourth by 4:3 (from do to fa) were incorporated into the tuning system called Just Intonation. Yet for some musicians and theorists the perfect component did not create the perfect system and Temperament was used to flatten some tones in favour of others in order to produce a more usable system. These proceedings gave birth to other systems and caused fierce disputes as presented in the book ‘Temperament’ by Stuart Isacoff (2002). Mathematicians, philosophers and musicians tried to reason the use for perfect fifths, thirds and forths. One of the most apt arguments was that of an overtone produced during a vibration of a string. Discovery made in 1673 proved that once a certain string is set to motion, it divides itself into innumerable segments, each of them producing a distinct tone. The overtone lays a perfect fifth from the frequency it is supposed to produce. While playing a ‘do’ together with not pure fifth (‘sol’), the overtone of ‘do’ would not much the tuning of ‘sol’, therefore rendering the combination dissonant. It seems that acoustic proved it to be a well justified reason for the use of the proportion of Just Intonation. Yet, still, that is not the tuning the octave, which we are used to nowadays. The shift of priorities and the convenience of Equal Temperament for orchestra performances caused that many musicians abandoned using Just Intonation. Another reason for the use of Equal Temperament was a discovery made by Galilei, who compared different musical tunings to the sounds produced when singers perform without the aid of instrument. He discovered that their voices were not fixed on any tuning and shifted, and alternated freely.
The conclusions seemed to be simple: it is natural to use the scale of the singing voices as a model for the one of the man-made instrument. As pure rations were not the natural foundation of singing, Equal Temperament was the best choice for achieving it. However perfect the Just Intonation system might have seemed at the beginning, it was dismissed by the Equal Temperament. At the same time, Galilei did not disregard other Temperaments nor Just Intonation tuning, for, after all ‘all the systems are man-made’. Johann Georg Neidhardt was one of the theorists and composers with an open attitude to that matter. He created more than two dozen different temperaments, some of which he claimed to be more suitable for villages, some for cities, and others for royal court.

The discoveries of many different systems of tuning point to the fact that there are yet other systems to be discovered. In ‘Seven Lamps of Architecture’ Ruskin (1885) wrote that the possibilities of proportion are infinite. It would seem logical to assume that new systems are possible and likewise also useful. Considering the idea of a system in mathematical terms; any algorithm is a unique system of proportion. An algorithm is a finite set of instructions that can be compared to the one set ratio of Golden Section. It has also the object or unit to start with, and an ‘action’ or calculation applied to that unit. Any algorithm can be used as a proportional tool. To any algorithm one might assign its value and find a use for it.

Many already know systems work like algorithms. In ‘Proportion’ Richard Padovan (1999) revises the many different systems of proportion and analyses the way they are built. He describes the basis on which all the systems were set. The axioms of their creation were a unit and a system; ‘That is to say, one needs both a static principle and a dynamic multiplication system’ as Van der Laan describes it. That multiplication system can be considered as a certain ‘action’ that is applied to a number to receive another. This is the same way in which an algorithm works. Comparing the already existing architectural systems of proportion to a mathematical algorithm broadens the possibilities for new inventions and their use. It is up to an architect to assign the use to a particular algorithm. Richard Padovan has also made
a research on the use of different systems of proportion. He defined the limitations of some systems that rendered them not useful. Those systems were ratios of: \( \sqrt{2}, \sqrt{3}, \sqrt{4}, \sqrt{5}, \) and 1.325 which is known as Van der Laan’s Plastic Number. The Golden Section, with the ratio 1.618, also belongs to the group. However, his research seems to cover only a particular part of the history. A more in-depth research might render his findings more as ‘guidelines’ and yet another restriction resulting from tradition and history. Let us consider Padovan’s research first. He writes that the development of proportion stats with creating a sequence of numbers. Counting was the easiest way to produce a sequence of numbers. Adding a certain unit (1) to any previous number would result in getting 1, 2, 3, 4 ect…. an arithmetic progression. Another simple option was to multiply the unit by a constant number (e.g. 2), to get 1, 2, 4, 8… and form a geometric progression. In the history of proportion none of those simple progressions gained popularity. This is due to the results they produce while applied to geometry. Let us take a simple room as an example: if we start with a square room of 3x3 meters, by extending the length of one side of the room according to geometric progression, the next room would measure 3x4 meters, and the next; 4x5 meters. Starting with the same square room, but this time following the rules of geometric progression our next room would measure 3x6 meters. The next one would be 12 meters long. Padovan points out the fact that the ratio of growth of these progressions was either too slow or too quick, respectively, to find it a useful proportion tool. These are two extremes which would not produce desirable results. His research shows that architecture used the growth ratio between consecutive numbers of the series that closed between 1 and 2. That is the ratios of: \( \sqrt{2}, \sqrt{3}, \sqrt{4}, \sqrt{5}, \) and 1.325, 1.618. One might ask at this point, what would happen to architecture if we go over the number 2. Wouldn’t a mathematical series with 3 or any higher number as a multiplier create a total chaos? If we go above 2, geometry starts to craft fractals. One of the most popular fractals is Sierpinski triangle. The system of triangles, with a growth ration of exactly 3, is
Settlement in Ba-ila, Zambia

The Chief’s Palace in Logone-Bini, Cameroon
made by subdividing the original triangle. The triangles that result from that subdivision are
further subdivided into smaller triangles. The concept of fractals began to take shape in
the 17th century, and was considered, indeed, a chaos. Till 1880, fractals were referred to
as mathematical ‘monsters’. But what had been considered a ‘monster’ in Europe, had a
valuable beauty already, for many centuries, in Africa. Ron Eglash, an ethnomatematican,
African architecture and design. The palace of the chief in Logone-Birni, Cameroon, is
an example of a plan with similar principle to the Sierpinski triangle. The palace was set
on rectangular plan which was subdivided into many more rectangles. As much as this
would have no logic in European architecture, African tribes used the plan to create social
scaling in their society. Entering from the bigger space to the constantly smaller and smaller
space created a sense of privacy and respect. Moreover, Eglash’s research showed that
fractal structures were spread all over Africa. A most common example of village layout is
represented by the settlement in Ba-ila in Zambia. The settlement was set up on a circle with
the chief house inside. The circle was subdivided into separate family houses, each with
an altar inside. One could imagine that this the geometrical progression would render some
houses too small to be useful. Indeed, some spaces were so narrow that they wouldn’t fit
a man inside. Tribesman considered those places as homes of their ancestors who, being
ghosts, would not need a lot of space. It was believed that their ‘settlement’ inside the small
cavity also followed the fractal progression. African tribes invented a perfect use for what
might have seemed an inconvenient system. It was not only the unconscious use or the
feeling of beauty that made fractal patterns the ‘African Golden Section’. Eglash points out
that the fractal pattern in the structure of a reed wall had other purpose than aesthetical. The
pattern was looser at the bottom, but stronger denser at the top. The progression of the
pattern matched perfectly the progression of intensity of the wind speed at different heights
from the ground. The design proved efficient and practical.
At this point, one may state that the ‘European invention’ of the golden section is nothing more than what Erwin Panofsky would name as ‘Kunstwollen’. In ‘The history of the theory of human proportions as a reflection of the history of styles’ Panofsky describes ‘Kunstwollen’ as an artistic intension of each epoch and style. In the light of previous examples, it is also an intension of a particular place. Inconceivable to the European geometry, fractal patterns are surprisingly convenient to African society. This proves that any number can be a ratio for a system of proportion, likewise: any algorithm can be used to produce proportional arrangements in space and time.
The design of the table is an attempt to answer the question set above; is any algorithm possible for the use as a tool for proportional arrangements? However, making the table is not only using a new algorithm, it is also an exercise into getting used to the new arrangement it produces and finding a function for it. The inspiration for the design was the project by Michael Hansmeyer, the ‘Platonic Solids’ (2008) is one of the many that pictures that relation. The object to start the design with, were the five of the platonic solids: tetrahedron, cube, octahedron, dodecahedron, icosahedron. Each of the solids undergone a division, a process of ‘digital folding’ that was possible by application of Catmull-Clark and Doo-Sabin algorithms. Starting with a form of a simple cubical unit, the results varied greatly. That is due to the fact that once set rule: folding, follows the personal choices of the designer (the number of folds, folding direction) to produce the final result.

The design of the table used Euclid’s algorithm. The algorithm was chosen at random. The Euclid’s algorithm is a method of calculating the greatest common divisor of two integers or length segments. Given two length segments, we need to subtract the length of the shorter one (B) from the longer segment (A). That creates a new segment - a remainder – which we subtract from the segment B. The calculation is finished when the last remainder is of exactly the same length as the segment that it should be subtracted from. That length is then the Greatest Common Divisor for the two lengths on which the process was conducted.

This description was found in Euclid’s ‘Elements’, and counts almost two centuries, which makes Euclidean algorithm one of the oldest algorithms still in common use. It is used for calculating timing systems in neutron accelerators, string theory in computer science, mathematics and music. For music the algorithm is a means of generating different kinds of rhythms (Toussaint, 2005). The calculation method for creating rhythms operates on a binary sequence. Each bit in such a sequence is considered as a one unit of time. In music ‘0’ represents no action or silence, and ‘1’ an onset of a sound. Tresillo, one of the most famous rhythms, uses Euclid(3,8). The ‘(3,8)’ means that calculation method would start
'Platonic Solids' by Michael Hansmeyer (2008)
by setting a sequence of 3 x ‘1’ bit, followed by ‘0’ to match the number of 8 bits in total:

\[
[11100000]
\]

The operation begins by moving the ‘0’ and placing them after each ‘1’. As we have 3 times ‘1’, in the first step only 3 ‘0’ are used:

\[
[11100000]
[10][10][10][0][0]
\]

The remaining ‘0’ are distributed in the same manner, as if added to the \([10]\):

\[
[10][10][10][0][0]
[100][100][10]
\]

The calculation is finished, when only one sequence is left that is different from the others. In this case that sequence is \([10]\).

\[
[100][100][10]
\]

Converting it into the language of music: we would hear 3 times a string bass sound over the period of 8 intervals of silence. Elvis Presley’s used it in ‘Hound Dog’. This rhythm, also known as Tresillo, is not an outcome of this calculation in the first place. The rhythm is older than this binary calculation method of Euclidian Algorithm. Not only this one, but many more examples of different kinds of rhythms that were created ‘naturally’ without help of any kind of calculation, yet they can be described and recalculated by Euclid’s algorithm. Godfried Toussaint (2005) gives a list of many different rhythms from all over the world. By this, Euclid’s algorithm presents itself as a computational, totally logical activity, which seems to deliver audible pleasure and, on the other hand, can be generated by a sense of ‘feeling’.
The design of the table uses Euclid’s binary calculation and translates it into segments of the table. The two binary strings E(6,16) and E(4,16) produce a series of ‘0’ and ‘1’. Each ‘1’ is materialized as a section of the table; a set of table legs. The ‘0’ represents the absence of material. The process of making the table in a 1:1 scale allowed me for more intimate experience of the spatial arrangement created using the algorithm. The transportation costs and the costs of the material allowed me to make 10 sets of table sections. Dividing those pieces into two different rhythms with set of 4 and set of 6 legs was a result of many experiments. Creating the table rose questions about the proportion in the distance between the table sets, the experience it creates and the subjective satisfaction of the final form.
The calculation of Euclid's algorithm generated the table rhythms

<table>
<thead>
<tr>
<th>E(6,16)</th>
<th>1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10)</td>
<td>[10] [10] [10] [10] [10] [10]</td>
</tr>
<tr>
<td>(100)</td>
<td>[100] [100] [100] [100] [10]</td>
</tr>
<tr>
<td>(10010)</td>
<td>[10010] [100] [100] [100]</td>
</tr>
<tr>
<td>(10010100)</td>
<td>[10010100]</td>
</tr>
<tr>
<td>(1001010010010100)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E(4,16)</th>
<th>1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10)</td>
<td>[10] [10] [10] [10] [10] [10]</td>
</tr>
<tr>
<td>(100)</td>
<td>[100] [100] [100] [100] [10]</td>
</tr>
<tr>
<td>(1000)</td>
<td>[1000] [1000] [1000] [1000]</td>
</tr>
<tr>
<td>(1000100010001000)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E(6,16), E(4,16)</th>
<th>1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>E(6,16), E(4,16)</td>
<td>1 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0</td>
</tr>
</tbody>
</table>
E(2,3) = [1 0 1] is a common Afro-Cuban drum pattern.

E(2,5) = [1 0 1 0 0] is a thirteenth century Persian rhythm called Khatif-e-ramal. It is also the metric pattern of the second movement of Tchaikovsky’s Symphony No. 6.

E(3,4) = [1 0 1 1] is the archetypal pattern of the Cumbia from Colombia, as well as a trochoid choreic rhythmic pattern of ancient Greece.

E(3,5) = [1 0 1 0 1] is another thirteenth century Persian rhythm by the name of Khatif-e-ramal, as well as a Rumanian folk-dance rhythm.

E(3,7) = [1 0 1 0 0 0] is a Ruchenitza rhythm used in a Bulgarian folk-dance. It is also the metric pattern of Pink Floyd’s Money.

E(3,8) = [1 0 0 1 0 0 1 0] is the Cuban tresillo pattern.

E(4,7) = [1 0 1 0 1 0 1] is another Ruchenitza Bulgarian folk-dance rhythm.

E(4,9) = [1 0 1 0 1 0 1 0 0] is the Aksak rhythm of Turkey.

E(4,12) = [1 0 0 1 0 0 1 0 0 1 0 0] a clapping pattern in the Flamenco music of southern Spain.

E(5,6) = [1 0 1 1 1 1] yields the York-Samai pattern, a popular Arab rhythm.

E(5,7) = [1 0 1 1 0 1 1] is the Nawakhat pattern, another popular Arab rhythm.

E(5,8) = [1 0 1 1 0 1 1 0] is the Cuban cinquillo pattern.

E(5,9) = [1 0 1 0 1 0 1 0 1] is a popular Arab rhythm called Agsag-Samai.

E(5,11) = [1 0 1 0 1 0 1 0 1 0 0] is the metric pattern in ‘Pictures at an Exhibition’ by Moussorgsky.

E(5,12) = [1 0 1 0 0 1 0 0 1 0 0 0] is the Venda clapping pattern of a South African children’s song.

E(5,16) = [1 0 0 1 0 0 1 0 0 1 0 0 0 0 0] is the Bossa-Nova rhythm necklace of Brazil.

E(7,12) = [1 0 1 1 0 1 0 1 1 0 1 0] is a common West African bell pattern.

E(7,16) = [1 0 0 1 0 0 1 0 1 0 1 0 0 1 0 1 0] is a Samba rhythm necklace from Brazil.

E(9,16) = [1 0 1 1 0 1 0 1 1 0 1 0 1 1 0 1 0] is a rhythm necklace in the Central African Republic.

E(11,24) = [1 0 0 1 0 1 0 1 0 1 0 0 1 0 1 0 1 0 1 0 1 0] is a rhythm of the Aka Pygmies of Africa.

E(13,24) = [1 0 1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0] is another rhythm necklace of the Aka Pygmies of the upper Sangha. It is usually started on the fourth onset.
Table sets after welding and sanding
M4 PROJECT
INTRODUCTION
The investigation of the nature of proportion as a system and its application on the experience of distance in one-dimensional and two-dimensional space.

During the M3 research I have investigated the notion of proportion. For many architects and theorists proportion of the parts of an object to each other was the most crucial factor that rendered the beauty of that object. My research revised theories presenting that point of view and their critique. I have presented arguments opposing the strong connection with subjective beauty related to proportion and tried to prove that proportion, in its nature, is a system; merely a calculation method that we can repeatedly apply on our designs. Possibilities of such a system and its applications are endless. To gain more insight into those possibilities, I chose Euclid’s algorithm for case study. Investigating the characteristics of this particular calculation method showed vast range of representations and application of the algorithm for disciplines like mathematics, physics and music. No applications of this particular algorithm in the field of architecture are known. Many systems of proportion have already been applied on volumes, measurements of width, length, and height of different spaces in a building. Euclid algorithm proved most efficient in producing division on distance. The proportional arrangement of certain elements over a distance was materialized in the design of the Philosophical table. It resulted in a rhythm of elements (table legs) spread over a particular distance. The abstract form of the table was able to perform the new algorithm. However the implementation might prove to be more complicated when we think about full scale buildings, which also have to respond to the constraints of the location, function and program. Application of a new system on such project might prove to be more difficult. Yet, applying a new kind of system could benefit the results on two levels. Firstly, during designing the building in a manner that we are not yet accustomed to might pose many questions about the nature of designing such a building. We might not realize what are the priorities we set, until those priorities need to match a new order. Secondly, we are also affecting the user with the new order in which the building is designed with. That influence
on the user was the major criteria, which guided the design in the choices of the rhythms in space. Those arrangements are to aid the perception of distance. The reception is set on more senses than the visual observation of the different distances occurring between elements like windows, doors, construction beams or rooms. The audible perception of the distance is also taken into account. To stimulate the sensorial influence of the rhythm the movement of the user in the building was carefully planned. While moving along a certain distance the user can experience the rhythm as he goes along. Trying to expose the user to such an experience will have the best result in a design of his private house. A private house is a very special place in which we would always like to feel good. The user can tolerate the discomfort in other buildings much easier. Finding comfort in the house designed with proportional arrangement of Euclid’s rhythm will be the case study. The new system can be applied in many different ways. To show the scope in which it can vary the design of a house, the design will result with two different residential buildings.
House One

The design is a 39-meter-long residential building with an atelier and a quest house nearby. Its long structure reflects the linear arrangement of functions and spaces inside. The proportion over the distance of whole structure is applied on the construction elements. The construction is built on a sequence of axes following Euclidian pattern in its one-dimensional representation (this representation will be explained later on). That pattern is going to be visible from the very first step of the building process; defying the axes on the location. This will provide a modular grid for the other elements of the building; widows, wall panels. In the finished structure, the construction will be visible from the inside to allow the user for the visual contact with the arrangement it creates. This experience in not only visual but happens through the sense of hearing and the perception of that distance while moving.
users of the same space. In small living spaces it is easier to communicate and keep in touch with each of family members. However, being crowded in a small home often means a loss of our private space and no space for possessions. This design aims at preserving the close bound in the family (parents and three to four children) typical for small homes, whereas, at the same time providing them sufficient private space and storage. The inspiration for this project comes from my parent’s second house. The reverberant main open living room of the 300 m² house brings the sound to smaller rooms, which allowed my family to communicate easily and follow what is happening inside. The round form of the case study house will combine this effect of reverberant spaces with the whispering gallery effect. The private spaces will be divided using the Euclid’s algorithm’s second representation. Two main rhythms chosen for that purpose will provide the distances between each and every wall dividing the private space in the house. Those distances will be clearly perceivable while walking around the inner atrium wall.

Whispering House
Whispering House, view from the south
The study of the Rhythm

Methodology

The theoretical standpoint described in the essay is being tested in the design of the M4 project. The characteristics of Euclid’s algorithm were further studied. Investigating the nature of this particular algorithm led me to the studies of the proportion of rhythm it creates. There are no examples available as to the use of Euclidian rhythm in architecture. The studies of music and mathematics were the fields that gave ground for the research. Music was always a great inspiration for architecture. The same role seems to be given to mathematical studies. A prominent example is, of course, the Golden Section or closely related to it; the division of an octave. It was Pythagoras, who used his mathematical background to study the division of the octave. As Padovan (1999) explains, it was only after Pythagoras’s discovery that Parthenon was built on those arrangements of an octave.

Therefore the investigation of the fields of mathematics and music is going to be reflected in the design research. It will provide ground for study of the characteristics that will make different rhythms fit each other, and rewrite them into the language of geometry. The aim is always to produce a composition of those rhythms to affect as many aspects of the building as possible: functions, openings, construction. In this chapter I will discuss those rhythm characteristics relevant to the design.

The two representations

There are many different ways of representing Euclid’s algorithm depending on the purpose it has to fulfil. To represent the rhythm that Euclid’s algorithm generates, we can use two different representations: one-dimensional and two-dimensional representations (Demaine et al, 2007). The first method happens only in one direction over a certain distance in space.
The algorithm spreads the rhythm onsets over that distance. If we simply draw the binary sequence of the algorithm on a line, the result will present a divided distance, where the ‘1’ bit is a dividing point, and the ‘0’ bit - the distance between the points. One-dimensional method has been performed in the design of The Philosophical Table, where the different sections of the table happened over the length of the structure. The second representation happens when we bend that distance and connect the beginning with the end to form a circle. This representation is referred to as Clockwise Distance Sequence or The Clock Diagram. Musicology and mathematics uses the two-dimensional representation for rhythm analysis. Connecting different points of onsets of the rhythm on the clock diagram creates an outline of a geometric figure inscribed in the circle. In ‘The Geometry of Musical Rhythm’ Toussaint uses those geometric figures to describe different rhythm characteristics (2013).
Interest in uneven

Euclid’s algorithm is designed to produce an even ‘beat’ for any combination of numbers. Let us consider the following example; Euclid’s algorithm, if asked to spread 4 onsets over the space of 8 would yield this rhythm: [1 0 1 0 1 0 1 0]. This kind of perfect beat, as being so obvious doesn’t even require a calculation. Most theorist and musicologist actually say that those isochronous sequences are not rhythms, for there is no audible pleasure in non-contrasting features. French musicologist Henri Rivière was one of those theorists, who stated that ‘A succession of sounds of equal duration, with invariable intensity and identical timbre, do not constitute a rhythmic event’ (1993). Moreover, the psychological research shows that those rhythms make us quicker tired or bored while listening to them (Toussaint, 2013). This idea of even division is also expressed in the work of John Ruskin. He explains that dividing a shape into identical parts is not an activity that will create proportion (1849). Considering this, in the example given at the beginning of this paragraph, it would be more natural to divide 8 on 3, 5, 6 or even 7 points than by using the divisors of number 8 (2 and 4).

This rhythm property can be observed in both of the designs. Considering the function and material large integers proved to be more useful. Though, to keep this characteristic still visible, the division of the distances were not performed by a number greater than 34, as greater numbers would result in almost isochronous sequences. In cases where the distance of the total length was too large, the length was divided in more than one rhythm instead (House One).
Mathematical analysis of African, Brazilian and Cuban Clave Rhythms’ (Toussaint, 2002) investigates the mathematical background of the most popular Euclidian rhythms. His investigation shows that what makes those specific rhythms interesting is the ‘tension’ and a ‘release of the tension’.

The ‘tension’ part is the part of the rhythm which is almost isochronous, and the ‘release of the tension’ is what seems like a more random pattern that follows the ‘tension’. This happens when the numbers that we choose for beats ‘1’ and pulses ‘0’ are relatively primitive number (have no common divisor larger than 1) (Demaine et al, 2007). In the case of 8 beats and pulses rhythms, the rhythms presenting that property are: E(3,8)Tresillo, E(5,8)Cinquillo, and E(7,8). More possibilities are yielded if we choose number greater than 8 for the timeline. Greater numbers proved to be more useful for dividing the distance in House One. The unit set for division in that building was short with respect to the distance of the whole structure and needed more dense division.

Constant timeline

The mathematical properties of the rhythms supply are also guidelines for musical improvisation (Demaine et al, 2007). One of them is keeping a constant ‘timeline’, which is the number of beats and pulses together. This feature has been used in the design of in the House One, where the ‘timelines’ have always 34 units: E(10,34), E(20,34), E(15,34), as well as in the Whispering House: E(8,30), E(6,30), E(13,30). For House One keeping to the constant timeline meant for geometry keeping the same length of certain distance. We can observe there the results of just changing the divisor on the same length.
**Location**

**Area**

Urkhoven, is the location of both of the designs of the residential buildings. Urkhoven is a suburban district of Eindhoven in the South-East of the city. The choice of this location was followed by the desire to discard of dense urban context, which would impose its proportion onto the plot and design. Urkhoven with its landscape and agricultural development seemed a suitable area. Despite lying close to the city its landscapes seems unaffected, due to the boarder of the railway truck Eindhoven-Weert on the west. To the South the Eindhoven Kanaal makes another border buffer from Geldrop. East side is framed by the wild meadows and Kleine Dommel. The North side the straight line of the Collseweg road encloses the area. Despite the fact that the fields over the road still belong to the district, the road makes a cut that divides the part of Urkhoven open to visitors.

**Landscape and building typology**

The area framed by those boarders developed its different building typology and landscape. The fields of Tongelresche Akkers separated by the railroad have much more sandy and dry ground. The development plan starting in the Tongelresche Akkers allocates there 900 new dwellings. The new district will reach till the banks of the railroad. This will make the landscape and building typology of the Urkhovense Akkers even more distinct than nowadays. On the Urkhoven area itself, are only a few row-house dwellings. Except those, the building typology shifts to old agricultural buildings. There are three old farms in the area. The farms Coll and Urkhoven date to the Middle ages. The Urkhoven farm lays in the middle of the field landscape on the crossroads. It constitutes of several buildings spread on the areas on different sides of the road. Some of the buildings are the Brabant langgevelboerderijen (long-facade-farm-buildings) for 1800-1930 (Doolstraat 2 and 7). On
the Oud Doornakker farm there are two more of these types (Urkhoverseweg 71 and Oude Doornakkersweg 1).

History

The existence of those farms is closely related with the agricultural history of the area. In the 19 century the agriculture became more intensive. The land was divided on smaller plots and used as pastures, due to the low fertilization of the land. The intensive land use reached its peak in the second half of the 20th century, the farm plots became bigger and the ground even less fertile. To prevent from further degradation and to stimulate the growth of fauna that was growing on the terrain in 1997 Urkhovense Zeggen were given a protective status issued by the Government and Province.

Nowadays

In 2006 as a part of the green project Randzone Urkhoven hedges and trees were planted. About 3km of pathways were arranged. There exist some wild pathways that lead through fenced areas. One of them is made as a reminiscent of old field-roads: Thomas van Roijpad. The pathway leads between the farms into the fenced pasture area. Those paths, together with bicycle paths and sand roads in the area form a peculiar network of routes leading around each and every of the 8 artificial ponds also made as a part of Randzone Urkhoven project. By each of the ponds stands a bench, form which visitors can enjoy the long view over the landscape, which is reflected in the shallow waters of the ponds.
A sketch of a painting
by Vincent van Gogh
‘Collse Watermolen’

A sketch of
Stourhead gardens
One of the greatest attractions for visitors to the area is the Collse Watermills. The buildings date back from before 1335 and were made famous by the painting of Vincent van Gogh (private collection, USA). Judging the beauty of the painting, some visitors decide to visit it mainly from the reason of seeing the building from the picture in reality, set in its landscape. They can stand in the same place from which Van Gogh painted the building. That place was not chosen randomly. It was chosen by the artist to convey the character and charm of the windmills in their surrounding in the best way possible. By reversing the process of painting: arriving at the shape and size of the building to fit the landscape from a certain point of view, we can benefit the design of architecture in the nature. The design of both of the residential buildings will get its inspiration by first thinking about a picturesque view of the buildings in the surrounding landscape and then making them, just as it was done in Stourhead (Wiltshire, United Kingdom).

Stourhead garden was designed by its owner Henry Hoare II. The garden that was bought by his father was redesigned having its inspiration in the paintings by Claude Lorrain and Gaspard Dughet. On the order of Henry Hoare a vast artificial lake was dug. Hoare planned a pathway around that lake with viewing points. From those points the landscape was supposed to look as if projected from a painting, and its design was given an utmost attention. Trees and small scale architecture was planned in such a way as to create a pictorial composition. The result of the design made the place famous and frequently visited by artists, who would paint those picturesque views of the garden.

Characteristics

The analysis of Stourhead Garden and Clause Lorren's paintings helped me define the criteria of the picturesque view, and use it in my design of the view in Urkhoven. A great
A sketch of a painting
‘Landscape with Aeneas at Delos’

A sketch of ‘Vieux Fort d’Italie’
importance given to landscape painting started during the 17th century. The landscape has become the theme of the paintings on its own, less connected with religious or mythological scenes. The word landscape itself originated at that time from the Dutch word ‘landschap’. It were Dutch paintings and the landscape, together with Italian landscapes, that were the most prominent and well-known in Europe at that time. The manner in which those paintings represented the nature is quite unique. The foreground, middleground and background are clearly distinguished from each other and aim to create the sense of depth in the picture. It gives the viewer the opportunity to enjoy long distance view and shows the vastness of the space painted. Another important feature was creating balance in the proportions of the painted elements. If a high building was painted on the right side of the picture on the left side of the picture the artist painted an object of an equal height to match the scale of the other building. A perfect example is Lorrein’s ‘Embarkation of the Queen of Scheba’, (1648). The balance is also visible between various features of nature: plain surfaces of fields, trees or small architecture. Each painter tries to use a wide variety of those elements to portray the ‘richness’ of landscape. Balancing the horizontal and vertical accents was not left to the matter of coincidence. Sea landscape was particularly difficult in that aspect. The monotonous plain surface of water framed by the distant line of horizon needed such elements like high lighthouse towers or harbour walls to break the monotony. This is exactly what Lorrein used in the ‘Landscape with Aeneas at Delos’. One can spot it even easier on the ‘Seascape’ or painted by Varnet. The artist places there ships with their wooden pointy masts and yards to make a contrast with flat, plain surface of the sea.

In practice

Water was an essential factor in 17th century landscape. Its absence made garden designs arrive at a decision of a huge investment to make artificial lakes, as was the case in Stourhead
A sketch of House One, view from the bench

A sketch of Whispering House, view from the bench
Garden. In Urkoven the artificial ponds lay on the route of the pathways laid in the area. The unique views from which the landscape was to compose into a picturesque view seem to already have been chosen. Each of the ponds has a bench next to it, overlooking the water. For the design of two residential buildings two ponds were chosen. One lays close to a sand road Zeggenweg. The other lays to the North, more visible from the Collseweg. The design of both of the houses will be composed into the view from the bench nearby. Features learned from the analysis of the 17th century paintings will aid in that process. Those aspects dominated the strongest the design decisions like: the placement of both of the houses with respect to the pond, the shape and size of the volume. The criteria of the picturesque view were not the major tool for the design, nevertheless they acted merely as guidance for other design decision. Each change in the design was confronted with the result it rendered for the view from that particular bench.
View from Zeggenweg
on the plot of
House One
view from the bench on the plot of House One
Program and location

The house design is made for a painter, who would like to work in his atelier next to his house. The beauty of landscape visible right out of the window of his private workshop is a prefect peaceful and inspiring scenery for its location. Most of the character and charm of that landscape happens when one strays off the main network of roads into the field paths, which are quite often leading through fenced areas. What seems to be a private gated land is actually a part of the pathway network. This feature of private pastures opening for public is reflected onto the design of the House One that, additionally to living and working spaces, hosts a small exhibition space. That space can be opened to public whenever the inhabitants decide. The house in this respect will become a part of the sightseeing experience of the area. The exhibition place, visible from the outside, will be drawing attention of passers-by. The location of the plot for the house will add to that interest: the house can be reached from many directions, as it stands on the crossroad of field pathway and Zeggenweg, and from the distance it is well visible form Urkhovenseweg, which is the main road through the area. The house will stand out with its design as a new building placed in the close proximity of two old farms. Its architecture and finishing differs from the existing brick façades. The house can be compared to Ton Smits house, which was a reference for the program and location of the House One. Ton Smits house stands on the verge of Gennep Park (Eindhoven) and is nowadays turned into a museum devoted to Smits works and life. Designed by Fons Vermeulen in 1956, that house with an atelier strikes with its uniqueness and a distinct look from the neighbouring buildings.

House One is designed with a capability to transform into a ‘living gallery’. Although the permanent exhibition space takes only 68 m², for the temporary exposition the whole house can be turned into a exhibition space. The interior design recalls a gallery when one focuses the attention on walls only high enough to make the division between different spaces, but not to enclose each room. Those walls are detached from the outer wall in such a way to create a convenient hallway around them. They are also used as a background for hanging
paintings. The living part of the interior is concentrated around the concrete and wooden cubes. The sleeping room, bathroom and walk-in closet are placed inside the last wooden cubical. Additional storage places for the atelier were placed in the building nearby together with the guest rooms. Each of the different function of the building nearby has its own entrance. The two quest rooms are also separated from each other and have their own entrances. In that way one of the rooms can be used by close family or relatives while the other, can be rented to the visitors to the area.

The historical reference

Dividing the buildings into two separate volumes related better to the layout of the old existing farms in the area. Analysing the setting of the buildings of those neighbouring farms influenced the decision to place the two designs parallel to each other and parallel to the road, exposing the long facade from the side of the street. The historical background for the form and material of Brabant farm houses was not the main goal of the study and was treated merely as an inspiration. Both buildings relate with their volume and footprint to the traditional farm houses, but the construction and materialization are given a new approach.
House One, view from the bench
Proportion in distance

One-dimensional representation

The main idea behind the form of the house was to create a unique experience of the distance using a new proportional tool. The house has been created from series of rhythms in 3 directions; height, width and length of the structure. The main focus of the design though is the sequence of rhythms over the length of the house, which is also the main direction of the movement which happens inside the house. On each of the directions the one-dimensional representation of Euclid’s rhythms is projected. The width of the house is divided into 3 rhythms, the length of the house into 7 rhythms. The onsets of those rhythms on the length of the house (‘1’) are the starting points for series of construction axes perpendicular to the main direction. Applying the rhythm on the construction axis means that the very first step of the building process is to define the position of those lines. Those axis lines will provide a grid for all the other elements of the building: construction walls and beams, windows and doors. Some of the thicknesses of construction elements will differ from the others. The thickness of wooden beams is 80 mm whereas the thickness of the concrete wall is 240 mm. When both of them are set on the same construction axis and their edges cannot be aligned. The question of commensurability of different wall thicknesses has been risen in Jan Turnovsky’s ‘Die Poetik eines Mauervorsprungs’. Turnovsky describes different attitudes towards placing such elements like windows: in the middle of either outer or inner wall, depending on the importance of either interior or exterior design. In the design of House One tries to avoid the incommensurability of two different materials. The wooden construction is therefore offset from the inner concrete walls. The vertical spacing of the concrete structure allows the user to pass closely by the outer wall experiencing the division better on the long surface of a 39-meter-wall. The concrete structure is spaced from the outer skin also on the vertical plane displaying the rhythm of the construction happening in the next room.
A walk around

Each of the individual rhythms inside combines into a composition. It can be admired right after entering the house. The main entrance is placed on the southern façade and is visible from the street and field pathway passing next to the house. After entering the house the visitor can see a slight glimpse of the exhibition and the concrete cubes dividing the spaces of exhibition and workshop. Entering right in the middle of those two functions gives us a choice to head to the exhibition or directly to the working space. The workshop is spaced on the E(9,33) pattern. The unit for the division is 240mm, which means that the length of the workshop is 7920mm (33x240mm) and has 9 structural beams. The concrete cube stands on the boarder of the workshop and exhibition space, providing storage from the workshop’s side, a cloakroom and a toilet from the exhibition side. The rhythm of the exhibition space is E(8,30) and the construction of the roof in that space slopes towards the inner wall. The sloping roof reaches a horizontal beam that makes a division between the atelier space and the private home. For walking further into the house one can choose the hallway close to the northern facade. This hallway is less visible from the outside and leads to the bedroom. Whereas, choosing for the hallway next to the façade on the South side, which is more exposed for the public, will lead to the storage space. Right after the living room is a kitchen space with a wooden staircase made from the same wood as the structural beams. It leads to the top of the concrete and wooden cubes. The office space on the first floor has a great overview onto the rest of the house and its construction. It is also possible to look down on the hallways leading to storage and master bedroom on two side of the wooden office cube. Choosing to go through the north hallway we have to our right a concrete wall, which is the back wall of the storage space. Having to walk between a concrete and a wooden wall for 3 meters creates a privacy buffer before we enter the most private area—the bedroom. However, if you follow the southern façade right after the
kitchen space you find yourselves next to a second entrance door. It is only in use for the inhabitants, to care for the convenience of a shorter route to storage and utility rooms. The entrance is also the shortest connection with the kitchen and storage space from the garage. Opposite the entrance in the concrete cavity is a cloakroom, ending with the door
to the utility room, behind the toilet. The next space is arranged as a storage area with its long closet at the back of the wooden structure. The long hallway seems to end with a dead-end, but actually after turning right, we move alongside the short eastern façade through a walk-in closet. We can continue our walk then alongside North part and all the way around the interior of the house.
House One, living room
House One, kitchen
House One, view from the office
House One,
bedroom
Construction

The construction of the inner and outer walls is strongly separated by a use of a different materials and the spacing provided by the hallway. The wooden beams of the construction of the outer skin are set in the first step of the building process, right after casting the foundations. The construction is a sequence of trusses that are created by the section cuts of the whole form of the building. Each of the trusses comprises of vertical studs and beams for the roof structure. The joints of those beams always connect 3 members together: one vertical beam is connected with two wooden members under the angle of the roof slope, the two members connect further with a horizontal beam. This way of connecting the beams splits and doubles the rhythm of the structure. The vertical stability of such a set of beams is carried by the plywood boards mounted between each of the sets. Therefore the distance between the axis of two neighbouring trusses is not greater than the standard width of a plywood panel – 1200mm. The short distances are often grouped together into 480mm and 720mm, so that both of those distances can be covered by one plywood panel of 1200mm. To ensure the stability of the construction and resistance to horizontal wind forces, the beginning and ending beam sets are strengthened by wooden studs and plywood panels. Additionally, on the axis dividing the living and atelier functions the beams are doubled and the joint connection is changed, to stronger, Finger Joint connection. This allows the 39-meter-long-structure to withstand the horizontal wind forces.

Materialization – the outside skin

The plywood panels mounted for stability of the beams are also the finishing layer of the walls and ceiling of the interior. The rest of the layers of the wall is added on the outer side of the plywood panels. Though the finishing of the roof and walls is looking the same, the layers of the skin of the building are different on the façade from the layers on the roof. The insulation of the roof is doubled, and a bituminous layer on plywood panels provides
waterproofing. The façade needs less insulation and the cavity together with the weathering membrane allows the layers of the façade for better ventilation.

The outer skin of the building serves as space through which electricity cables can be distributed. Ventilation shafts for the mechanical ventilation system with heat recovery unit are also placed in the outer walls and ceiling. In that way the ventilation system is spread all over the building. This type of ventilation in comparison to gravitational ventilation does not need vertical pipes in the interior, which is to the advantage of this particular design. The inner walls are detached from the roof and no other vertical connections are in view. The ventilation system is connected to the heat recovery unit that is placed in the utility room. The supply of fresh air and the exhaust shafts are mounted in the roof.

Materialization – the inside

The interior walls are made from in situ cast concrete. In the concrete walls and floor is led all the necessary plumbing. The plumbing system is concentrated around concrete cubes, which are the toilets, bathrooms and utility spaces. The heating system is set in the floor all over the house.
House One, wooden structure

House One, inner walls

House One, wooden construction with inner walls
House One, doubled middle truss, with finger joint connection
House One, construction of the second floor
WHISPERING HOUSE
Design goals

The house is located on the plot next to Collseweg and a bicycle pathway (the extension of Schuurstraat). The field with the pond, where the house stands is surrounded from the other two sides, with green fields and pastures. Such an open location was suitable for the large program for this residential building. The house is designed for a family with 3 younger children. The design of house considers the positive and negative effects of living in a large house with big private and common spaces. While living in an apartment or small housing the inhabitants meet much more often due to the small common and private spaces than in the larger houses. Keeping in touch is much easier. However, if the house is becoming too small one can have a feeling of loss of his private space. The design of this house aims to give each inhabitant their large private space and at the same time maintain the connection with other inhabitants. That contact is ensured by the open layout of the floor plan of the building and its audible characteristics.

One of the case studies was taken from my personal experience while living at my parents’ second house. It is a double storey house of around 300 m². While building the house in every room was laid a phone line. Every room had its own telephone, to ensure quicker contact with each of my family members. That phone installation has become unnecessary once my family moves in. The acoustical qualities and the long reverberation time of the main space brought the sound all over the house. With open doors to each room it is possible to hear other family members talk in the room one floor below. Hearing a person’s voice and walk made you prepared for the visitor that is soon going to enter your room or knock on the door. This audible quality of the space is used in of the Whispering House.
Whispering House, view from the bench
Whispering House
Landscape

Designing Whispering House was a process that considered the importance of the landscape it was set in. The volume of the house and its placement on the plot was chosen on the basis of the point of view of a visitor to the area; the bench. On the left side of the view from the bench one can see a vast area of open field, which is in a strong contrast to the high trees on the left side of the pond. The building is therefore set really close to the pond. This breaks the monotony of the large grass field, and gives the impression of the gradient in height between tall trees and a grass field.

The house is not only to be observed from the outside, but gives the user a 360 degrees view on the landscape. Those views are “framed” by the windows with thick golden anodised aluminium profiles. The windows are very wide in areas in common areas like living room or kitchen space, and smaller in the sleeping rooms. Each window overlooks the natural landscape. Therefore, the character of flora on the building plot is kept in the same state. To preserve the natural look of that area no new types of trees or plants are planted. The plot of the house is not faced to keep the area open for visitors and keep the view out of the windows undistracted. The lack of private outdoor space is compensated by the inner courtyard of 615 m².
Whispering Gallery effect, and the field of view in the circular space.
Proportion in distance

The design of the Whispering House is a case study on the use of a new proportional system—Euclid’s algorithm. That new system was applied in such a way as to affect the proportion between the visual and the audible characteristic of the space. Altering those features of the space will result in different perception of the distances in the house to which the user might not yet be accustomed to.

Being able to see the space and judge the distance is not only a matter visual ability, but happens on the audible level as well. The audible qualities of a space add to our perception of the size of the interior we are in. Even with our eyes closed, one will be able to make a difference between a small cosy bedroom and the interior of a cathedral. The design uses this sense of perception. The long reverberation time would make the house seem larger than it actually is. The voices of inhabitants would be clearly heard, while visual contact with them is going to be limited by the round shape of the house. We might hear other people talking but to see them we would need to walk around the hallway till they appear our field of view.

Soundscape

To reach the longer reverberation time and to allow the sound to travel through interior spaces the design has been specially adjusted. The ceiling is higher (from 2.8 till 3.5 meters) and the finishing of the walls reflects the sound. There are no doors to the rooms, instead curtains are used. Private rooms are open to the circular hallway, which leads around the patio and through all the rooms. The idea to use curtains as a flexible mean to separate or connect the private bedrooms to the walkway was inspired by Jean Englebert’s private house (1959). The architects used there curtains to connect 3 bedrooms with the 2-meter-broad hallway. When the living room was too small to host the number of quest invited, the
Whispering gallery,
St Paul's cathedral,
London
curtains were open and the hallway with the bedrooms acted as a large open space with a dining table on the walkway. In the interview with Jan Schevers, the architect was describing the open hallway and bedrooms as a perfect setting to watch his children play, while he was sitting and working in the office room at the end of the hallway. This idea of using hallway space as an extension of living room was used in design of the Whispering.

Whispering gallery

A unique sound aspect is possible thanks to the round shape of the building. The round outer wall produces a Whispering Gallery effect. There are many examples of such audible properties of spaces like: New York’s Grand Central Station, St Peter’s Basilica in Rome. One of the most stunning and well known Whispering Galleries is the gallery in St. Paul’s Cathedral (London). The gallery underneath the main dome is a circular space of 42 meters in diameter. Facing the wall of the gallery, it is possible to hear a person whisper on the other side. In the same way the wound outer wall of the house is going to reflect the sound. To make the effect possible all the inner walls are detached from the outer wall, which enables the sound to travel further. In cases of bathrooms or spaces that needed to stay closed from 4 sides, their circular outer wall is doubled.
Division of the 10 functions on E(10,34)
Two-dimensional representation

The proportional arrangement divided the common spaces and private rooms for each of the inhabitants of the house. For that purpose two rhythms were chosen, and set on a two-dimensional representation of Euclid's algorithm. The two-dimensional representation is used for dividing the round shape onto specific distances. Those distances are actually edges of a geometrical figure inscribed in the circle. The main rhythm $E(10,34)$ divides the shape into 10 different spaces. Euclid $(20,34)$ is introduced to subdivide those spaces into smaller areas for additional functions like: storage, bathrooms, utility room. The rhythm is also visible in the arrangement of windows which switches from $E(20,34)$ in the private spaces to $E(10,34)$ in spaces like living room, creating a long glazed wall.
Division of the $E(20,34)$
Adjustments of the wall structure done after the application of the rhythms:
Whispering House, views on the courtyard and landscape
Whispering House, hallway and kitchen
Whispering House, the detached wall
Whispering house,
roof construction
Construction

The wall and floor of the house is made from in situ cast concrete. One of the reasons for the choice of the material is the ability to store heat. Standing in an open area, the house is exposed to sun from the early morning till late afternoon. The thermal mass of concrete will diminish the temperature differences of different parts of the house, and the difference between day and night. The outer circular wall, which is more exposed to the sun, is thicker and higher. The circular wall around the patio is lowered to prevent self-shading of the courtyard garden.

The method used for casting the concrete will allow the inner and the outer layer of the wall to be made at the same time. Using the insulation nailed through inner rods of the shuttering will keep the insulation in place while pouring concrete. After removing the shuttering the rods are removed as well and the holes are filled till half of the depth of the with insulation material to prevent heat bridges. The 120 mm insulation placed between the layers of 220 and 180mm thick concrete needed a connection with the window frame. The glass pane, for the acoustical reasons, was aligned with the inner surface of the wall. The thick golden anodized aluminium profile bridges the gap between the insulation in the middle of the concrete wall and the profile of the window aligned with the inner wall surface.
Whispering House
REFLECTION
Though both of the residential buildings were designed using the same algorithm for proportion, each of them demonstrates is a different way. Each design considers the perception of that proportion differently as well. House One was a study of the grid generated using Euclid’s rhythms. It combines the measurements: 480, 720, 960 and 1200 mm, into a unique modular grid. This grid is visually less rigid than most of the modular systems used for building construction. It yields more possibilities of different combinations. Euclid’s algorithm in this case was a tool was used for composing different modular elements into a pattern alike a musical beat. Its calculation method serves as guidelines to alter those patterns. Euclid’s algorithm can be used on many other designs to generate the construction grids.

While House One is focuses on a construction process, Whispering House considers the perception of the distance through different senses. Through the visual sense it is the division of the house on different rooms. The perception of distance in the house is not only visual but strongly audible. The house enlarges the distance in space by the reverberant main space or shortens it by the effect of Whispering Gallery. This all affects the feeling of a private zone of each inhabitant. That feeling lets us judge if the space is either too big or too small for a certain number of inhabitants.
TECHNICAL DRAWINGS
Section A-A
sliding window, double glazing
4mm float + 16 mm + 4 mm thermofloat
cavity for the sliding window

B - B

22 mm wooden planks, second layer plywood
22 mm rafters for planks
40 mm weather membrane
60 mm cavity
40 mm insulation on rafters
100 mm insulation on rafters
18 mm vapour barrier
22 mm plywood

wooden planks
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 mm</td>
<td>wooden planks</td>
</tr>
<tr>
<td>18 mm</td>
<td>bituminous sealing layer</td>
</tr>
<tr>
<td>18 mm</td>
<td>plywood</td>
</tr>
<tr>
<td>100 mm</td>
<td>insulation on rafters</td>
</tr>
<tr>
<td>100 mm</td>
<td>insulation on rafters</td>
</tr>
<tr>
<td>18 mm</td>
<td>vapour barrier</td>
</tr>
<tr>
<td>18 mm</td>
<td>plywood</td>
</tr>
<tr>
<td>22 mm</td>
<td>wooden planks</td>
</tr>
<tr>
<td>180x80 mm</td>
<td>construction beam</td>
</tr>
</tbody>
</table>

Details,
1:10
Whispering House,
Floor plan
double glazing:
4 mm float + 16 argon
+ 4 mm thermofloat

2 mm aluminium sheet,
golden anodized, bent
to shape

160 mm  in situ concrete
120 mm  insulation
200 mm  in situ concrete
BIBLIOGRAPHY


Ton Smits huis, from http://www.tonsmitshuis.nl/, 16.08.2013

IVN afdeling Eindhoven,(2005). Urkhoovense Akkers