Appendix 1 to
Guidelines for Preparation, Defence and Storage of Final Projects

KAUNAS UNIVERSITY OF TECHNOLOGY

CIVIL ENGINEERING AND ARCHITECTURE FACULTY

Emin Vahid

CONTEMPORARY TRENDS OF ARCHITECTURAL GEOMETRY. HELIX AND ITS IMPLEMENTATION IN ARCHITECTURE.

Master’s Degree Final Project

Supervisor

Lect. Arch. Vytautas Baltus

KAUNAS, 2017

KAUNAS UNIVERSITY OF TECHNOLOGY

CIVIL ENGINEERING AND ARCHITECTURE FACULTY

TITLE OF FINAL PROJECT

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Appendix 4 to
Guidelines for Preparation, Defence and Storage of
Final Projects

KAUNAS UNIVERSITY OF TECHNOLOGY

Civil Engineering and Architecture

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Master degree Architecture 6211PX026

(Title and code of study programme)

"Contemporary trends of architectural geometry. Helix and its implementation in architecture"

DECLARATION OF ACADEMIC INTEGRITY

22 05 2017

Kaunas

I confirm that the final project of mine, **Emin Vahid**, on the subject “Contemporary trends of architectural geometry. Helix and its implementation in architecture.” is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarized from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this thesis.

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Baigiamųjų projektų rengimo,

gynimo ir saugojimo tvarkos aprašo

5 priedas

Emin Vahid. Baigiamojo projekto pavadinimas: Šiuolaikinės architektūros geometrijos tendencijos. Spiralės forma ir jos pritaikymas architektūroje. *Magistro* baigiamasis projektas / vadovas Lekt. Arch. Vytautas Baltus; Kauno technologijos universitetas, Statybos ir architektūros fakultetas.

Mokslo kryptis ir sritis: Architektūra, Parametrine architektūra

Reikšminiai žodžiai: Parametrine architektūra, Generatyvinis dizainas, Geometrinė-Matematinė analizė laisvos formos tyrimuose, Spiralė, DNR struktūra

Kaunas, 2017. 105 p.

SANTRAUKA

Projektas analizė geometrinė pusė rezoliuciją per DNR struktūras, siekiant ištirti ją modeliuoti savo formą, kuri parametrų verčių, atitinkanti šiuolaikinių tendencijų architektūros projektavimas.

Projektas parengtas esminis pagrindas metodais parametrinio ir generatyvinių projektavimas. Pagrindinis rūpestis ir srautas Šiame darbe, yra analizė taikant matematinius-geometrinis lygtis ir teorijas, kurie iš jų padeda parengti ir tiksliai suprojektuoti DNR struktūros formą reguliuoti į modernią bokšto struktūrą.

Be šio susirūpinimą, yra dar vienas ketinimas už projektinių sprendinių eksperimentinis projektas. Jie analizė žaliosios energijos. Kiekvienas dizaino sprendimas yra skirtas generuoti vieną konkretų natūralus energijos šaltinis. Tačiau šie žalieji energetikos bruožai bokštai, taip pat glaudžiai susijęs su geometrinių parametrų kiekvieno dizaino sprendimas. Taigi, vienu žodžiu, viskas, projektas yra daroma matematinėmis-geometrinis teorinių lygtis ir parametrinių architektūros taisykles.

Šio darbo rezultatas yra atskleidė ne eksperimentinį etapą, kur buvo atliktos keturios dizaino sprendimai už tai tyrimai užduotis siekiama.

Vahid Emin. *Title of the Project*: *Contemporary trends of architectural geometry. Helix and its implementation in architecture. Master's* thesis in Architecture / supervisor Lect. Arch. Vytautas Baltus. The Faculty of Civil Engineering and Architecture, Kaunas University of Technology.

Research area and field: Architecture-Parametric and Generative-Design in Architecture

Key words: Parametric architecture, Generative design, Geometric-Mathematical analysis in freeform research, Helix, DNA structure.

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SUMMARY

Project is about geometrical side of resolution over DNA structures, in order survey it and transform into the shape which's parametric values are corresponding to contemporary trends of Architectural designing.

Project is being elaborated by methods of Parametric Architecture. Main concern and stream of this work, is about using Mathematical-Geometric equations and theories, which ones are helping to elaborate and precisely design the shape of DNA structure to adjust into modern tower structure.

Beside this concern, there is another intention for the design solutions of experimental project. They are about green energy. Each design solution is aimed to generate one specific natural energy source. However, these green energy features of towers also tightly linked to Geometric parameters of each design solution. So, by one word, all project is being done by Mathematical-Geometric theoretic equations and Parametric Architecture rules.

The result of this work is being revealed at experimental stage, where four design solutions have been conducted for this research task aims.

Abbreviations:

RP1- Research Project 1

RP2- Research Project 2

RP3- Research Project 3

SE- Solar Energy

WE- Wind Energy

PV- Photovoltaics

n.a- Sharp Solar panel module series

Fig- Figure

Content:

Introduction

Current stage of thesis is analysis to collect and summarize data from all RP series.
In order make comprehensible presentation of whole thesis, RPs sections are divided here, in content part. From each RP, have been extracted key parts for short valuable expression and explanation in this thesis.

Aim of the research

Aim of this research is explanation of investigating DNA family structures and later advancing the best suited one for further aimed parametric design solutions. Sequence of this work follows typical generative algorithms, however, there are extra other mathematical analysis which distinguishes method.
DNA’s helix is an experimental object taken into this survey in order check the reliability of method and present at least one example for this case study research.

Relevance of thesis

Research starts from RP1 and ends at RP3. At RP1 was done analysis and comparisons to find the most suited DNA structure to adjust into modern tower structures. During that elaboration, were found some mathematical formulas related to that DNA’s some significant geometric parameters. At the end, there is plotted hypothetical statement for procedure sequence of research project 1.

Systematically in RP2 (Empirical research) that hypothetical statement was taken into five major new hypothetical statements, where the best-chosen DNA structure was analyzed alone and was adjusted to different type of ecological resolutions and examined in aspects of geometrical resolutions. At the end, there is scheme responding to conceptual model for consequence of empirical research procedure.

After RP2, at RP3 (Experimental project) according those statements, have been done comparisons between four modelled design solutions. Again, the main weight of evaluation in that comparison, was given to geometrical side of resolutions. That was, because even ecological resolutions were carrying geometrical features and those features are important for evaluation premises between towers. One-word geometry, plays full role in this project’s whole concept.

“In Mathematics, topology is a relatively new way looking at the world, although as early as 1679 Gottfried Leibniz identified the need for strictly geometrical analysis to express ‘situm’ (situation, or qualitative place relationship), equivalent to the term ‘analysis situs’ was born, and remained in use until transmuting to topology in the 20th century”. (Source: The New Mathematics of Architecture book by Jane Burry and Mark Burry. Chapter Topology, Page 156.)

This project’s geometrical resolution and its main heavy evaluation at RP3 was done according chapter 4.5 of RP2, where it was dedicated and analyzed according Helicoid’s Topological nature.

1. Helix

‘‘A helix (pl: helixes or helices) is a type of smooth space curve, i.e. a curve in three-dimensional space. It has the property that the tangent line at any point makes a constant angle with a fixed line called the axis. Helices are important in biology, as the DNA molecule is formed as two intertwined helices, and many proteins have helical substructures, known as alpha helices. The word helix comes from the Greek word ἕλιξ, "twisted, and curved".’’ (1-Henry George Liddell, Robert Scott, *A Greek-English Lexicon*, on Perseus. 2004.)

“Types: Most hardware screw threads are right-handed helices. The alpha helix in biology as well as the A and B forms of DNA are also right-handed helices. The Z form of DNA is left-handed.

The pitch of a helix is the height of one complete helix turn, measured parallel to the axis of the helix.

A double helix consists of two (typically congruent) helices with the same axis, differing by a translation along the axis.

A curve is called a slant helix if its principal normal makes a constant angle with a fixed line in space. It can be constructed by applying a transformation to the moving frame of a general helix.” (2- Izumiya, S. and Takeuchi, *New special curves and developable surfaces.* N. (2004))

In mathematics, the helix is being specified like this: it is a curved line in extent form. Apparently ordinary formulas for helix is like (1.1).

$$x(t) = \cos(t)$$

$$y(t) = \sin(t) \qquad (1.1)$$

$$z(t) = t$$

For the left-handed helix formulas are different in basic parametrical sate in Cartesian. Other typical features are the under same equation forms regarding to basic Cartesian ones. That is because, there is mirror transformation relation between right and left handed helices.

Length spacing, twisting and curvature features of any helix is being computed out in same way for right and left handed helices. For particular helix like: x= r cos (t), y= r sin (t), z= kt.

$$\text{Lenght spacing: } S = \varphi \cdot \sqrt{r^2 + k^2}$$

$$\text{Curvature: } B = \frac{|r|}{r^2 + k^2} \qquad (1.2)$$

$$\text{Torsion: } T = \frac{k}{r^2 + k^2}$$

2. Attempts to apply helical twisting form in buildings through Architecture history

There were many attempts in architecture history, to build helical twisting towers. Although, the lack of construction technologies and materials advancement and beside these, the lack of geometrical decisive knowledge, didn't allow them to achieve this type of projects. Many geometrical shapes like box, cylinder, even pyramid and so on were applied in castle and building form structures while helix and such complex ones stood out of this classification. One of the attempts about implementation of helix in architecture is known by Architect Frank Lloyd Wright's work, named Guggenheim Museum was built at New York city of America.
"In June 1943, renowned architect Frank Lloyd Wright received a letter from Hilla Rebay, the art advisor to Solomon R. Guggenheim, asking him to design a new building to house Guggenheim's collection of non-objective art, a radical new art form being developed by such artists as Vasily Kandinsky, Paul Klee, and Piet Mondrian." Guggenheim's one requirement of the architect was that the building should be unlike any other museum in the world. (Fig.1)." (3- The Solomon R. Guggenheim Foundation, New York. Printed in the U.S.A. © 2003.)

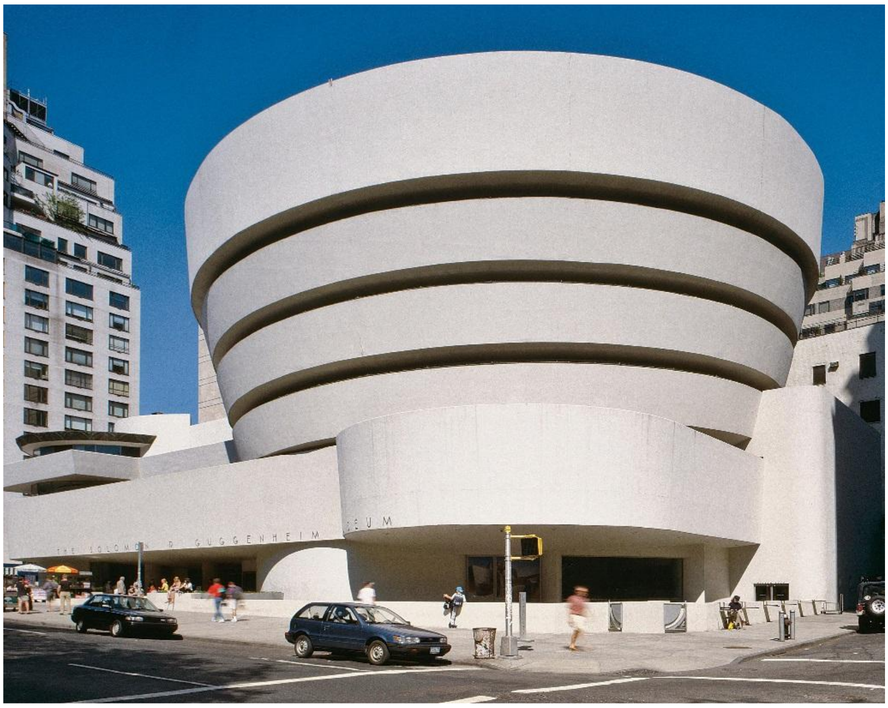


Figure.1. Guggenheim Museum. Photo from main entrance direction. (Guggenheim Architecture...2003)

Certainly the architect Frank Lloyd was not thinking to design exactly helical formed building for museum. Apparently he tried to imitated form.
"Nature not only provided the museum with a respite from New York's distractions but also lent it inspiration. The Guggenheim Museum is an embodiment of Wright's attempts to incorporate organic form into architecture." (4- "Form follows function— Frank Lloyd Wright: From Within Outward Audioguide (New York: Antenna Audio, Inc. and the Solomon R. Guggenheim Foundation, 2009).

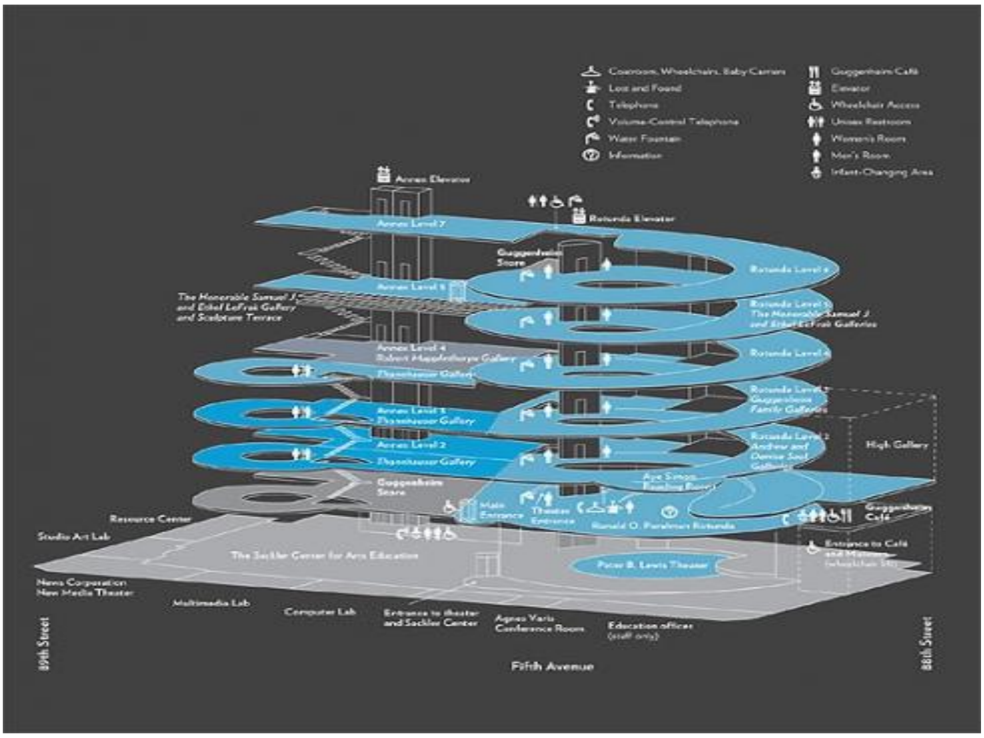


Figure.2. Solomon R. Guggenheim Museum floor plan… 2009

Terraces are tracked in harmonic routine by high rise helical way, while major volume is lost in interior space of building. According many references, that was an idea of architect Frank Lloyd as immanent design solution for Guggenheim Museum (Fig.2).

Nowadays there lately was considered and currently being executed project, “Agora tower”. This project also was inspired by human DNA structure.

“The concept of a green skyscraper is by no means new, but Vincent Callebaut's DNA-inspired design is impressive nonetheless. (Fig.3) Construction recently started in Taipei on Agora Garden, which has two sections that twist a full 90 degrees as they ascend. The resulting twenty-story building will resemble a giant double helix on completion, permeated by hanging gardens on every floor and surrounded by a small forest. The building will be topped off with an array of solar panels. It hasn't provided any energy efficiency estimates — we don't know how much power will be created by the building's solar panels. The trademark twist of the vertical garden-cum-luxury residential block was inspired by the double helix of the DNA molecule”.3 Conclusion by author: In spite of all these problems, it worth to put in reality. ” (5- Work begins on 'double helix' skyscraper in Taipei. by Aaron Souppouris Mar 22, 2013)

Figure.3. Agora Garden tower. Downside view.

The agora shape, in full scale composition reminds B-DNA form, which is added pith in middle (core part). In this research, that DNA form wasn't concerned, is because of there is no much geometrical parametric features to elaborate and develop further.

Figure.4. Canton tower. Construct view and downstairs position view.

Although the design visually beautiful and attractive, it is not much appreciable due to its geometrical side of work, as hard work or desirable idea. Why? Because, this design is quite simple and no any invention in its geometrical structure. It was done simply wrapping a slim vertical box around its weight-center vertical axis and by dividing it in different layers (floors). All floors are being rotated under constant angel. It is preferred design named "Canton tower" (build in Guangzhou, China) (Fig.4) than Agora tower. That is why, Canton tower has its some hardness in its geometrical resolution. It is about twisting same parameterized ellipses around their weight-center axis in vertical position, while one stays ground level and second one is moved vertically to 600m. They divided both of those ellipses in same amount of division parts and joined corresponded points to each other. They achieve linear surface for that tower. The most controversial part of that project is its waist part dimensions. That is because of, derived shape came out to be looked like woman body and waist part is slim as young attractive lady's waist. Even for the core sections erection through that was controversial. And that is why that is visible, the desirable precise geometrical modelling in that project than Agora tower. This feature of Canton tower was major motif for starting this project.

Description of double-curved surfaces geometric principles for design analysis intend: double-curved (bended) surfaces are in two directions bended. The special ones are linear surfaces. Example of double curved linear surfaces could be one-hole hyperboloid and hyperbolic paraboloid. Canton tower has façade frame like double-ruled exteriority. The basic difference between its façade structure and one-hole hyperboloid surface is in their trace figures, which in canton tower façade is ellipse and in one-hole hyperboloid is circle.

Thus, canton tower façade also is double-curved surface structure. Those main big diameter vertical tended pipes in canton tower structure are in twisted position manner as they resemble precise ruled surface shape in exterior (Fig.5). Same principe is being followed in our case study helical body surface under certain twisting of chord joint parts. Main difference in canton tower is its pipe lines twisting between certain ellipses while in helical body surface chord joint parts are constantly in twisted motion between circular rises. Hence, it is practicable to notice that, helical body is also double curved linear surface.

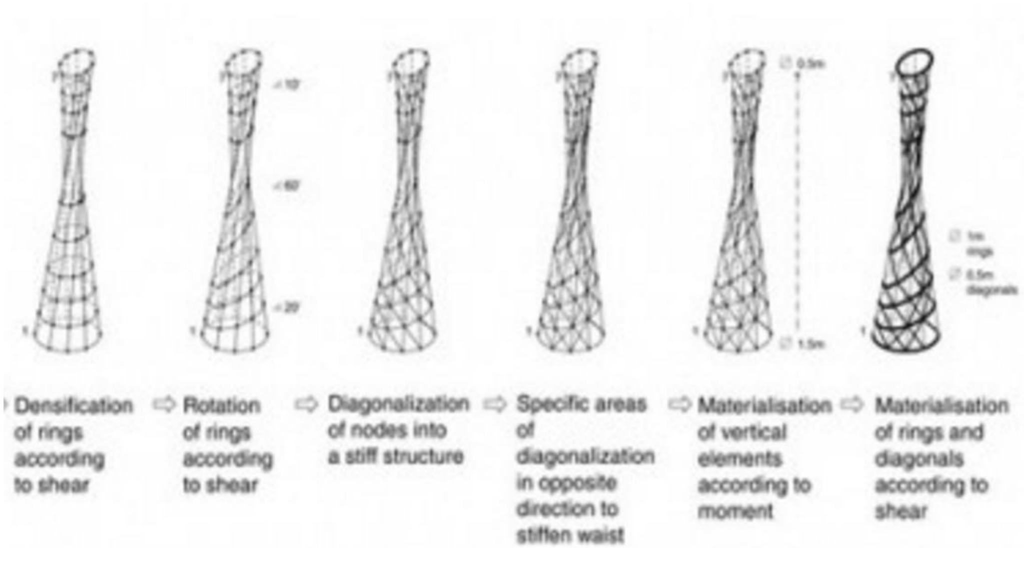


Figure.5. Metamorphosis of the Canton Tower from cylindrical to twisted lattice. ©2011 Information Based Architecture (IBA)

3. Forms of DNAs

DNA is very good example of helix line and helical shapes co-existence. DNA consisted of molecules and has helix shape in its groove's (tendril) path. There are many known DNA forms, as Agora tower design was inspired by the B-DNA form (right and left handed helices combination). Generally, there are well known four types: A-DNA, B-DNA, Z-DNA and Triple-Helical DNA. (Fig.6). It has two main parts, major and minor grooves. Each of them represents one helix, first one right-handed helix, second one left-handed helix. Each groove has same structure.

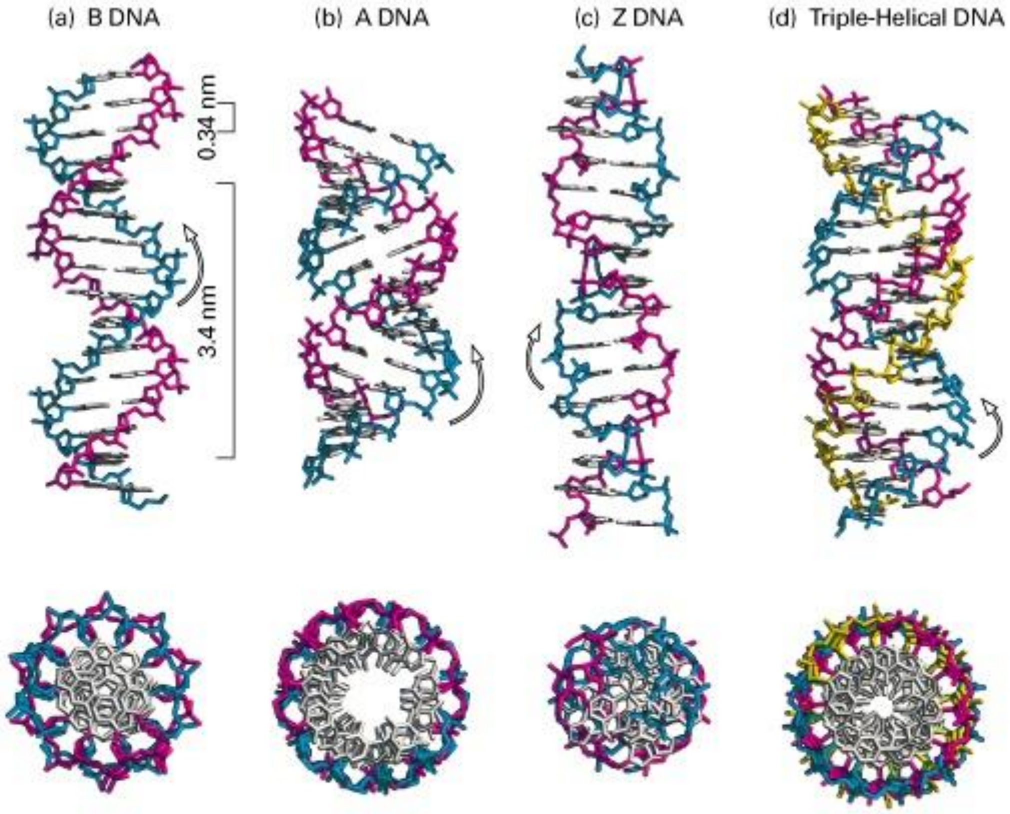


Figure.6. This is a particularly useful figure for getting an apparent idea for the structure of the double helix since both side views and views looking top down along the helical axis are shown. © 2009.

DNA derives by these grooves opposite sides combination. That is why there derives volume and core section in A and Triple-Helical DNAs (which one has been chosen as most suited one for architectural aim of designing). DNAs' shape deformability happens according their base circles' divisions and joint conditions (by geometrical side of look).

"The three-dimensional structure of DNA—the double helix—arises from the chemical and structural features of its two polynucleotide chains[1]. Because these two chains are held together by hydrogen bonding[2] between the bases on the different strands, all the bases are on the inside of the double helix, and the sugar-phosphate backbones[3] are on the outside" (6- Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al. New York: Garland Science; 2002.)

1. Polynucleotide chain- is a chain of polymer (polymer is structure consisting of big molecules derived from small molecules back to back merge). This elements are existing at inner volume of DNA. Their orientated places matching with chord joints in research helical body design case.
2. Hydrogen bonding- is electrostatic attractive force among two polar parts. It happens in microscopic level when hydrogen atoms stick to huge electronegative atoms. Exactly is because of these components appears to be core section in helical body of some DNAs.
3. Sugar-phosphate backbone- the sugar phosphate backbone is a significant constructive part of DNA. It is composed of five carbon deoxyribose sugars and phosphate bands. It is main helix line around DNA (it is named tendril in this research helical design structure).

In order to understand DNAs derivation of their base circles, it has been read and surveyed some bio-genetic literatures and found some useful illustrated materials, showing exact division and ingredient joint combinations in DNAs. (Fig.7)

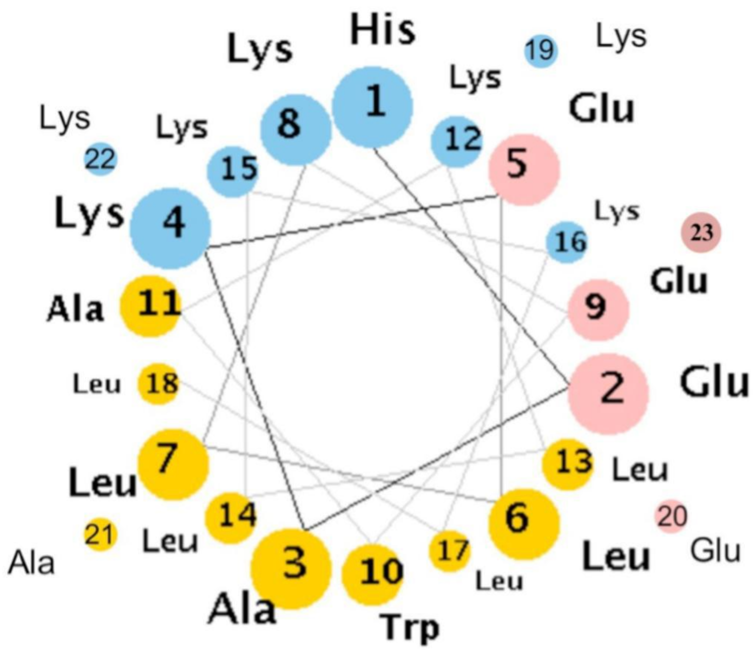


Figure.7. Helical Wheel for the model peptide system, where hydrophobic (yellow), basic (blue) and acidic (red) are highlighted. © 2009.

In these materials, are used a lot terminology words of genetics. They are expressed here in simple words for easy comprehensibility. Peptides mean molecules combined joints together in DNA, it is named in this research case study as division points' chords. In actual case, there illustrated all molecule particles are representing division points of helix's base circle. That is basic form how DNA structure is going to be imagined and understood. And according this simple rule, it is being gone to analyze and evaluate all known DNA and other helical possible structures to find which one suits to architectural aim properly.

There are many DNAs in nature, as well in Human body also in animal world and even in small biological creatures as in some viruses and microbes and so on. One of the most similar DNA structures to human DNAs, are existing in Ebola viruses. (Fig.8)

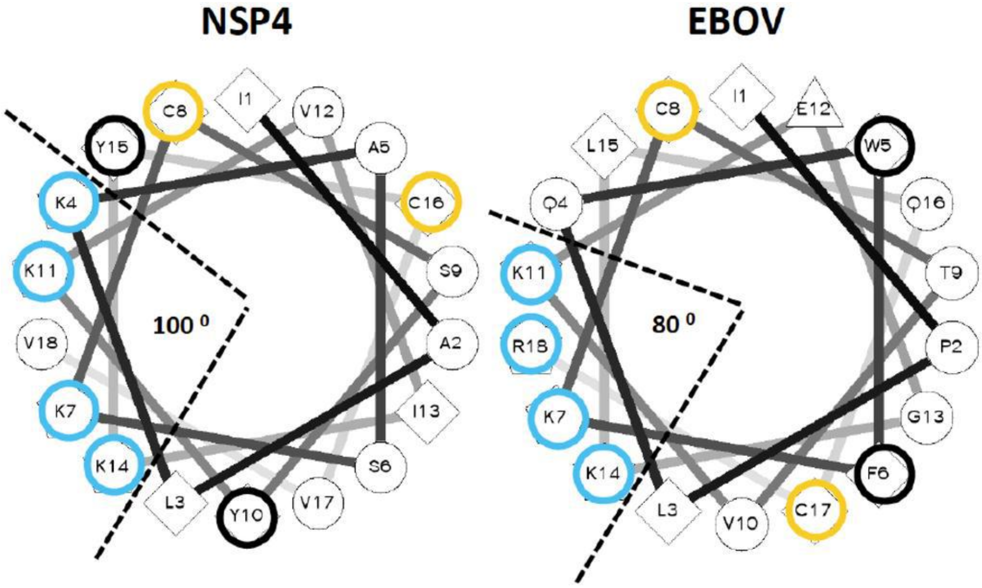


Figure.8. Helical wheel projections for the lytic peptide of NSP4 protein of Rotavirus and the carboxy-terminal half of Ebola virus delta peptide. An online utility was used to project NSP4 and carboxyl terminal amino acids of EBOV delta peptide as an alpha helix. The applet also computes the value and angular direction of hydrophobic moment of each peptide. For emphasis, lysine and arginine residues are circled in blue, cysteine residues in yellow, and aromatic residues in black. © 2015.

Wheel in this material referred to base circle of DNA. Ebola virus DNAs are very likely to Human DNAs. And there are visible conformations of their structures for precise geometric survey.
"To confirm that the carboxyl terminal[1] sequence of the EBOV delta peptide[2] can be modeled as an amphipathic[3] alpha helix displaying an array of lysine or arginine residues[4] in a 3/4/7 spacing on one aspect, and hydrophobic amino acids[5] on the opposite aspect, the EBOV delta peptide was visualized as a helical wheel projection." (7- Modeling of the Ebola Virus Delta Peptide Reveals a Potential Lytic Sequence Motif. W. R. Gallaher 1,2, * and Robert F. Garry. 2015.)

1. Carboxyl terminal- is a molecular chain of proteins in retro-viruses DNAs as polynucleotide in human DNA.
2. Delta peptide- is a same peptide chain as in human DNA. They are referred as chords in base circle.
3. Amphipathic- is protein molecule which owns hydrophobic and hydrophilic components. In this design case, they resemble division points around base circle (in biochemistry it is entirely different array position of amino acids around projective wheel of DNA, however, in this case study that is not important to concern as effective issue).
4. Lysine or arginine residues- these are protein residues around DNA helical wheel. In this design solution, all of them were not marked as division points in base circle, because some of them belong to minor groove helix (that helix presumably would go along waist part of helical design body, as it would be half pitch higher than main tendril helix). Here the concern is in major groove's amino acid residues which compose around sugar-phosphate backbone (tendril line in helical design).

5. Hydrophobic amino acids- it is molecular chain joint, which is out of normal acids array sequence in DNA wheel, because of each third or fourth residue components' absence. There is relative survey at second chapter of RP2, to such abnormal derivation of helical forms.

Major groove's amino acids are joining to opposite helix's amino acids under 100 degrees, thus alpha DNA is being made up. EBOV delta peptide distinguishes from alpha DNA NSP4 by the non-existence of V18 hydrophobic between amino acids. And that is why that helicoid derives under 80 degrees from amino acids correlatively joints. In this project, there are in RP2 at section 3.2 it was examined and determined by complex figures implementation in division points joint, as which condition is the best for derivation of proper helicoid for further deign purpose.

4. Analysis over Helices Geometrical structures

First, it should be expressed, the helix shape has been found in nature before it was found in bimolecular-genetics scientific research field in DNA at 20th century (Fig.9). And later, from 18th century there were many helical surfaces analysis and discussions by historical Geometrics and Mathematics. However, despite these considerations there were no Mathematical equations for all the helix surfaces. As far as known and only taken in strict consideration in geometry, is minimal helicoid surface (about which one I wrote in RP2 and RP3 and regarding its some topological nature parametric equations).
Some writers wrote articles about helix surfaces, while there are no exact Mathematical equations for all of them and. They were handled as for illustration aim and short description of their technical projections.

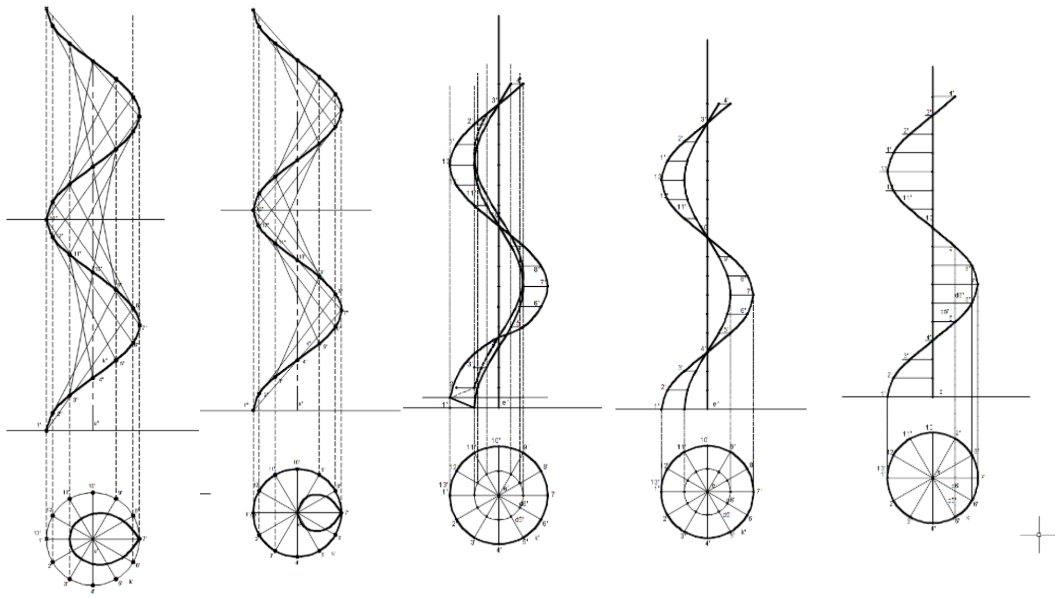


Figure.9. Helices in various forms of generations.

These surfaces were known to Architecture and Geometry for more than a century. In mechanical engineering and in civil engineering they were used profoundly. However, in architecture just some of them were used just for staircases. There was never concern or idea about advancing and implementing in architectural building, tower or etc. designing of those helices surfaces. Main

reason of that was the lack of knowledge in mathematics of architects, and those surfaces are not completely analyzed and described for architects to be ready for easily usage in architectural designing. Now here in this research project, some of those surfaces in human and Ebola virus DNA strands were drawn, analyzed for making sure about their parametric equations of needed features in order to make certain which of them and how much that helical surface is eligible to be implemented through parametrical designing in architectural requirements. So far it is RP1's task. Above at DNA forms chapter it was explained that DNA structures are consisted of hydrophobic and amino acid residues. Basically, those molecular elements are combining to each other under the same conditional state. Those joints are called peptides and they are being referred in circle as chord lines. There are 20 hydrophobic amino acid residues in different molecular states.
There is no term like "core" of helices. That was noticed in DNA forms due to above mention hydrogen bonding sequence order in alpha and triple DNAs.

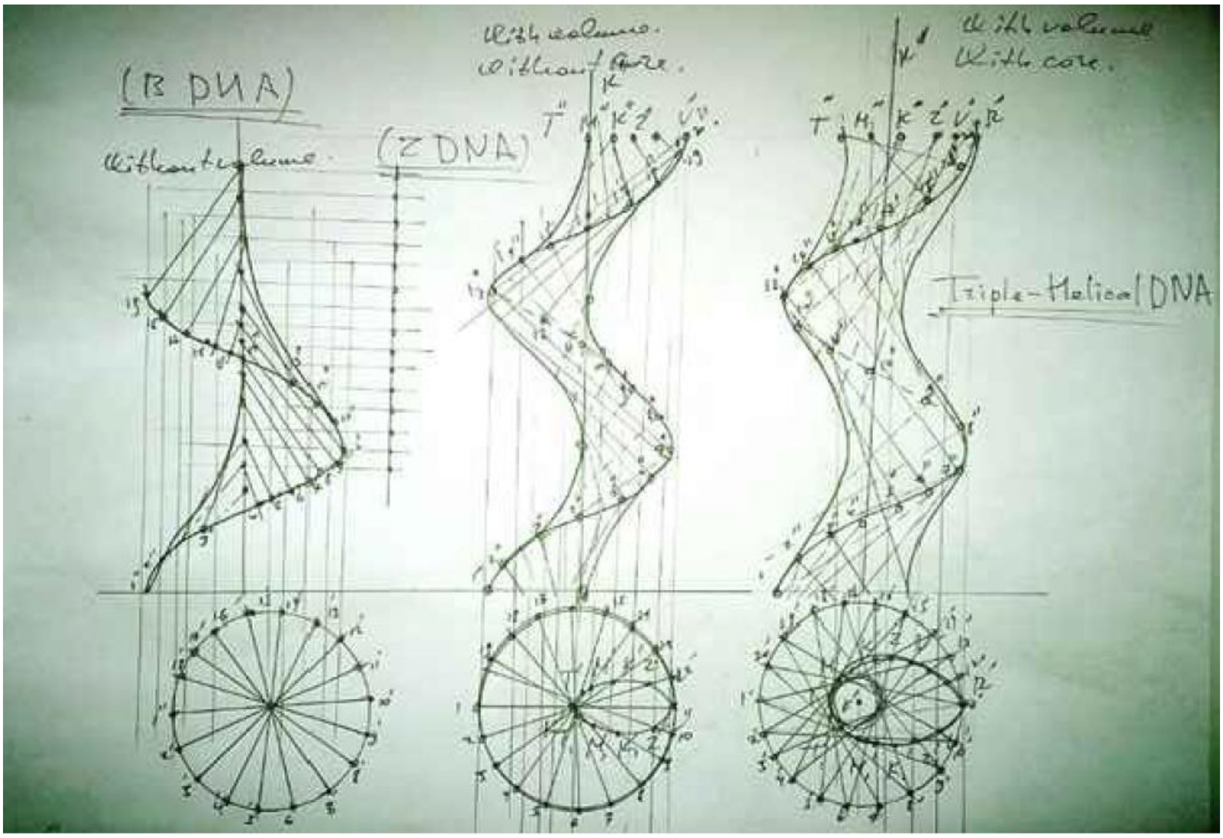


Figure.10. Helices corresponding to DNA forms.

In other DNAs that is not binding as in circular order, for instance in B-DNA the peptide (chord) merging is being followed in internal core part as in a straight form, that there is no circular core procreated (Fig.10). In B-DNA the peptide (chord) merging happens in a straight diameter directions, which engenders a form alike to minimal helicoid surface (but not exact in its parameterization). Although, there are some alternative B-DNA forms in nature, which have very close form to alpha DNA helices. That happens due to hydrophobic amino acids (division points) array sequence order varies sometimes. Z-DNA has slightly different helical body structure comparing Alpha DNA, its minor and major grooves are bigger than any DNA type, due to that rough molecular outer enclosure, it has interior volume but not core section in that, on account of same reason as in B-DNA. The Alpha DNA and Triple Helical DNA nearly are the same structure if we not count one of its major helix grooves in Triple DNA, which is not consisted of much of those molecules and is not playing strict role in DNA's inner shape. For easily analysis Alpha and Triple DNAs are a good models to start. They are right handed helices which has 3.6 residues in each pitch height, and each pitch height has 5.4 Angstroms (1 Angstrom = 10^{-10}m). So, the space between residues equal to 5.4 Å/3.6= 1.5 Å. That distance means the DNA's helix division height is under that distance. From there, is being found its base circles division angel. So, if there are 20 amino acids and one pitch rotation is equal to 360°, it makes 18° for each division part and those peptide joints are basically derives the chord lines and thus the Alpha DNA outer surface is being derived, however, the core section is not clearly derives in Alpha Helix and it is visible and remarkable in better condition at Triple DNA. It is may be because of in this DNA hydrogen backbones are tightly closer to each other and allows more visible core section inside helix. About this core section there is no information in any Geometry and Architecture literature. I analyzed and determined its existence in DNA, because of it is very important part for a tower constructive design structure. The Ebola viruses NPS4's and EBOV's DNAs are very alike to human DNA strand Fig 7 and Fig 6. As it is noticed in NSP4's and EBOV's DNA strands above, the twist angel's peptide merging, about that order was analysis in RP2's 3.2 chapter, and according to that analyzes was declared basic rule for proper helical shapes derivation to make eligible appliance in Architectural aim.

5. Mathematical Formulations

In RP1 graphical part presented main helical tower structure, which was being designed according those Alpha and Triple DNA helices.

However, they were not sufficient, as just using that surface design and its modelling core section according DNA strands to implement in Architectural designing. Because they were not resembling precisely parametric values of heliacal surface, they were simple technical drawings, and they were not responding to any scientific research state. Some known formulas were mentioned in this thesis at the above at page 8. They are found for helix line in ancient times by some Greek geometrics. Here, initially I have taken surface and its core section under strict mathematical survey in order to obtain mathematical-geometric parametric equations for that. (Fig.11).

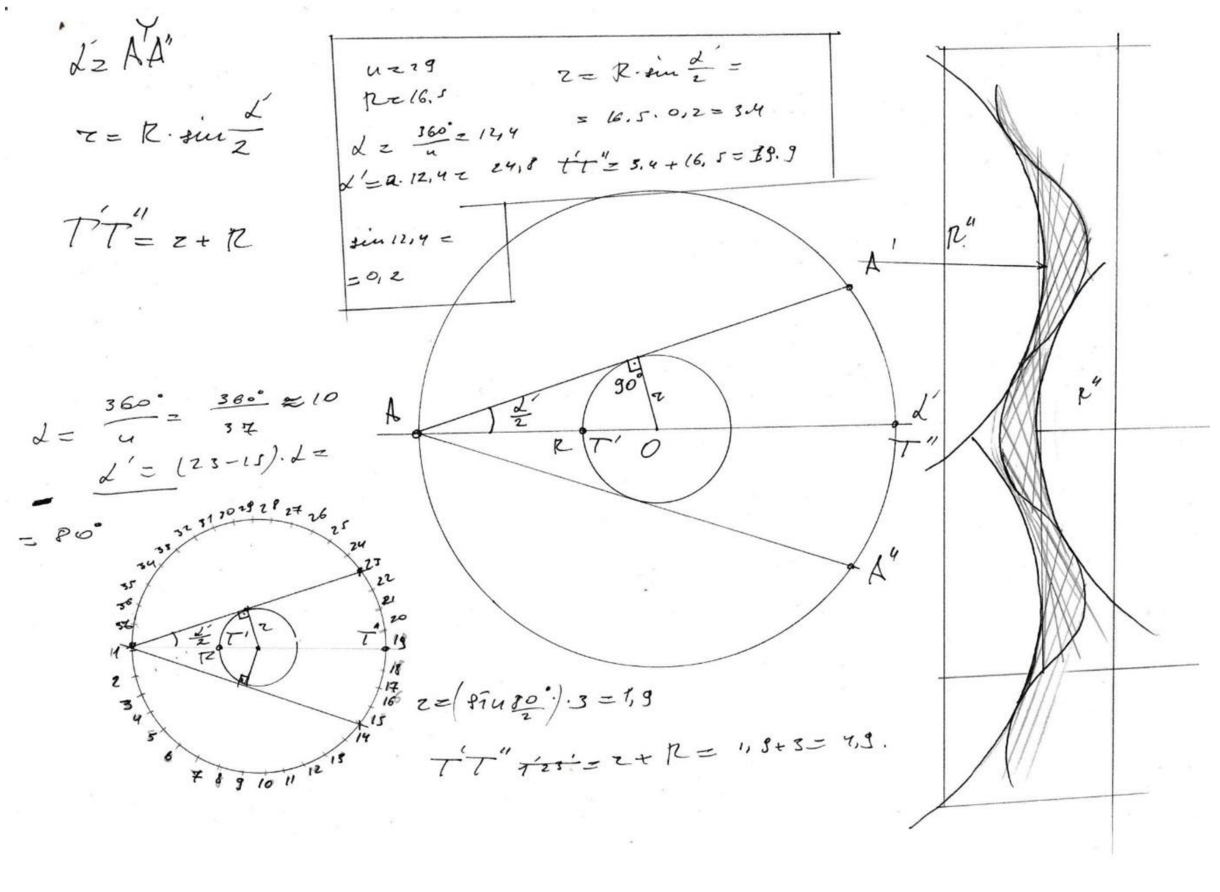


Figure.11. The found formulas over related topic issue. Parameters changes are affecting change of shape of helix and same time it helps formerly to find out which kind of dimensions will be in this object before plotting that.

T'T" distance is resembling the major length of floor (which is shaped as mesh). That distance's parametric equation is important to make certain in this research. In next RP series according that equation and that parameter other parameterizations were done. The helical surface on right side that was drawn that by hand according those DNA surfaces. That R" radius is showing envelope radius (about which will be later survey and will be found exact equation for that too in RP3). One of most important parameters was core section radius, which is written with “r” in figures and formulas. There found also equation for that because it was one of the significant parts for fulfillment of this design solution.

One of the most and vital parts of this surface is its parametric equation in Cartesian coordinate system (5.1):

$$x = p\big(R\cdot\cos\big((u+v-1)\cdot\theta\big) - R\cdot\cos\big((v-1)\cdot\theta\big)\big) + R\cdot\cos((v-1)\cdot\theta)$$
$$y = p\big(R\cdot sin\big((u+v-1)\cdot\theta\big) - R\cdot sin\big((v-1)\cdot\theta\big)\big) + R\cdot sin((v-1)\cdot\theta) \qquad (5.1)$$
$$z = p\cdot u\cdot\theta + (v-1)\cdot\theta$$

Parameter “p” is changing between 0 value and 1 value, it means its oriented interval is: [0;1] Only and in this case the needed surface is derives. There is its explanation as proof for any mathematician, geometric and architect and any concerned person or community.

The floor plan perimeter arrives in that surface structure, its parametric equations were found according structures surface equations (of 5.1) (5.2):

$$x = \frac{\theta - \theta v + k}{u\theta}\big(R\cdot\cos\big((u+v-1)\cdot\theta\big) - R\cdot\cos\big((v-1)\cdot\theta\big)\big) + R\cdot\cos((v-1)\cdot\theta) \qquad (5.2)$$
$$y = \frac{\theta - \theta v + k}{u\theta}\big(R\cdot\sin\big((u+v-1)\cdot\theta\big) - R\cdot\sin\big((v-1)\cdot\theta\big)\big) + R\cdot\sin((v-1)\cdot\theta)$$

As it is visible, here is no Z coordinate indicator, however, the “k” is presenting ordinate height according Z here. X and Y are parametric equations of that floor’s perimeter line. Now, the “v” variable parameter is changing in certain interval, it happened because of while transmuting the 3D structure of helicoid in its two-dimensional cut section, the variable p correlatively reflected its interval values into “v” variable. Thus, new interval for “v” variable is being computed out like [k/ θ+1; k/ θ-u+1].

In mathematical formulations, one of the achieved is the distance T'T" which indicates the long axis length of floor. And another one very important parameter is 'r' which indicates the circle radius of core section.
It is important because of this core section is only shape or how to express like path which is continuously going down in this helix. Through this cylinder the all stair lift cases and other electric water-supply systems are going to all floors and same time the all building weight in each floor are being delivered by this core section.

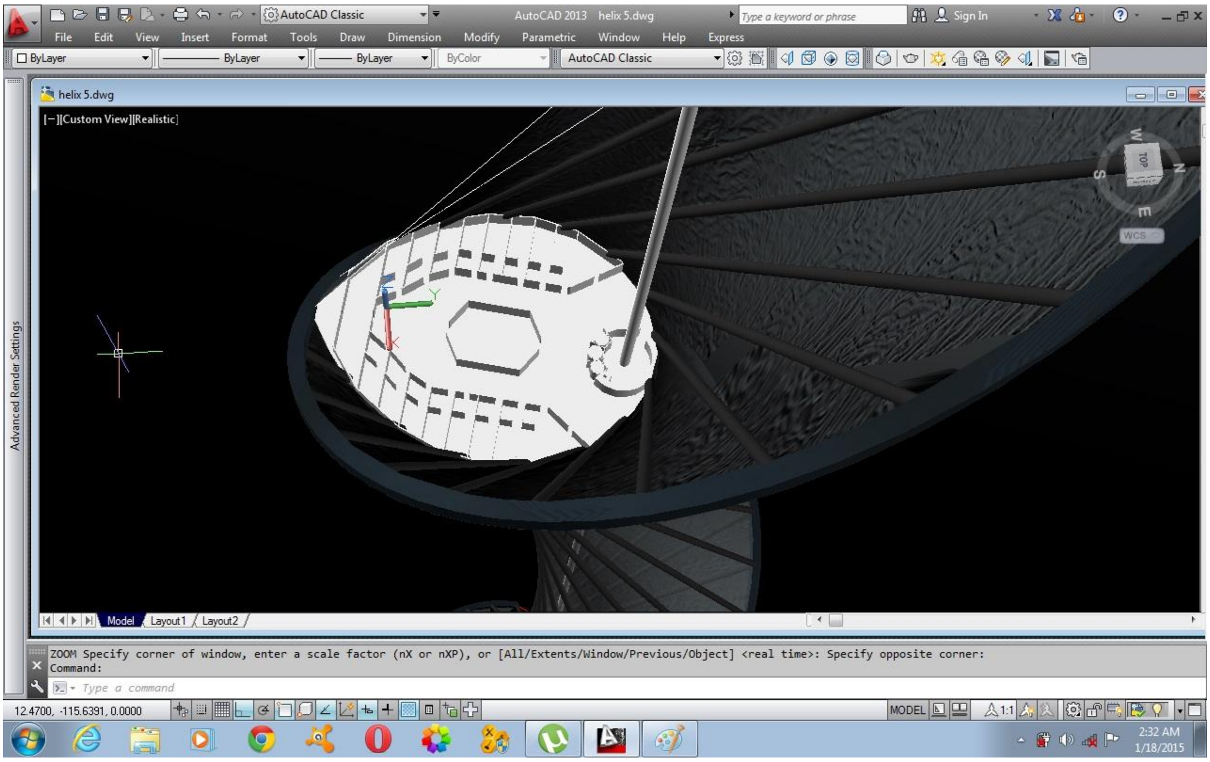
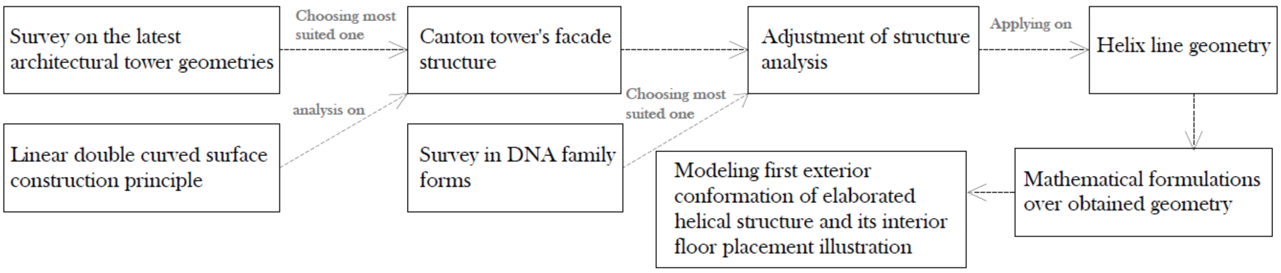


Figure.12. Achieved form of DNA strand and the one of the similar type floors' placement situation in the building.

6. Hypothesis

Surveyed on the latest architectural geometries. Chosen Canton tower's façade structure as most suited one. Considered linear double curved surface construction principle on this chosen surface structure. Meanwhile, surveyed in DNA family forms and found most architectural point of suited kind. Structurally analyzed and adjusted into one certain surface façade forms as was done in Canton tower's façade form. Later applying that DNA form in helix line geometry (as it is major tendril line of that helical surface). Mathematical formulations over obtained geometry. Modelling exterior conformation of elaborated helical structure and its interior floor placement illustration.

Hypothesis of research project 1



Conclusion of Research Project 1

“Conclusion: The inspiration of this work, based on many different sources. As in same time all those sources have common point, which gives essential base to this work.
The project of Canton tower in China, Guangzhou city is one of them. The tower as mentioned at the above in text, designed by the form, volume and structure generated by two ellipses, one at foundation level and the other at a horizontal plane at 450 m (1,480 ft.). These two ellipses are rotated relatively to each other. The Canton tower's twisted shape or hyperboloid structure corresponds to the Russian Federation patent No. 1896, dated 12 March 1899 received by Vladimir Shukhov, the Russian engineer and architect. The structure is similar to the Adziogol Lighthouse (designed by Vladimir Shukhov in 1910) in Ukraine's Dnepr delta.” (8 – Research Project 1. Conclusion. 2015. Page: 47)

The main work in this research project was, first, looking latest tower designs and making consideration of them to find key factors of modern Architectural demands for towers and skyscrapers. After that step elaborating and analyzing human DNA structures, after that, making comparison between known helical surfaces and shapes with DNA structures and making decision for best suited DNA and its helical surface. Finally, the most important part analyzing the chosen shape and making strict parametric equations for that to implement in contemporary tower standards.

Notice: Those, I have found in RP1 main work result helical body and other helical shaped design solutions in RP3 and their parametric equations and other calculations and scientific mathematical researches in all RP series, all are belonging to me. Also for main helical DNA bodies and their interior volume arrangements, I have done them according personal investigation in DNA forms!

Hypothetical statements for empirical research

7. Geometrical Resolutions

Geometrical resolutions of this research are consisted of three hypothetical statements. There are strict considerations' analysis over certain features of chosen DNA surface and its core section. The one latest statement here 7.3 (in RP2 report it is 4.5) is the most important statement, according to what the best optimal design solution was chosen of three ecological aimed design solutions. There are profound explanations at 7.3 chapter and at RP3 section about this statement.

7.1. Helicoid surface could be implemented and included as contemporary linear double-curved building façade surfaces

"1.1 Helicoid surface could be accepted as latest contemporary linear double-curved facade structure: After Russian constructor and engineer Vladimir Shukov (1853-1939) patented research is anent of double-curved linear surfaces in Architecture, this principle got its place at latest statistic architectural design solutions. Research project 1's result helix might be accepted as such kind of project because of there is such rule exists in its surface geometric formula."
(9 – Research Project 2. *1.1 Helicoid surface could be accepted as latest contemporary linear curved buildings' surfaces*. 2016.)

Asseveration of this hypothesis is coming from minimal helicoid's linear character. Minimal helicoid is origin of merely of all helical surfaces.

For minimal helical surface: "It could be analyzed in this way. The helicoid can be continuously deformed into a catenoid by the transformation:

$$x(u,v) = \cos(\alpha)\cdot\sinh(v)\cdot\sin(u) + \sin(\alpha)\cdot\cosh(v)\cdot\cos(u)$$

$$y(u,v) = -\cos(\alpha)\cdot\sinh(v)\cdot\cos(u) + \sin(\alpha)\cdot\cosh(v)\cdot\sin(u) \qquad (7.1.1)$$

$$z(u,v) = u\cdot\cos(\alpha) + v\cdot\sin(\alpha)$$

When α=0 it transforms into Helicoid and when $\alpha=\pi/2$ it transforms into catenoid.
In order to get line families over surface is needed to simplify the formula of achieved by: α=0.

So, corresponding to helicoid: α=0.

$$x\ (u, v) = \sinh(v)\sin(u)$$

$$y\ (u, v) = -\sinh(v)\cos(u) \qquad (7.1.2)$$

$$z\ (u, v) = u$$

There is on each z height one horizontal line. They are rising up under different angel tendency to x axis depending on z height:

$$y = -x \cdot ctg(u) \qquad (7.1.3)$$

Here "u" is certain value of z-ordinate. Such expression allows to confirm that minimal helical surfaces is linear.

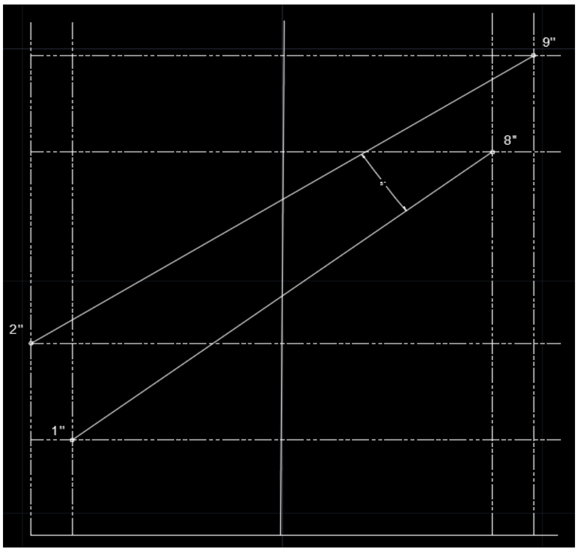


Figure.11. Orthogonal frontal view of Helicoid

$$\frac{x - R \cdot \cos(v-1)\theta}{R \cdot (\cos((u+v-1)\,\theta) - \cos((v-1)\theta))} = \frac{x - R \cdot \sin(v-1)\theta}{R \cdot (\sin((u+v-1)\,\theta) - \sin\,((v-1)\theta))} = \frac{z - (v-1) \cdot \theta}{u \cdot \theta} \qquad (7.1.4)$$

These eqautions represent first line family of our designed helical surface.

The second line family of surface is a reversive coeeficiented one of this formula. First family is presented by white and red chords. The second family lines are shorter and has not being marked in illustration. (Fig.13).

And this is exactly matching with hyperbolic-paraboloid. Just analyzed formulas shows the whole helicoid body and these two chords just one part of that whole body. And all body consists of same such parts.

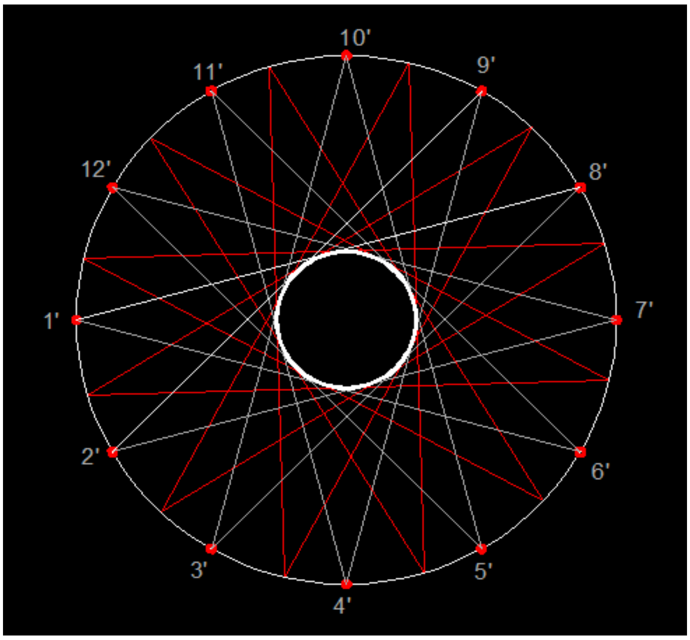


Figure.13. Planar view of chord lines families

(10 – Research Project 2. 4.1 Helicoid surface could be accepted and included as latest contemporary linear curved buildings' surfaces. 2016.)

7.2. It is not possible to obtain DNA shape always from helix as it was revealed at Research Project 1. There are some geometric-mathematical related conditions, which are vital to find out, in order declare how much the project real and applicable

It is not possible to get DNA shape always from helix as it was revealed at research project 1, but there are some geometric-mathematic related rules which are vital to find out to declare how much the project true and applicable. At research project 1 it was proved that, from helix line, it is possible to gain helicoid volume which will be suitable to integrate into building design construction. Here will be shown some problems which occurs while transforming helix line into helicoid body, and will be explained the main reason of that and its responsive solution.
First, some analyzed cases are being taken in survey:

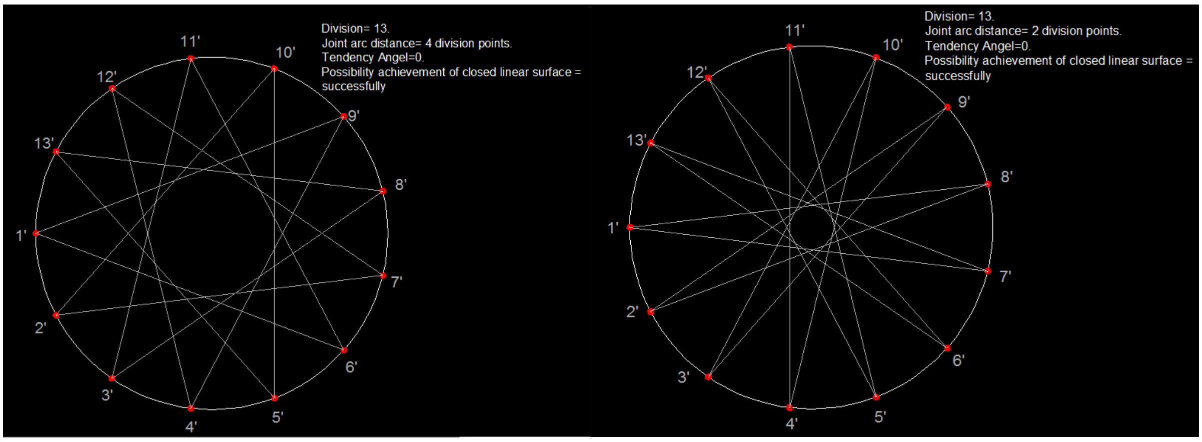


Figure.14. Normal order

In the figure 14, are illustrated normal order transformations of helix lines into DNA helicoid bodies.

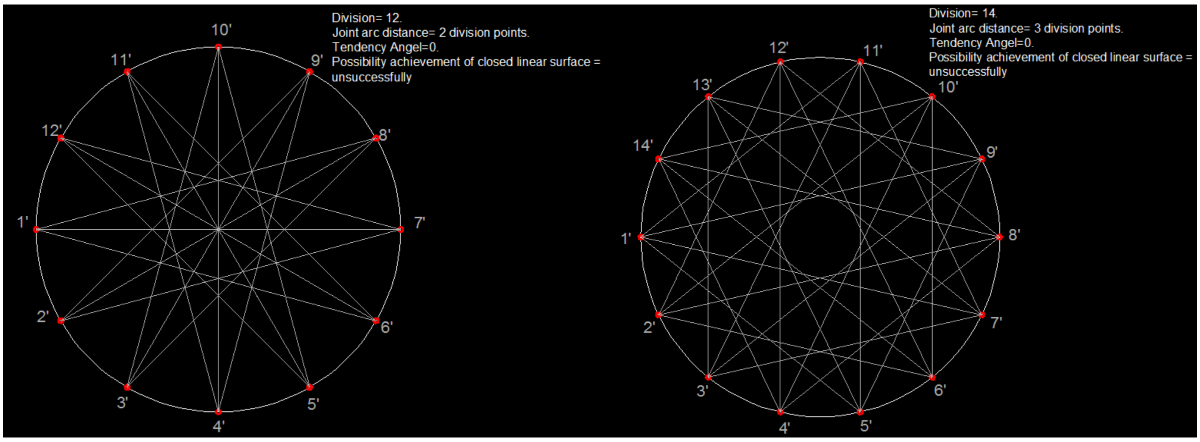


Figure.15. Abnormal order

The reasons of abnormal order transformations, are different in each type case study as shown in the figure 15 above, there is no need to write about their explanations.

In this report only, will be looked to solution of problem, by other words finding the method of correct helicoid transformation.

For this method search, one example should be taken:

The circle's division number is equal to 18 parts and radius equal to 1 (this is for easily appliance of complex figures in forward).

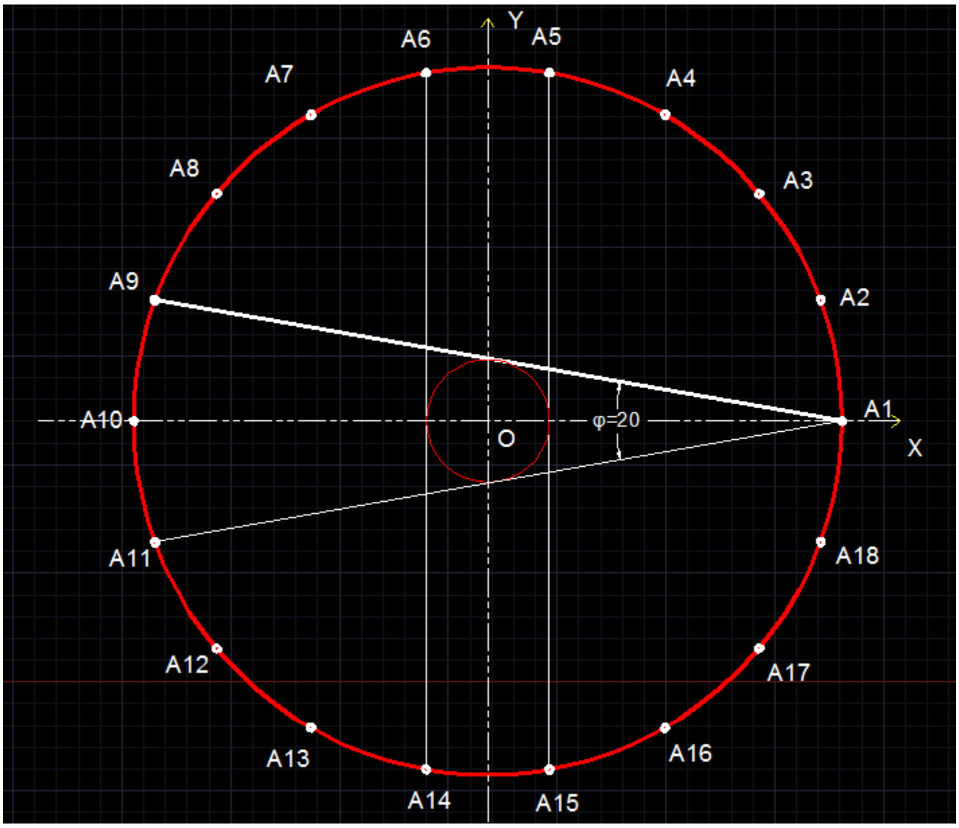


Figure.16. 18-part division

The angel φ is equal to 20 degree in 18 times division.

$$\varphi = \frac{360°}{18} = 20° \quad (7.2.1)$$

Now time to mark all points by affixes like from A1 to A18 by a1, a2, a3…. a18.
Each point affix price will be:

$$a_n = \cos[(n-1)20°] + i\sin[(n-1)20°] \quad (7.2.2)$$

For example, A2 and A10 points affixes:

$$A_2 = \cos 20° + i \sin 20° \quad (7.2.3)$$

$$A_{10} = \cos 180° + i \sin 180° = -1$$

The line's (crossing those points) formula here would be:

Its complex angular coefficient is:

$$\aleph = \frac{\cos 180° + \mathrm{i}\sin 180° - \cos 20° - \mathrm{i}\sin 20°}{\cos 180° - \mathrm{i}\sin 180° - \cos 20° + \mathrm{i}\sin 20°} = \frac{-1 - \cos 20° - \mathrm{i}\sin 20°}{-1 - \cos 20° + \mathrm{i}\sin 20°} \quad (7.2.4)$$

Now the distance from center to this line should be stable in order to achieve in all turnings normal transformation of helix line.

So, the shortest distance of center till this line (the perpendicular from center point till this line) should be constant. And it should be proved it is not intersecting with core section circle.

The line's (crossing through this perpendicular) complex angular coefficient is:

$$\aleph' = -\aleph = \frac{1 + \cos 20° + \mathrm{i}\sin 20°}{-1 - \cos 20° + \mathrm{i}\sin 20°} \quad (7.2.5)$$

So, the line crossing through center and this point has complex line formula like this
$z = \aleph'\bar{z}$

Now, the perpendicular project point affix of center should be found from this system equation

$$\begin{cases} z + 1 = \aleph(\overline{z + 1}) \\ z = \aleph'\bar{z} \end{cases} \Rightarrow 2z = \aleph - 1$$

$$\aleph - 1 = \frac{-1 - \cos 20° - \mathrm{i}\sin 20°}{-1 - \cos 20° + \mathrm{i}\sin 20°} - 1 = \frac{-2\mathrm{i}\sin 20°}{-1 - \cos 20° + \mathrm{i}\sin 20°} \quad (7.2.6)$$

$$z = -\frac{\mathrm{i}\sin 20°}{-1 - \cos 20° + \mathrm{i}\sin 20°} = \frac{\mathrm{i}\sin 20°}{1 + \cos 20° - \mathrm{i}\sin 20°} =$$

$$= \frac{\sin 20°(\cos 90° + \mathrm{i}\sin 90°)}{\cos 0° + \mathrm{i}\sin 0° - \sin 20°(\cos 90° + \mathrm{i}\sin 90°) + \cos 20°} \quad (7.2.7)$$

$$= \frac{\mathrm{i}\sin 20°}{(\cos 20° + \cos 0° - \sin 20°\cos 90°) + \mathrm{i}(\sin 0° - \sin 20°\sin 90°)}$$

Module of complex figure is its length in coordinate system (length from start point till end point), exactly this parameter is needed here for determination of chord intersects or not into core section circle!

Numerator: $\mathrm{i}\sin 20°$

Denominator: $(\cos 20° + \cos 0° - \sin 20°\cos 90°) + \mathrm{i}(\sin 0° - \sin 20°\sin 90°)$

Both of them numerator and denominator are complex figures of some points affixes'. The length of numerator is: $\sin 20°$

The length of denominator is:

$$\sqrt{(\cos 20° + \cos 0° - \sin 20° \cos 90°)^2 + (\sin 0° - \sin 20° \sin 90°)^2} =$$
$$= \sqrt{(\cos 20° + 1)^2 + (\sin 20° \sin 90°)^2} = \sqrt{\cos 20°^2 + 2\cos 20° + \sin 20°^2 + 1} =$$
$$= \sqrt{2 + 2\cos 20°} \tag{7.2.8}$$

After separately finding these distances should divide them. That result will give the distance from center till its projection on chord line same time which is core section circle radius:

$$\frac{\sin 20°}{\sqrt{2(1+\cos 20°)}} \tag{7.2.9}$$

Simplifying this equation:

$$\frac{\sqrt{1-\cos 20°^2}}{\sqrt{2(1+\cos 20°)}} = \sqrt{\frac{1}{2}\frac{(1-\cos 20°)(1+\cos 20°)}{(1+\cos 20°)}} = \sqrt{\frac{1}{2}(1-\cos 20°)} \tag{7.2.10}$$

$\sqrt{\frac{1}{2}(1-\cos 20°)}$ - This formula analogically could be written for all division points' cases. Then it would be like - $\sqrt{\frac{1}{2}(1-\cos k°)}$, where "k" is argument of point's affix. So, the length of needed part and its intersection in core circle is depending only on "k" parameter, and as in formula it is under Cosines function. The Cosines function is not changing due to angel's positive or negative value changes. So, it means the normal transformation could happen only and only in one order – "the two chords coming out of one division point should be symmetric relatively to diameter of circle (helix's base circle)."

(11 – Research Project 2. 4.2 It is not possible to get DNA shape always from helix as it was revealed at research project 1, but there are some geometric-mathematic related rules which are vital to find out to declare how much the project true and applicable. 2016.)

There were other ways too, for researching and finding this fact, however one of more precise and scientific solutions was this one than technical drawings. Despite the surface is known to geometry by the name curved open helicoid ore open helical conoid and some named just triangular thread (Look at different geometrical sources and http://old.pskgu.ru/ebooks /kngg/kng_ gl_08_052.pdf), there is no any parametric descriptions for that.

7.3. Helicoid due to its topological nature useful for further more design solutions

4.5 Helicoid due to its some topologically connections with catenoid could be usefully designed for other type of forms. Helicoid has topological equality with Catenoid. The mutual equality comes through some parametric transformational formulas (7.1.1). (12 – Research Project 2. 4.5 Helicoid due to its some topologically connections with catenoid could be usefully designed for other type of forms. 2016.)

This is a nature of helicoid (minimal surface). It is essential characteristic of helicoid, for continue research on that and generate at least one more design solution (however several ones are possible). helicoid has topological nature, it means in further regulated transformations of that will have the same nature too (it would occupy more 40-50 pages in thesis, to write and explain its reasons, and at the end would be accepted as mathematical and geometrical scientific work only). This statement came out true in research project 3 results, readers of this thesis will get acquainted with that at the ahead.

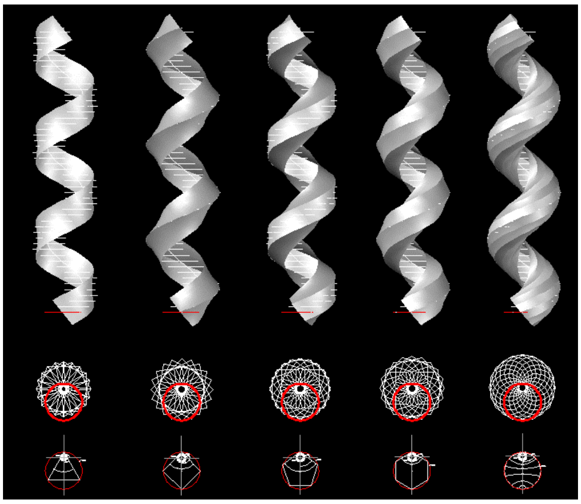


Figure.17. Replacing base planar object (perimeter border line) with some other polygonal objects to get new type of shape for helicoid tower design solution.

Figure 16, describes and illustrates different types of helical shape transformations due to their basic planar object forms. From right triangle till right octagon, all convex polygon types are replaced with standard planar form. It was not concerned to find parametric equations for all of them, rather it was going to be taken one solution of more complex shape comparing to basic helical surface. By that way, if in experimental stage, that would be obtain same family generative equations for both surfaces then, it would prove that research was successful. According that equations, the best design solution is determined.

That complex design solution was helical shape which one was gained by combining Archimedes' spiral with basic helical surface structure (in ahead at RP 3 will be legible description and explanation of that).

8. Ecological Resolutions

Three design solutions are aimed to generate energy power from nature sources. One of them intended for obtaining energy by SPs (Solar panels) from solar radiation and other two ones by natural wind energy and air pressure. The methodic and calculations are not 100% exactly precise and not comparable to professionals methods of these fields. However, enough precise for making common comparison between these three ecologically intended design solutions.

After making comparisons, the most energy generated design solution was accepted more efficient comparing other two ones. Later that design's Architectural Geometric parameters were considered with 4.5 solution of RP2 and RP3 (here 7.3, topological nature). That comparison allowed to now which design solution by its parametrical formulations is in much closer relationship with 4.5. That is because of the ecological settlement demands should match with all three design structures geometric features. So, it means they could be transmuted and adjusted to another design solutions as well, if there are enough parameter equalities between this ecological aimed designs and that design solutions.

8.1. First and Second aimed solutions

First aimed Design Solution (Conversion of Wind Energy):

This solution is anent of two main factors: 1st air pressure, 2nd wind velocity. They are correlative factors in nature and playing role in any wind energy conversion mechanisms. Here was used one known mechanical engineering research named INVELOX turbine system. This work is new way of approaching in wind energy projects and there is allegation that it converts 600% more energy than conventional wind turbines in open fields.

There are no special features in helical tower structure for such device settlement as a privilege comparing other skyscrapers. The major factor here is height of tower, where wind velocity increases and air density decreases. And getting down level vice versa velocity decreases and pressure increases. In calculations, according this devise energy conversion formulas it came out to be explicit that in lower heights energy conversion is smaller than higher levels. It could be expressed as the wind velocity in this system's work procedure is playing more efficiency than air pressure. It is same as well in conventional wind turbine systems. "2. Description of the INVELOX delivery system: In contrast to older designs of traditional ducted turbines, INVELOX separates the location of the intake, shroud and turbine generator system; the intake is on the top while the turbine generator system is placed at ground level inside the narrowest section of the ducted pipe carrying captured wind towards the turbine. This unique feature allows the engineers to size the intake wind delivery system for any speed increase required without increasing the turbine size. The size of an intake depends on local wind speeds, user requirements, and environmental conditions." (Fig.17).
(13 –INVELOX with multiple wind turbine generator systems Daryoush Allaei, David Tarnowski \, Yiannis Andreopoulos. Department of Mechanical Engineering, City College of New York, New York, NY 10031, USA 2015.)

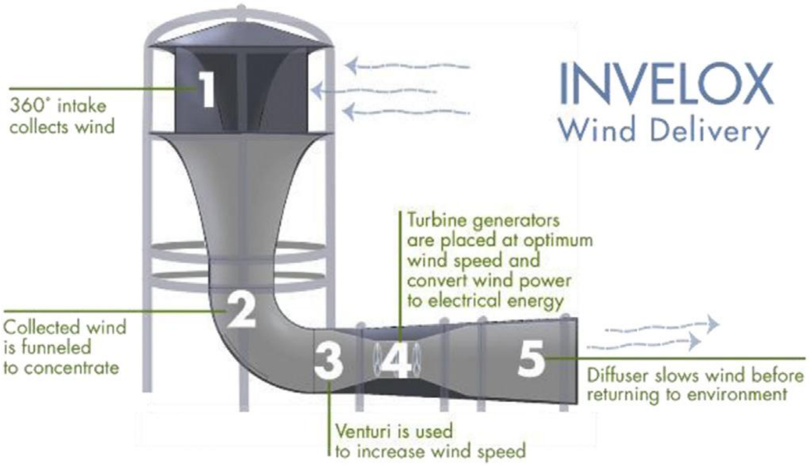


Figure.18. Schematic of the INVELOX wind delivery system with its key components, (1) intake, (2) channeling wind, (3) wind concentrator, (4) Venturi plus up to three wind power conversion system, (5) diffuser returning wind to nature. © 2014.

$$E = \mu A_1 S_R \left(1 - c_{pb} - k_b\right) \frac{1}{2} \rho U_1^3 \quad (8.1.1)$$

This equation is alike to conventional wind turbine energy conversion formula. However, here are more specific coefficients and complex internal relations in this formula. One of them, fraction of kinetic energy loss and incoming kinetic energy coefficient which does not exist in conventional turbine formulas.

Second aimed Design Solution (Conversion of Wind Energy):

"2.3.2. Wind Energy. As it is well known screw form of objects are very easy rotated figures by the wind flow. This characteristic of it, will give big opportunity to use wind energy in this helical tower project. There was project in ASME DC Company about creating helical shelter covered volume and in each tendril concave path placed propellers to be worked by wind energy and gain electricity, this project clearly illustrates how wind flows are rushing in those concave tendril paths which allow propellers rotate in enough speed to generate electricity energy." (14– Research Project 2. 2.3.2 Wind Energy. 2016.)

"A wind tower system having a three-dimensional heliacal wind deflecting structure is studies in this work. The purpose of the helical structure is to increase the natural wind speed and direct the follow of the wind toward two columns of horizontal-axis rooftop-size wind turbines that are installed in the grooves of the helical structure, diametrically opposed to each other. Computational fluid dynamics analyses were conducted to determine the influence of the helical structure on the wind speed reaching the turbines. A wind speed amplification coefficient was determined for a helical structure of 6.7 m outer diameter. This study shows that the helical structure having an outer diameter of 6.7 m results in an average wind speed increase factor of 1.52." (15 – ASME 2012 International Mechanical Engineering Congress and Exposition Volume 7: Fluids and Heat Transfer, Parts A, B, C, and D Houston, Texas, USA, November 9–15, 2012 Conference Sponsors: ASME.)

Basically here, it is believed and accepted as in the narrow waist part of helicoid, there is smoothly wind flow curves around, while helicoid is standing in a vertical position and wind flow approaching to it, in horizontal direction. Another used advantage is making open holes in that waist part settled wind tunnel. That is because to accelerate inner air pressure and air flow speed by allowing outer wind air to flush inside tunnel through those holes (it is tactic which copied from first version system). Holes are planned like ramp as outer air could enter but inner air flow cannot rush out from those holes.

This design solution and as well other two green energy conversion aimed solutions were not put in practical model test for real life survey, they were only calculated on papers, according theoretical rules each of them.

8.2. Third aimed solution

One of the nature's green energy sources, is solar radiation. Methodology of conversion solar energy into electricity is known from 1980s till nowadays and widely used in open fields and on some residential building's facades or roofs. Solar panels have been known when a technological advancement for collecting solar radiation energy and later generating it into electricity power arrived.
Panels at least demand some polygon area for placement or settlement (some latest modernized panels are capable to be deformed into bended states too) which suits with surface structure of helical tower. Because the wings (chord joints' segments) are exactly saddle-rectangle shape which consists of two triangles. There are other factors playing roles beside this solar panel settlement on helical tower façade, they are: 1- interior natural day time lighting problem and 2- panels underneath cable and other technical stuffs appropriately placement for interior volume occupation and for technical problems fixation of those stuffs in panels. This is where main problem occurs. However, this problem is an advantage same time, for learning and adjusting helical tower's geometric resolution parameters with those solar panels settlement parameters. That is where the new design solution derives. Binding those parameters to each other, it allows to manipulate design's geometry together with those panels settlement form. Thus aimed solution has double-skin facades. Solar panels are supposed to be placed on second (outer) façade. Here is how they were matched to each other:
For second façade layer in double façade designing will not be used homothetic rule for intermediate cavity, because there will be dismissed order between height levels of turns among two helicoid surfaces.
The desirable solution is offsetting only for planar view and rising all turns on same heights.

In this case, there will be just diameters one bigger and one smaller base circles, where gap distance will be visible between them.

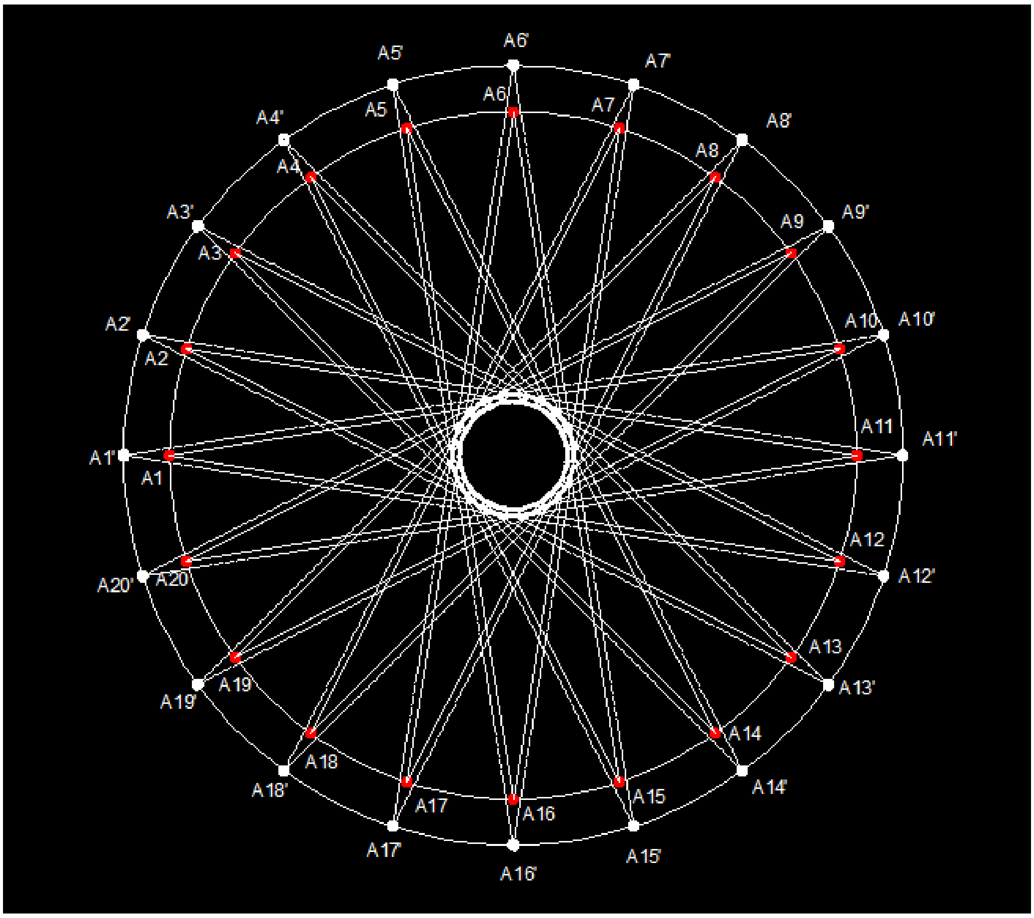


Figure.19. Double facades planar view.

If the distance from center till first surface chord was "K" (till surface) then till second homothetic bigger one will be

$$K' = h \cdot K. \tag{8.2.1}$$

Due to that, the distance between two facades and the same time between chords would be

$$M = (h - 1) \cdot K \tag{8.2.2}$$

In order for no intersection of both surfaces, all chords should follow same distance order in disciplinary manner.

From side view some of these constructional chords will look like overmatched, but from front view they will look like in distance equal same to M.

That is one version of necessity, but it could be in such case, we already have examined model to plan for special need as the gap is already accepted and being given as for example equal "d", in order we should to plan it from start correctly. Accepting distance difference "Δr"" (it is being written with delta sign, because there is gap between double surfaces, which is appeared by distance between chords over perpendicular radiuses).

There is a need to calculate the radius of second surface's base circle. Considering the division will be equal to "n" and first radius would be "R1" and the gap between facades is "d", then the second surface's radius "R2" could be found like this.

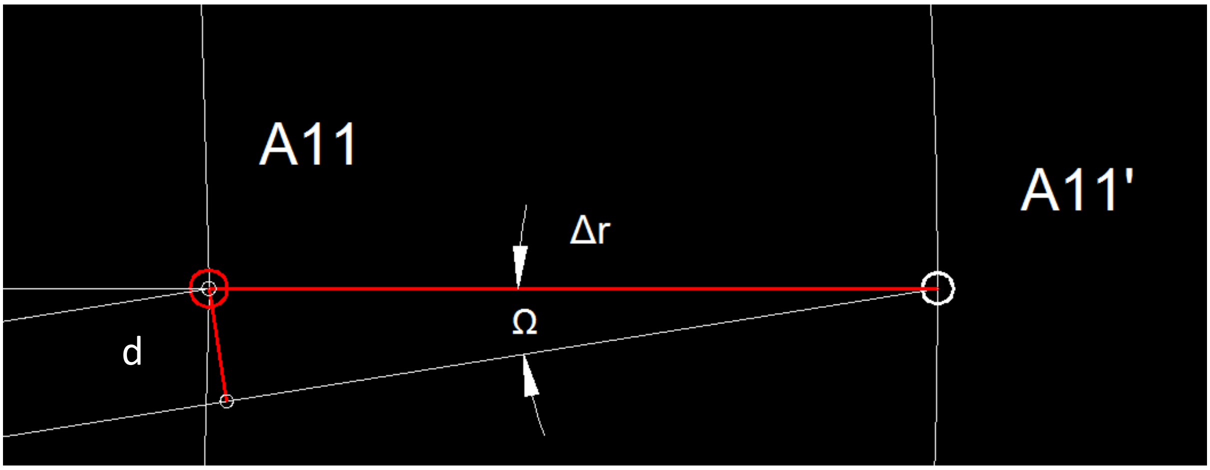


Figure.20. Distance between surfaces and difference between radiuses.

The "**Ω**" is an angle between chords and their end joint radiuses. In both surfaces' radiuses, it is equal and should count like:

$$\Omega = \frac{90^\circ}{n}. \qquad (8.2.3)$$

Where "n" is number of basic circles' divisions. The difference of radiuses is equal:

$$\Delta r = \frac{d}{\sin \Omega} = d \cdot \csc \Omega \qquad (8.2.4)$$

Then the "R2" will be:

$$R_2 = R_1 + \Delta r \qquad (8.2.5)$$

As it is remarkable from Frontal view illustration, the chords are not being intersected into each other, they are going on parallel levels. (Fig.20).

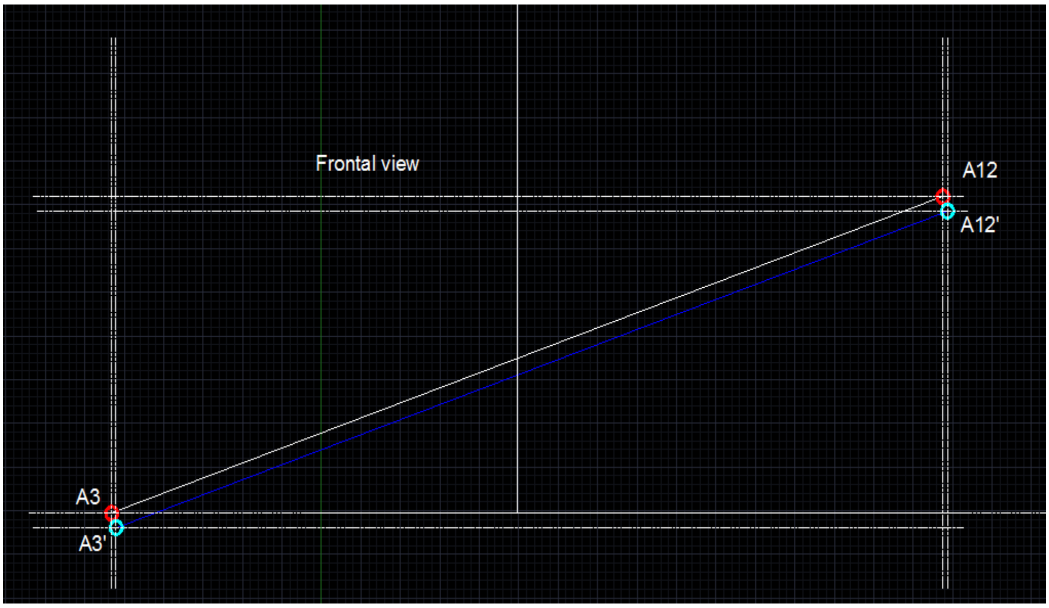


Figure.21. Double facades' chords Frontal view.

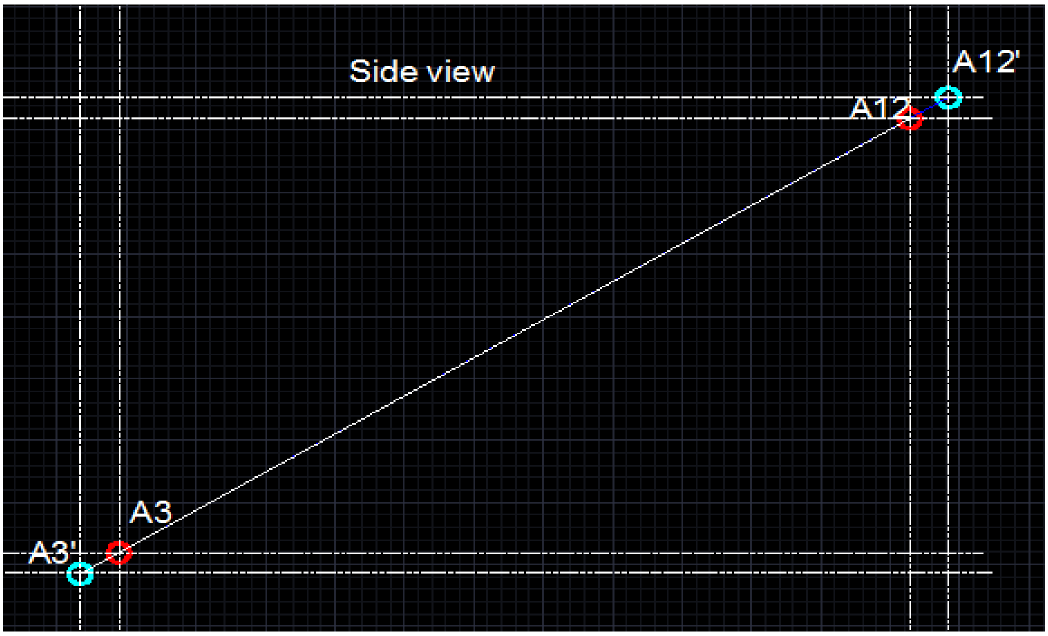


Figure.22. Double facades' chords Side view.

Solar panels would be installed on this helicoid body surface at separated chordal segment surfaces (wings of new derived helical tower design). They are in saddle rectangle shape, it means they are suitable for settling on them solar panels and having some gap underneath for technical cable stuff placements. That is because this design solution has been accomplished according to basic rules of RP1's best designed and elaborated helical tower structure presented at graphical part of RP1.So, all formulas and theoretical hypothesis from RP1 and RP2 and even further in RP3 for that structure, applies to this structure as well.

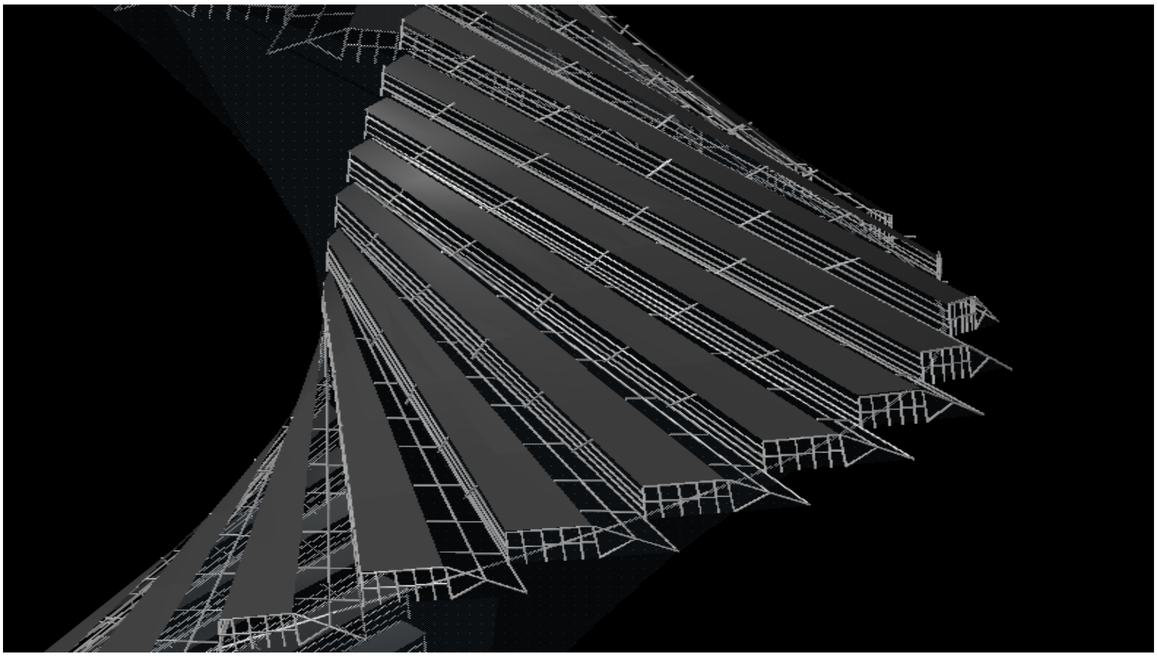


Figure.23. Double facades’ solar panels horizon Perspective view.

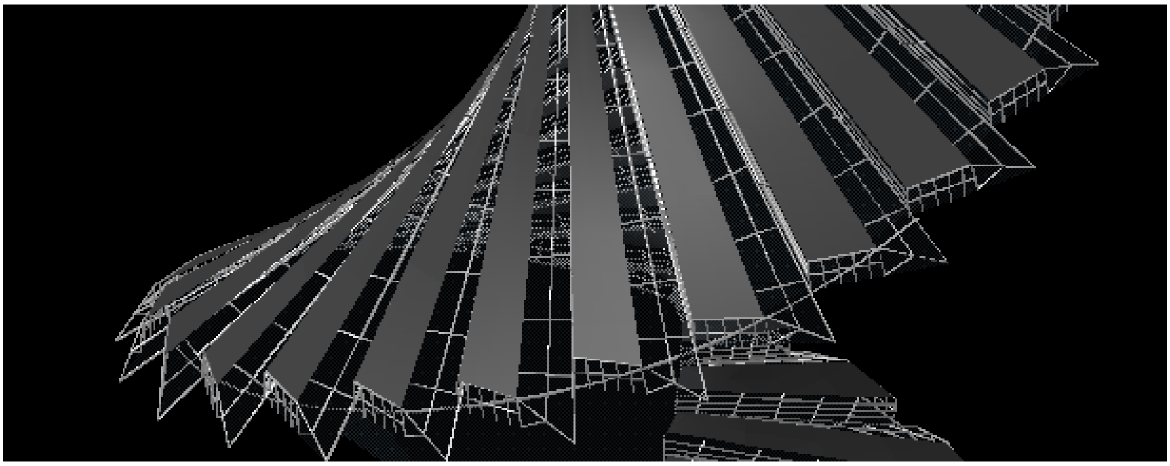


Figure.24. Double facades’ solar panels upper Perspective view.

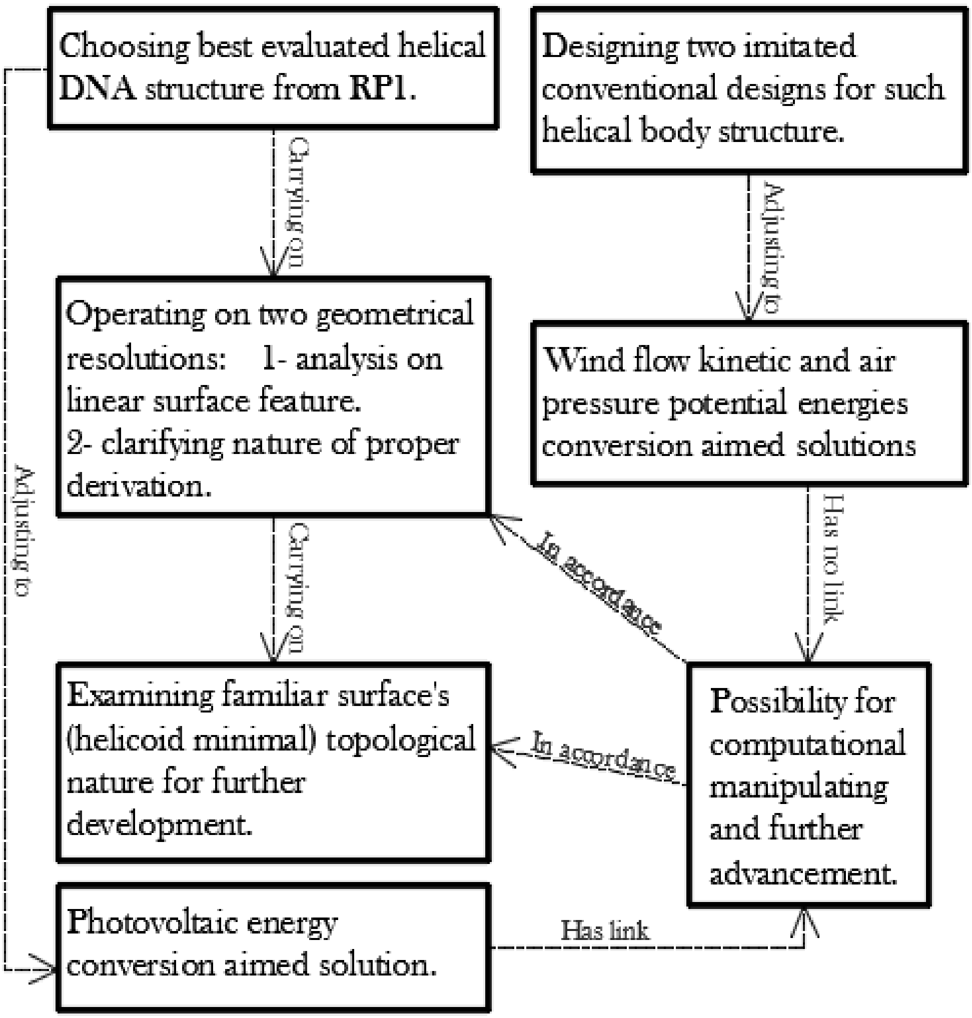
These are illustrations from designed version for solar energy panel settlement on helicoid tower. Those complex tubes are for sustainable placement of panels on saddle rectangle segmental sectors of second surface. After all last calculations, could be computed solar panels area calculations same time it could be done for windows areas. That is quite harder part, because the area of saddle rectangle is being computed with double-integrals and beside that, there is known parameter by the name area element, which is hard to calculate. (16 – Research Project 2.4.3.3 Solar energy. 2016.)

That area element is infinitesimal integration computation, which is quite big and complex to write here and explain. However, it is possible to calculate those saddle rectangle wings areas by CAD measurement tools for easy.

9. Conceptual model

(A)-Choosing helical tower structure from RP1 graphical part. Carrying on that for operation over two geometrical resolutions: 1- analysis on linear surface feature (as in Shukov's patented principle), 2- clarifying nature of proper derivation for correct surface enclosure and interior volume. Next, carrying that proper derived structure, into new examination, where making certain helical surface has topological equality with catenoid. That was necessary in this case study to develop helical surface in evolutionary state. (B)- Simultaneously adjusting that helical DNA structure from RP1, to photovoltaic energy conversion aimed solution state. (C)- Meanwhile, designing two imitated conventional designs for such helical body. Adjusting them to wind flow kinetic and air pressure potential energies conversion aimed solutions. (D)- possibility for computational manipulating and further advancement. (B)-developed structure has link to (D) in accordance with (A)'s geometrical resolutions, while (C) hasn't.

Conceptual model of research project 2



Conclusion of Research Project2

Here in RP2 (Empirical Research) DNA-helical tower structure gained from RP1, was analyzed in wider aspect according three major empirical statements under geometrical resolution subset. And only one of three ecologically aimed design solutions was modelled according those rules and formulations from RP1 and RP2, that was Solar aimed design solution.
What was the purpose of this empirical research and what was motif for carrying it till experimental research?

1- According the title name of this Project series: “On the other hand, the architectural context also poses new problems to geometry. Around these problems, the research area of architectural geometry has emerged”. Really it was considered somehow controversial shape of helical surface types, there was no such profound mathematical formulations and those analytical researches for that helical form in geometry. I have made them in order just for making sure and possible to implement that type of helical shape in architectural designing. But later, I realized I found new equations for geometry too.
2- One of the significant purposes of this research is about even beyond simple parametric designing, making green energy design solution under computational designing methodology, and proving its privileges over simple conventional design solutions according geometric hypothesis.
3- The motif to carry this project till experimental project stage, came from the topological equality statement. Exactly it was reason of proving and evaluating that, which of this ecological design solutions is more beneficial and could be modified into more advanced design solution as was done at RP3 (regarding this, will be explicitly explanation in RP3).

10. Chosen building-site for experimental projects

The place has been chosen for building-site purpose, is located in Baku, capital city of Azerbaijan. (Fig.24)

"Chosen building-site for Experimental project: The reason of choosing Baku is because of Baku is progressing towards for erecting higher towers and skyscrapers. In Baku there is going to be built new tower which is name Azerbaijan Tower, expected completion is 2020 the total height will be 1050m. In our case the highest tower, 1316.53 m for latest residential floor and 2003 m for whole building." (17 –Research Project 3. Chosen building-site for Experimental project. 2016.)

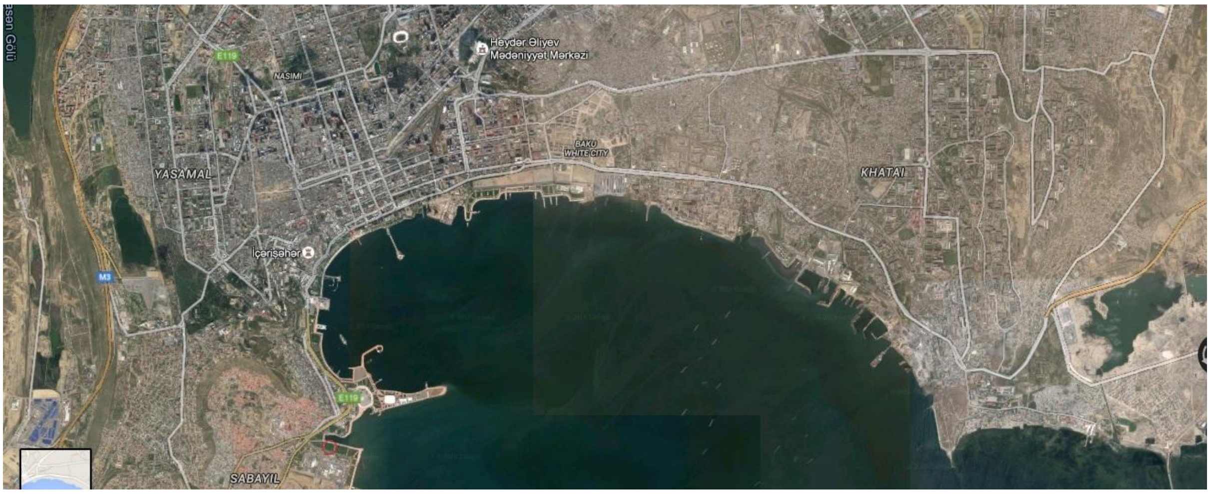


Figure.25: Building-site is marked by red circle in both maps.

11. Elaboration over the determined design solutions

"Data necessary to prepare the project and its analysis: Now here will be handled theories and formulas respectively for each design solution, afterwards, sequentially those equations will be computed and the necessary values of energy amount will be taken into decision of comparison. Same algorithmic way all projects will be held in hand till finding their total energy generation amount in apart from each other. In spite of that, this problem could be solved by some known relevant software. There was some lack of possibility to reach those software, because they are too much expensive to buy and plus hard to learn them for this short time of requirement. And there is no need so far in this RP aim, to find exact amount of energy it could be approximately, but it should be known which one is most value by comparison." (18 –Research Project 3. Data necessary to prepare the Project and their Analysis. 2016.).

1-(Research Project 2: 8.1) First aimed: So, here it should be looked first for proper approach of theoretical fundamentals (as well in all of design solutions).

Here and at second version of WE is needed first of all to look out for wind speed in different altitudes and air density (which in its turn always proportional with pressure in all liquids and gasses)

These two factors are decisive in both of WE designs. Other factors will derive from these ones step by step. At the end of collecting all necessary parameters, energy output will be defined by concerning formulas.

Initial parameters are known from designs' geometrical solutions.

Here in WE 1 variant, the initial parameters are heights and areas of tubes' entrance and exit parts, others are Betz coefficient as known by 0.59 and finally $\mathrm{R_{specific}}$ (The specific gas constant for dry air is 53.35 ($\mathrm{Ib_f \cdot ft}$). (19- Density of dry air. Marshall,John and Plumb,R. Alan (2008), Atmosphere, ocean, and climate dynamics).

And the $\mathrm{c_{pb}}$ pressure coefficient is a special parameter of INVELOX wind turbine system which is mentioned at RP2 for applying in WE 1 version. The specific characters and distinguished calculation algorithms of this tech is slightly different than conventional wind turbine calculations. (20-Received 17 February 2015, Revised 25 August 2015, Accepted 17 September 2015, Available online 22 October 2015)

Here concern directly will be spot on simplified final formula (8.1.1), for direct inputting parameters and gaining needed result.
That is:

$$E = \mu A_1 S_R \left(1 - c_{pb} - k_b\right) \frac{1}{2} \rho U_1^3 \tag{8.1.1}$$

This is INVELOX system energy output calculation formula. By this equation is possible manually calculate energy output of this system. Here beside this some other sub-formulas exist (11.1) for this special variable parameters:

$$k_b = S_R^2(A_1/A_2)^2 \text{ and } S_R = U_1/U_2 \tag{11.1}$$

Here:

U_1 - top entering free wind stream velocity.

U_2 – side entering free wind stream velocity.

c_{pb} – pressure coefficient.

μ – Betz coefficient.

A_1 – top part entry hole area.

A_2 – down part leaving hole area.

ρ - top level air density.

S_R – velocity amplification.

k_b – fraction of kinetic energy loss and incoming kinetic energy

E – the output energy amount.

So according all these equations, on each part settled INVELOX turbines of tower's inner surface will be defined. The dimensions of tubes will decrease as it is approaching to ground level, that is because of there is less wind speed as it is going to be less altitude.

Equation for wind speed relatively with altitude:

$$v_h = v_{10}(\frac{h}{h_{10}})^\alpha \tag{11.2}$$

Here:

v_h - velocity of wind at height h

v_{10} – velocity of the wind at 10 meters

h - altitude

h_{10} = 10 meters

α – Hellman exponent

"The Hellmann exponent depends upon the coastal location and the shape of the terrain on the ground, and the stability of the air." (21- Wind turbines. Source: Heier, Siegfried (2005). *Grid Integration of*

Wind Energy Conversion Systems. Chichester: John Wiley & Sons. © 2005.)
This rule will be used at WE2 too. However, there will be conventional wind turbine.

2-(Research Project 2: 8.1) Second aimed: The principle of this variant design energy generation is basically about creating artificial air pressure on top upper part of tower to increase air velocity to down part propellers in order to gain more increased energy collection.
It is being executed by setting big fan on top of the roof on tower which will be accelerated by some amount of energy to generate artificial hurricane in its inside volume, which in its turn joined from one hole to helix channel from down part. That helix air influx-channel is twisting down along waist part of helical tower.
The artificial hurricane inside top-roof fan will have pressure in its own as the real hurricanes have. That pressure will try to exit from down part hole which connects to channel (it is because of special physics that is not necessary to explain here, it is enough long and complicated explanation), due to that, it will make pressure at down part hole to exit and flow inside air influx-channel. That will create air flow with velocity:

$$v = \sqrt{\frac{2q}{\rho}} \qquad (11.3)$$

Here:

$v -$ air flow velocity

$q -$dynamic pressure

$\rho -$ air density in kg/m^3

(22- Dynamic pressure. Link Source: https://en.wikipedia.org/wiki/Dynamic_pressure) The pressure "q" (measured pressure) will be more than normal altitude pressure (statistic pressure).

According Betz limit the maximum possible energy conversion coefficient is $C_p = \frac{16}{17} = 59\%$. That means 59% of energy from first artificial air flow will be consumed by 11th propeller which one on the heights than other ones and so on the remain 41% of air flow will go to down to travel through other propellers. Of course, on its own alone that will not be enough to achieve sufficient energy, because while air flow inside channel will pass each propeller there will be less energy remained for next propellers. So, upper of helical channel will be replaced punctures, they will be in small size under certain small degree opened alongside of inner artificial air flow movement direction. That is why they will not allow inner flow to run out and vice versa through them outer nature air flow will be sucked inside channel, and there will be more pressure and velocity again in channel to down side propellers. So, as much as wind kinetic energy will be lost in each propeller 59% and the remain part will go with 41% there will be additional air velocity joined to that from outside. Of course, it could not be 100% proved but according physics' basics it should work like that as far.

The principle for calculating inner pressure in hurricane is coming out like this:

$$C_p = \frac{P_m - P_s}{\frac{1}{2}\rho V^2} \quad \rightarrow \quad P_m = C_p \cdot \frac{1}{2} \cdot \rho \cdot V^2 + P_s \tag{11.4}$$

Where:

C_p − pressure coefficient

P_m − measured pressure (inner pressure created by top big fan)

P_s − statistic pressure (outer pressure naturally depended on altitude)

ρ − air density

v − wind velocity (23- Pressure Measurement in within large Hurricane. Timothy M. Samaras. Julian J. Lee. Applied Research Associates, Inc. 2002.).

Here, we will accept the pressure coefficient equal to 0.7 because the wind flow enters on same angel of rotation horizon plane of big fan. Entire principle is close to WE1, while aim is gaining potential electricity energy from wind kinetic energy. However, here supposed conventional wind turbine settlement as in WE1 was INVELOX system.

For the conventional turbine energy conversion:

$$E_{avail} = \frac{1}{2}\rho A v^3 C_p \tag{11.5}$$

Here:

E_{avail} − available gained potential electricity energy

C_p − Betz coefficient=59%

ρ − density of air

A − area of propeller rotation surface

v − velocity of wind flow. (24- Wind turbine power calculations.2003)

3-(Research Project 2: 1.3.3) Third aimed: At the RP2 it was clarified out that solar and passive solar energy combined design solution is exactly suited for helical form and solar panel placement on surface segments. That was due to the proper designing the surface according hypothetical statements 7.1 and 7.2 at RP2.

Furthermore, in this section will be general conclusion for description and justification of whole research project. There will be explanation of main reasons of this designs' privilege.

Solar energy collector panels are differing from their voltage to currents. The maximum energy efficiency coefficient according that differs too.

$$I= I_{pv} - I_0 \cdot (e^{bv} - 1) \tag{11.6}$$

$$I_0 = 4.1 \cdot 10^{-5}$$
$$b = 0.5$$

The photovoltaic current $\mathrm{I_{pv}}$ is variable and depends on the amount of solar radiation, which in its turn depends on the time of day (how much time panel stays under solar lights per day):

$$\mathrm{I_{pv}} = 2.54 \cdot \sin\left[\frac{\pi}{12} \cdot (t - 6)\right] \tag{11.7}$$

here:

$t = 6$ corresponds to sunrise

$t = 12$ to solar noon

$$\mathrm{P = IV} \tag{11.8}$$

Here P-is power, I- is current, and V- is voltage. For the maximum power generation needs to accept both parameters in high values.

The maximum voltage and current is estimated when time is equal to 12 hours. So, $t_{max} = 12.$ (25-Maximum Power from a Solar Panel. Michael Miller, University of South Florida.)

$$\mathrm{E_{max}} = \left\{\left[2.54 \cdot \sin\left[\frac{\pi}{12}\right] \cdot (t_{max} - 6)\right] - I_0 \cdot \left(e^{v_{max}/2} - 1\right)\right\} V_{max} \approx 39.92\mathrm{W}. \tag{11.9}$$

4-(Research Project 2: 1.5) Topological transformation. Geometrically general analysis and their formulas for best evaluation: The difference of this methodology is simply anent of representing the more importance of human independence in controlling on full resolution of projects in spite of it is possibility to make them in software.

The structure of this method, is alike with AAD (Algorithmic Aided Design), the difference is: this project series carry wider analytical aspects than simple AAD. As was declared in parametric architecture terminology: “Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response.”(26- Parametric design. *Jabi, Wassim. Parametric Design for Architecture. London: Laurence King.*). © *2013.*)

The words: rules, define, encode, design response, these words are vital factors of AAD. Here in 1.5 hypothetical statement, the same principles are being examined. What is different? The whole procedure are being taken in that all steps in mathematical-geometric formulations, this way, it is being made sure that, factors and design responses are correct. Software will not be able to keep whole composition in once, from begging till the end results (response) as it is done here. In software in each step, it will be slightly tend to other direction of design due to its limited functions and at the end this design response will be even at the most possible precise case insignificantly distinguished than this methodology way response. It is obvious for nearly 90% of Architects, it will be hard to accept it because of they are not interested in geometry. Although, this project mainly is about geometrical survey of contemporary architectural designing. Architecture now in some branches, is about Art and in other branches, is about technical and parametric elaborations. There is need to respect each other's skills and works as much as we all want to improve and advance. This hypothetical statement has two chapters. Each one is related to different features. First one related to interior volume parameters while second one related to exterior surface structure parameters. Both of them, are considered according RP2 hypothetical statements 7.1 and 7.2 together with simultaneously RP1 chapter 5.

It was revealed in RP1: the naturally derived floor perimeter has special shape like almond-shaped (Fig.25). Now here, that floor shape also will be deeply and exactly examined and parameters of it will be linked to each other and to whole tower structure parameters.

This is first part of this statement.

The second part also was mentioned in RP1, it was the curvature and radius of towers surface along vertical standing position. They are very important indications of tower nature and of its whole curved surface and plus nature of lines which ones are placed on that.

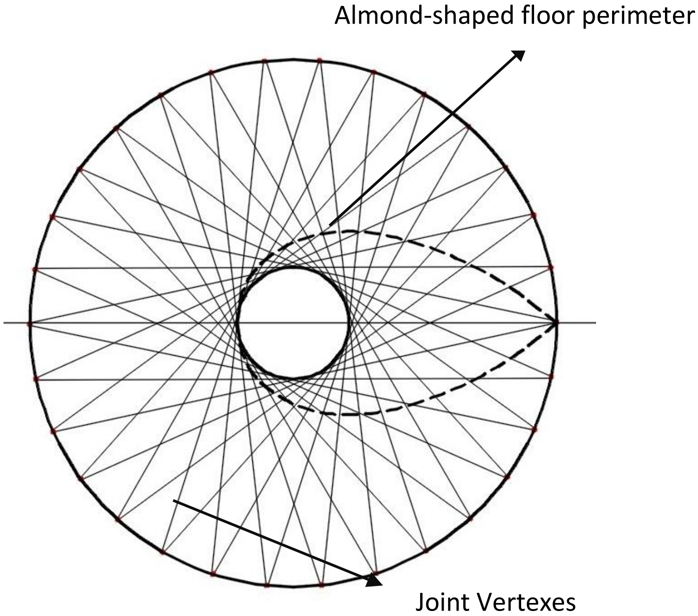
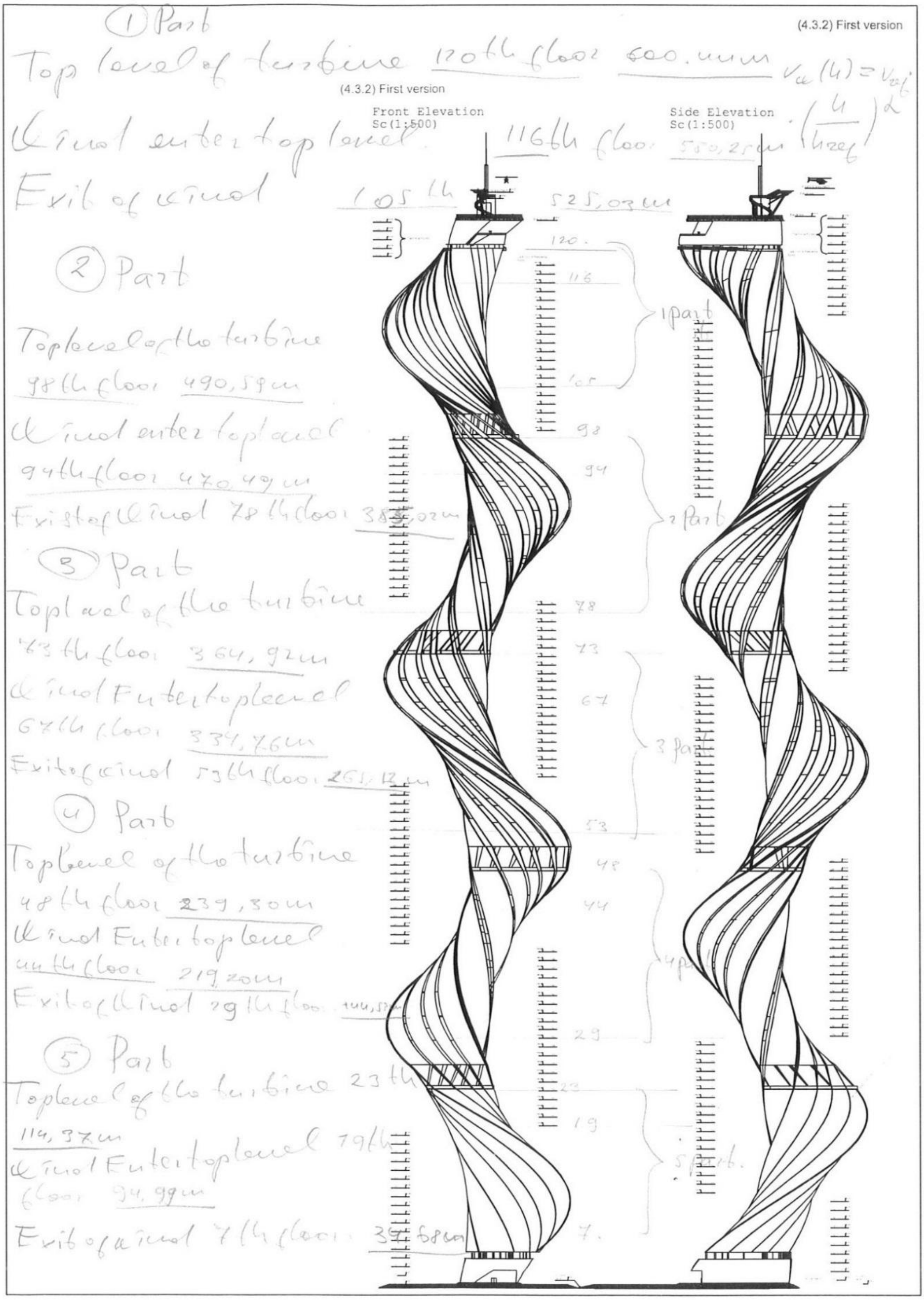


Figure.26. Floor perimeter of DNA-Helical tower.

Those lines same time decide the fate of inner volume of tower as well they decide outer parameters on surface. There is true beauty of mathematical-geometry in that tower object. That curved line of surface is called envelope in geometry terminology. It means family curve line of those surface lines while all they are tangent to that. According that envelope curve and inner volume parameters parametrical connections, the project has been evaluated with reasonable carefully explanations: which design solutions obeys to those algorithmic design rules and which ones out of those rules.

Just by replacing basic circle with any type of spiral or any suited curvatures, it is possible to achieve different types of objects for tower forms. However, there should be enough fundamental formulations of them in order to make sure what type of inner volume and outer shape will be examined in order to match with reality. The essence of whole research project series will be once again clearly presented in this statement again.

11.1. (Research Project 2: 8.1) First aimed design solution.



1-Part

$h_{top} = 600\ m$

$h_{fw} = 580.25\ m$

$A_1 = 6.64995\ m^2$

$A_2 = 5.5991\ m^2$

$$v_{top} = 0.134 \cdot \left(\frac{600}{10}\right)^{1.7} = 141.2413708\ mph$$

$$v_{fw} = 0.134 \cdot \left(\frac{580.25}{10}\right)^{1.7} = 133.4290985\ mph$$

$141.2413708\ mph = 63.140542402432\ m/s$

$$k_b = \left(\frac{v_{top}}{v_{fw}}\right)^2 \cdot \left(\frac{A_1}{A_2}\right)^2 = \left(\frac{1412.13708}{13342.90985}\right)^2 \cdot \left(\frac{6.64995}{5.5991}\right)^2 \approx 1.1205 \cdot 1.4106 \approx 1.5806$$

Velocity by amplification:

$$S_R = \frac{v_{top}}{v_{fw}} = \frac{141.2413708}{133.4290985} \approx 1.059.$$

$P = 94.1\ kPas.$

$T = 16℃$

$R_{specific} = 53.35$

$c_{pb} = -1$

$\mu = 0.59 \rightarrow$ Betz co.

$$\rho = \frac{P}{R_{specific} \cdot T} = \frac{94.1}{53.35 \cdot 16} = 0.110238\ q/m^3 \tag{11.1.1}$$

$$E_1 = \mu \cdot A_1 \cdot S_R \cdot (1 - C_{pb} - k_b) \cdot \frac{1}{2} \cdot \rho \cdot (v_{top})^3 =$$

$$= 0.59 \cdot 6.64995 \cdot 1.059 \cdot (1 + 1 - 1.5806) \cdot \frac{1}{2} \cdot 0.110238 \cdot (63.140542)^3 = 24.178\ kW$$

2-Part

$h_{top} = 490.59\ m$

$h_{fw} = 470.49\ m$

$A_1 = 5.4811\ m^2$

$A_2 = 4.921\ m^2$

$$v_{top} = 0.134 \cdot \left(\frac{490.59}{10}\right)^{1.7} = 100.3059219\ mph$$

$$v_{fw} = 0.134 \cdot \left(\frac{580.25}{10}\right)^{1.7} = 93.42013135\ mph$$

$100.3059219\ mph = 44.840759\ m/s$

$$k_b = \left(\frac{v_{top}}{v_{fw}}\right)^2 \cdot \left(\frac{A_1}{A_2}\right)^2 = \left(\frac{100.3059219}{93.42013135}\right)^2 \cdot \left(\frac{5.4811}{4.921}\right)^2 \approx 1.152848 \cdot 1.1138$$
$$\approx 1.28406$$

Velocity by amplification:

$$S_R = \frac{v_{top}}{v_{fw}} = \frac{100.3059219}{93.42013135} \approx 1.07370.$$

$P = 94.95\ kPas.$

$T = 16℃$

$R_{specific} = 53.35$

$$c_{pb} = -1$$

$\mu = 0.59$ → Betz co.

$$\rho = \frac{P}{R_{specific} \cdot T} = \frac{94.95}{53.35 \ \cdot 16} = 0.11123\ q/m^3$$

$$E_2 = \mu \cdot A_1 \cdot S_R \cdot \left(1 - C_{pb} - k_b\right) \cdot \frac{1}{2} \cdot \rho \cdot \left(v_{top}\right)^3 =$$

$$= 0.59 \cdot 5.4811 \cdot 1.07370 \cdot (1 + 1 - 1.28406) \cdot \frac{1}{2} \cdot 0.11123 \cdot (44.840759)^3 = 12.465\ kW$$

<u>3-Part</u>

$h_{top} = 364.92\ m$

$h_{fw} = 334.76\ m$

$A_1 = 4.8330\ m^2$

$A_2 = 4.214\ m^2$

$$v_{top} = 0.134 \ \cdot \left(\frac{364.92}{10}\right)^{1.7} = 60.6514\ mph$$

$$v_{fw} = 0.134 \ \cdot \left(\frac{334.76}{10}\right)^{1.7} = 52.3783543\ mph$$

$60.6514\ mph = 27.113602\ m/s$

$$k_b = \left(\frac{v_{top}}{v_{fw}}\right)^2 \cdot \left(\frac{A_1}{A_2}\right)^2 = \left(\frac{60.6514}{52.3783543}\right)^2 \cdot \left(\frac{4.8330}{4.214}\right)^2 \approx 1.3408 \cdot 1.31536 \approx 1.76363$$

Velocity by amplification:

$$S_R = \frac{v_{top}}{v_{fw}} = \frac{60.6514}{52.3783543} \approx 1.340843$$

$P = 96.7\ kPas.$

$T = 16℃$

$R_{specific} = 53.35$

$$c_{pb} = -1$$

$\mu = 0.59$ → Betz co.

$$\rho = \frac{P}{R_{specific} \cdot T} = \frac{96.7}{53.35 \ \cdot 16} = 0.11328\ q/m^3$$

$$E_3 = \mu \cdot A_1 \cdot S_R \cdot \left(1 - C_{pb} - k_b\right) \cdot \frac{1}{2} \cdot \rho \cdot \left(v_{top}\right)^3 =$$

$$= 0.59 \cdot 4.833 \cdot 1.3110943 \cdot (1 + 1 - 1.76363) \cdot \frac{1}{2} \cdot 0.11328 \cdot (27.1136)^3 = 4.221\ kW$$

<u>4-Part</u>

$h_{top} = 239.3\ m$

$h_{fw} = 219.20\ m$

$A_1 = 3.944\ m^2$

$A_2 = 3.391\ m^2$

$$v_{top} = 0.134 \cdot \left(\frac{239.30}{10}\right)^{1.7} = 29.601068\ mph$$

$$v_{fw} = 0.134 \cdot \left(\frac{219.20}{10}\right)^{1.7} = 25.49962\ mph$$

$29.601068\ mph = 13.2328614\ m/s$

$$k_b = \left(\frac{v_{top}}{v_{fw}}\right)^2 \cdot \left(\frac{A_1}{A_2}\right)^2 = \left(\frac{29.601068}{25.49962}\right)^2 \cdot \left(\frac{3.944}{3.391}\right)^2 \approx 1.3478 \cdot 1.38033 \approx 1.860409$$

Velocity by amplification:

$P = 98.5\ kPas.$

$T = 16℃$

$R_{specific} = 53.35$

$$S_R = \frac{v_{top}}{v_{fw}} = \frac{29.601068}{25.49962} \approx 1.160843495.$$

$c_{pb} = -1$

$\mu = 0.59 \rightarrow$ Betz co.

$$\rho = \frac{P}{R_{specific} \cdot T} = \frac{98.5}{53.35 \cdot 16} = 0.11539\ q/m^3$$

$$E_4 = \mu \cdot A_1 \cdot S_R \cdot (1 - C_{pb} - k_b) \cdot \frac{1}{2} \cdot \rho \cdot (v_{top})^3 =$$

$$= 0.59 \cdot 3.984 \cdot 1.1608 \cdot (1 + 1 - 1.86041) \cdot \frac{1}{2} \cdot 0.11539 \cdot (13.2328614)^3 = 0.2041\ kW$$

5-Part

$h_{top} = 114.37\ m$

$h_{fw} = 94.99\ m$

$A_1 = 3.01\ m^2$

$A_2 = 2.399\ m^2$

$v_{top} = 0.134\ \cdot \left(\frac{114.37}{10}\right)^{1.7} = 8.437920\ mph$

$v_{fw} = 0.134\ \cdot \left(\frac{94.99}{10}\right)^{1.7} = 6.153995969\ mph$

8.437920 mph = 3.772087757 m/s

$$k_b = \left(\frac{v_{top}}{v_{fw}}\right)^2 \cdot \left(\frac{A_1}{A_2}\right)^2 = \left(\frac{8.437920}{6.153995969}\right)^2 \cdot \left(\frac{3.01}{2.399}\right)^2 \approx 1.87999\ \cdot 1.574245 \approx 2.96$$

Velocity by amplification:

$$S_R = \frac{v_{top}}{v_{fw}} = \frac{8.437920}{6.153995969} \approx 1.37113.$$

$P = 100.8\ kPas.$

$T = 16℃$

$R_{specific} = 53.35$

$c_{pb} = -2$

$\mu = 0.59 \rightarrow$ Betz co.

$$\rho = \frac{P}{R_{specific} \cdot T} = \frac{100.8}{53.35\ \cdot 16} = 0.11808\ q/m^3$$

$$E_5 = \mu \cdot A_1 \cdot S_R \cdot \left(1 - C_{pb} - k_b\right) \cdot \frac{1}{2} \cdot \rho \cdot \left(v_{top}\right)^3 =$$

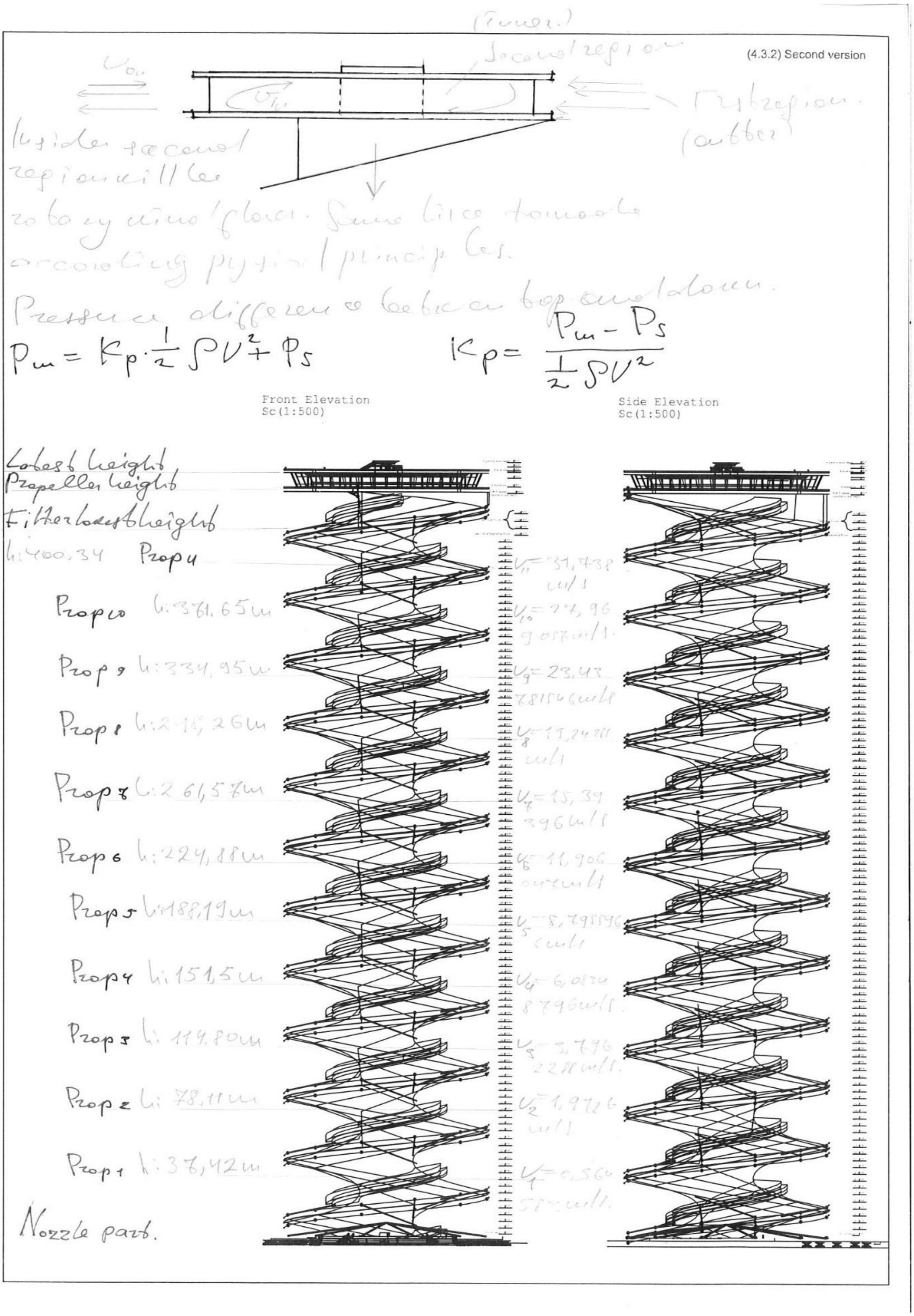
$$= 0.59 \cdot 3.01 \cdot 1.37113 \cdot (1 + 2 - 1.5806)\ \cdot \frac{1}{2} \cdot 0.11808 \cdot\ (3.77209)^3 = 0.0003086\ kW$$

Total energy collection from all five parts altogether:

$E_1 + E_2 + E_3 + E_4 + E_5 = 24.178\ kW + 12.465\ kW + 4.221\ kW + 0.2041\ kW +$
$0.0003086\ kW = 41.37678749 kW/s$

$$\frac{41.37678749kW}{s} = \frac{148956.4332kW}{h} = \frac{148.956MW}{h}$$

11.2. (Research Project 2: 8.1) Second aimed design solution.



Top-roof fan is placed on the helical tower as its centre matches with the centre of helicoid tower (Fig.26).

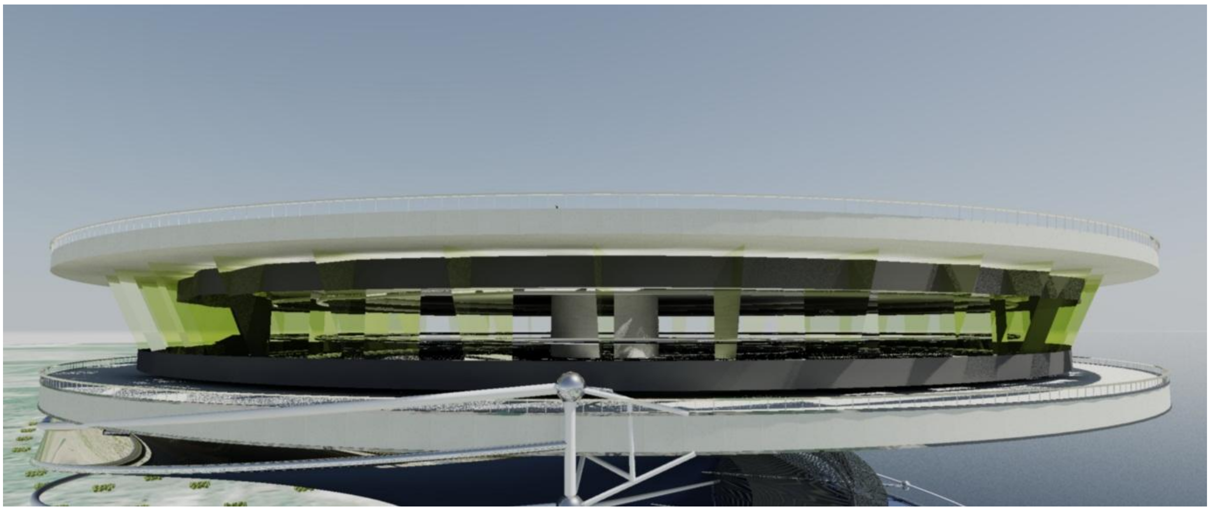


Figure.27. Top-roof fan of WE 2nd Version

That fan helps to create inner artificial pressure which is several times more than normal same altitude outer presser. It allows to increase the velocity of air flow in tube explained in (RP2-8.1 and RP3-11) WE 2nd version.

Calculus of inner pressure in hurricane:

$$P_m = K_p \cdot \frac{1}{2} \cdot \rho \cdot v^2 + P_s \tag{11.2.1}$$

Here, the outer pressure and density are in right proportion and pressure could be found according schedule of The Engineering Toolbox. (27-Altitude and Air Pressure. Link Source: http://www.engineeringtoolbox.com/air-altitude-density-volume-d_195.html)

$K_p = 0.7$

$\rho = \frac{99.4}{53.35 \cdot 23} = 0.08kq/m^3$

$v = 0.134 \cdot \left(\frac{454.15}{10}\right)^{1.7} = 87.9718\ m/s$

$P_m = 0.7 \cdot 0.08 \cdot 7739.04 + 99.4 = 316.09\ kPas.$

In sequential order air flow velocity derived from that artificial air pressure:

$$v = \sqrt{\frac{2 \cdot 316.09}{0.08}} = 88.894\ m/s$$

Density of this air flow is:

$$\rho = \frac{316.09}{23 \cdot 53.35} = 0.2576 \;\; kq/m^3$$

So, the first generated electricity energy in 11th propeller is:

$$E_{11} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (88.894)^3 \cdot 0.59 = 1552.314 \, W$$

Afterwards the propellers will take less wind kinetic energy according Betz theory. Each one will decrease 0.41 times relatively previous one. But, that will not affect on energy conversion directly, first it will affect on released next air flow velocity, and that velocity will show up the energy decrease in conversion at next propeller.

It will be complicated to write them all in once, so, it is better to write them separated in different schedules down here.

First let's schedule the outer wind speeds according their altitudes:

Propeller 10:

$$v_{10} = 0.314 \cdot \left(\frac{371.65}{10}\right)^{1.7} = 62.565 \, mph = 27.9690576 \;\; m/s$$

Propeller 9:

$$v_9 = 0.314 \cdot \left(\frac{334.95}{10}\right)^{1.7} = 52.4289 \, mph = 23.43781546 \;\; m/s$$

Propeller 8:

$$v_8 = 0.314 \cdot \left(\frac{298.26}{10}\right)^{1.7} = 43.04436 \, mph = 19.24255 \;\; m/s$$

Propeller 7:

$$v_7 = 0.314 \cdot \left(\frac{261.57}{10}\right)^{1.7} = 34.4353 \, mph = 15.39395 \;\; m/s$$

Propeller 6:

$$v_6 = 0.314 \cdot \left(\frac{224.88}{10}\right)^{1.7} = 26.63307 \, mph = 11.9060476 \;\; m/s$$

Propeller 5:

$$v_5 = 0.314 \cdot \left(\frac{188.19}{10}\right)^{1.7} = 19.675189 \, mph = 8.795596 \;\; m/s$$

Propeller 4:

$$v_4 = 0.314 \cdot \left(\frac{151.5}{10}\right)^{1.7} = 13.608375\, mph = 13.608375\ \ m/s$$

Propeller 3:

$$v_3 = 0.314 \cdot \left(\frac{114.8}{10}\right)^{1.7} = 8.491922\, mph = 3.7962288\ \ m/s$$

Propeller 2:

$$v_2 = 0.314 \cdot \left(\frac{78.11}{10}\right)^{1.7} = 4.41271\, mph = 1.9726\ \ m/s$$

Propeller 1:

$$v_1 = 0.314 \cdot \left(\frac{37.42}{10}\right)^{1.7} = 1.2629357\, mph = 0.564583\ \ m/s$$

Now, time to estimate relevant propellers energy conversion:

Propeller 10:

$v_{pr10} = \ v_{pr11} \cdot 0.41 + v_{10} = 88.894 \cdot 0.41 + 27.969057 = 64.42\ \ m/s$

$$E_{pro10} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (64.42)^3 \cdot 0.59 = 590.778\, KW$$

Propeller 9:

$v_{pr9} = \ v_{pr10} \cdot 0.41 + v_9 = 64.42 \cdot 0.41 + 23.44 = 49.85\ \ m/s$

$$E_{pro9} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (49.85)^3 \cdot 0.59 = 273.752\, KW$$

Propeller 8:

$v_{pr8} = \ v_{pr9} \cdot 0.41 + v_8 = 49.85 \cdot 0.41 + 19.24 = 36.68\ \ m/s$

$$E_{pro8} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (36.68)^3 \cdot 0.59 = 109.056\, KW$$

Propeller 7:

$v_{pr7} = \ v_{pr8} \cdot 0.41 + v_7 = 33.68 \cdot 0.41 + 15{,}39 = 30.4288\ \ m/s$

$$E_{pro7} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (30.4288)^3 \cdot 0.59 = 62.261\, KW$$

Propeller 6:

$v_{pr6} = v_{pr7} \cdot 0.41 + v_6 = 30.43 \cdot 0.41 + 11.91 = 24.39\ m/s$

$$E_{pro6} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (24.39)^3 \cdot 0.59 = 32.062\ KW$$

Propeller 5:

$v_{pr5} = v_{pr6} \cdot 0.41 + v_5 = 24.39 \cdot 0.41 + 8.8 = 18.8\ m/s$

$$E_{pro5} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (18.8)^3 \cdot 0.59 = 14.684\ KW$$

Propeller 4:

$v_{pr4} = v_{pr5} \cdot 0.41 + v_4 = 18.8 \cdot 0.41 + 6.08 = 13.79\ m/s$

$$E_{pro4} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (13.79)^3 \cdot 0.59 = 5.795\ KW$$

Propeller 3:

$v_{pr3} = v_{pr4} \cdot 0.41 + v_3 = 13.79 \cdot 0.41 + 3.8 = 9.45\ m/s$

$$E_{pro3} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (9.45)^3 \cdot 0.59 = 1.865\ KW$$

Propeller 2:

$v_{pr2} = v_{pr3} \cdot 0.41 + v_2 = 9.45 \cdot 0.41 + 1.97 = 5.85\ m/s$

$$E_{pro2} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (5.85)^3 \cdot 0.59 = 0.442\ KW$$

Propeller 1:

$v_{pr1} = v_{pr2} \cdot 0.41 + v_1 = 5.85 \cdot 0.41 + 0.56 = 2.96\ m/s$

$$E_{pro1} = \frac{1}{2} \cdot 0.2576 \cdot 29.08 \cdot (2.96)^3 \cdot 0.59 = 0.057\ KW$$

Total energy collection:

$$E_{pro1} + E_{pro2} + E_{pro3} + E_{pro4} + E_{pro5} + E_{pro6} + E_{pro7} + E_{pro8} + E_{pro9} + E_{pro10} + E_{pro11} = 2643.066\ KW$$

For top-roof fan rotation and keeping stability of inner artificial air-flow pressure, must be wasted some energy, (Fig.27).

So, here back going calculating of the fan's energy consumption:

Diameter= 138 m

Width= 4.245 m

Area= 1839.44 m^2

$E_{Fan} = \frac{1}{2} \cdot 1839.44 \cdot$

$\cdot (87.9718)^3 \cdot 0.08 =$

$= 2073.224\ kW$

Net gained energy is:

$E_{Total} - E_{Fan} = 569.842\ kW$

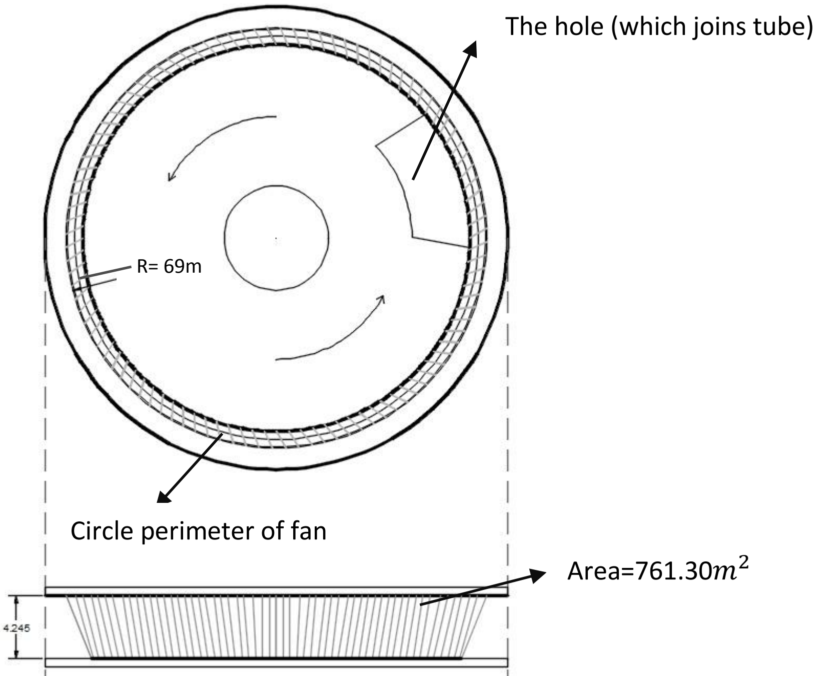
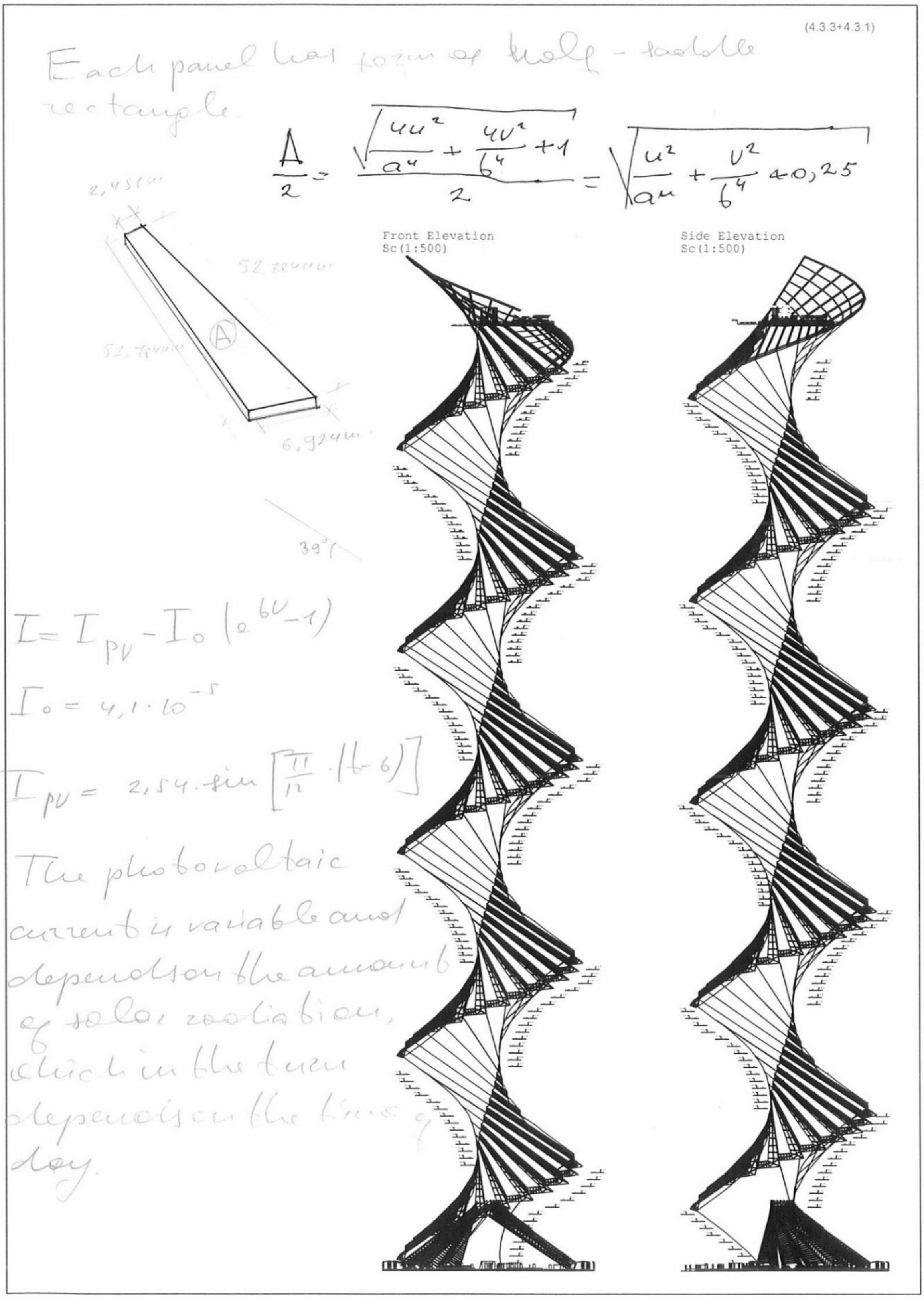


Figure.28. Top-roof fan plan and side views of WE 2nd Version

Comparing with first energy aimed design version, here achieved energy is nearly fourteen times bigger.

$$569.842 \frac{kW}{s \cdot 3600} \cdot 3600 = \frac{2051431.200kW}{h} = \frac{2051.431MW}{h}$$

11.3. (Research Project 2: 8.2) Third aimed design solution.



This aimed solution is in regular design order from small dimensions to whole composition due to maintenance of basic rules in RP2 4.1+4.2 (basics of RP1 hypothetical statement for general conclusion according chosen of DNA of its family series).
Over on each divided section is imagined to set solar panel which one will be by its shape same to segment panel and area will be equal to its half area (Fig.28). It would be over saddle-rectangle shape as was mentioned at RP2.

And they are tended under 39°,(Fig.29) relatively to horizon line .

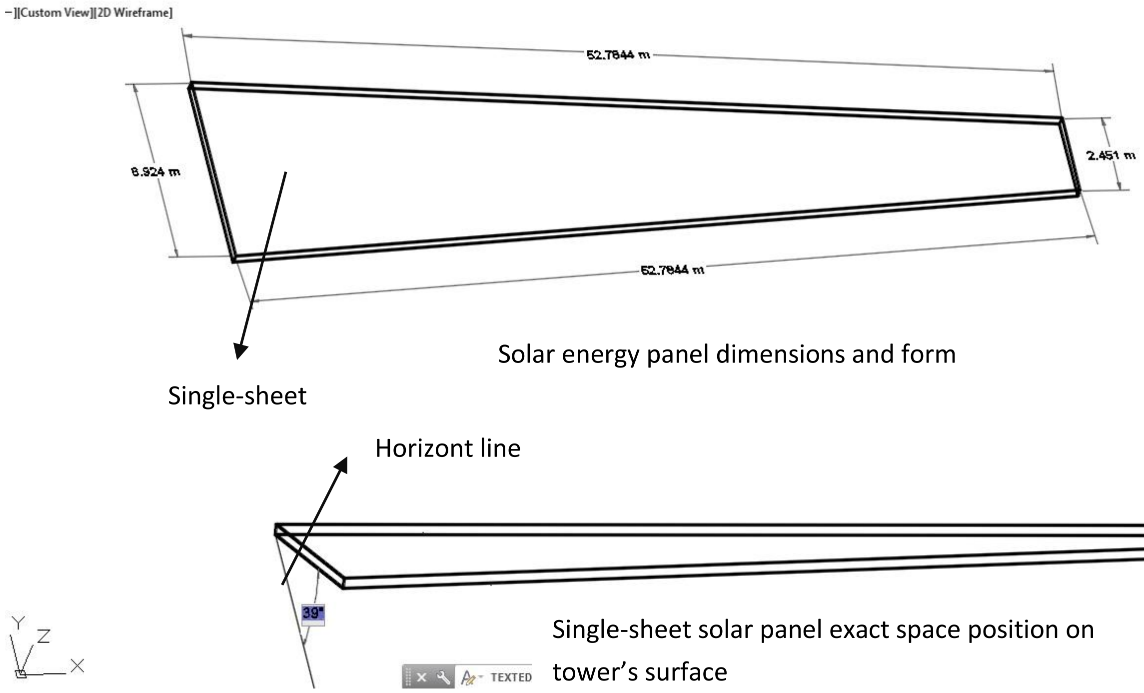


Figure.29. Solar-Panel dimensions and tend angel to horizon.

Area each of that solar-panels:

$$A = \frac{2.451 + 6.924}{2} \cdot 52.73 = 247{,}17\ m^2$$

According geographical regions the solar potential radiation differs. Baku capital of Azerbaijan located on coordinates: $40^{\circ}\ 23'\ 43''N, 49^{\circ}\ 52'\ 56''E,$ where the solar potential max up to 1500kWh/m^2. (28- Annual-sum of Solar Energy. SolarGIS © 2015 GeoModel Solar.)

Building parameters.

Climate type: Mediterranean

Building size: h=542.09 x r=53.535 m

Building solar panel covered area: 26694.36 m^2

Building location to poles: building is symmetrical helical shape, looking under same aspect to all poles.

Solar panel parameters.

Supposed kind of solar panels: PV Multicrystalline cells

Manufacture name: Solar world AG

Product characteristics: n.a

Module size: n.a

System size: each panel is over half saddle-rectangle (2.451m x 52.7844m x 52.7844m x 6.924m) total settlement area= 26694.36 m^2.

System position on the building: Spiral rotational rising up under same angel to all poles, only on one whole side façade.

Energy production nominal power: 1309.77kW/h. (29- Solar Energy System in Architecture. © 2012).

One simple whole wing panel is inclined under 39° degree relatively to horizon line, it means there will not be full consumption of solar radiation but according its fall angel on panels. That angel is:

$$90° - 39° = 51°$$

So, panels will receive only that part of energy which is equal to $\sin 51°$,(Fig.29).

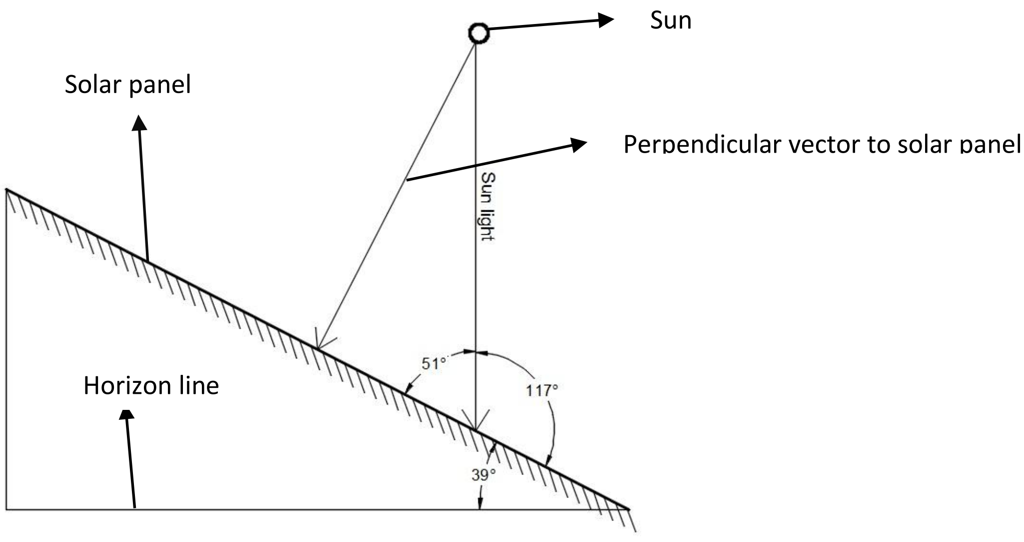


Figure.30: Sunlight fall on Solar-Panel under angel 51° to horizon.

One whole wing panel area is: 247.17 m^2

Energy calculation:

$$E_{wing\ panel} = {}^{E}/_{N_p} \cdot A_{wing\ panel} \cdot \sin 51° = 1\,309.77 \cdot 247.17 \cdot \sin 51° = 232.483\ MWh$$

For entire building, there are 108 such panels:

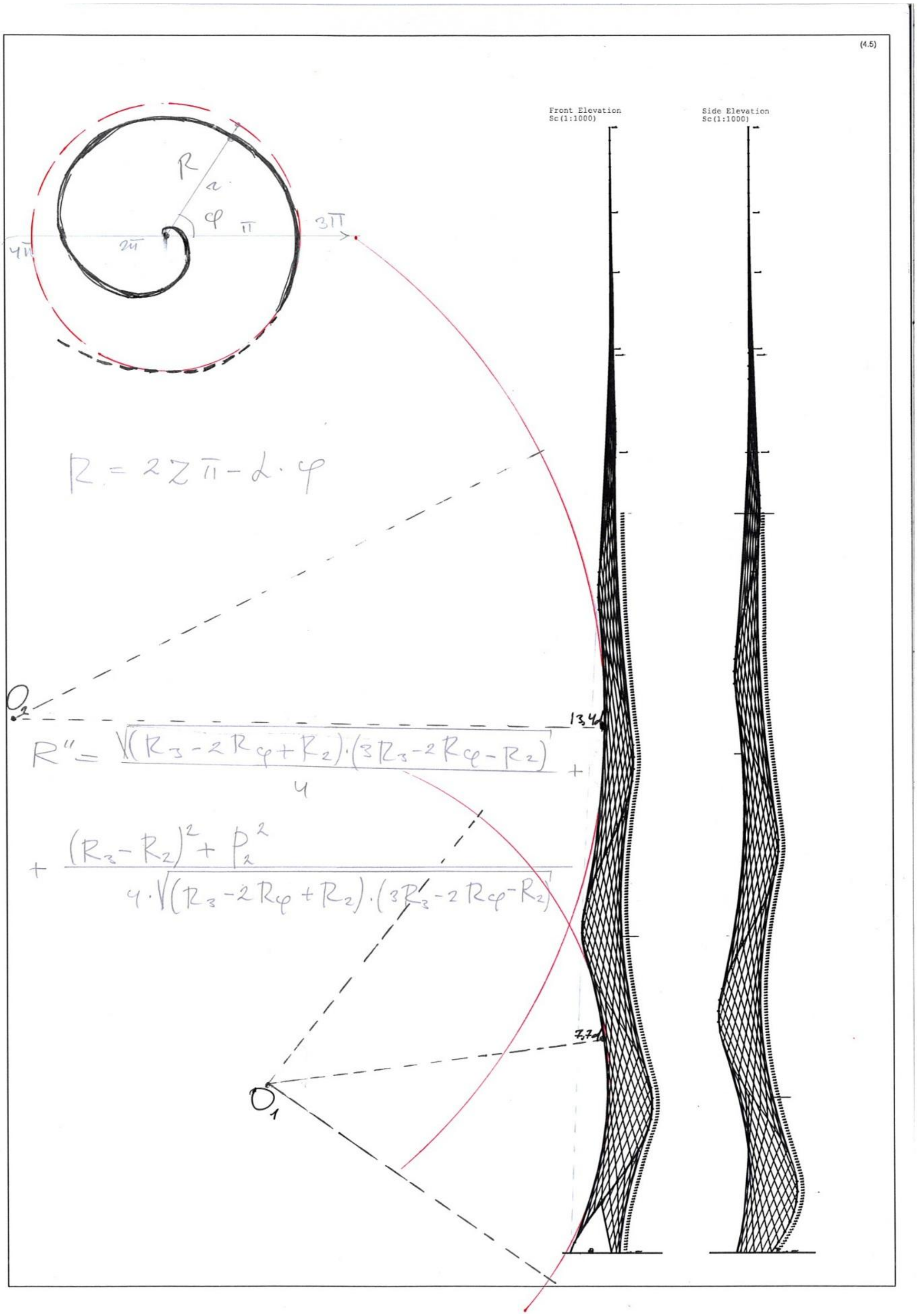
$$232.483\ MWh \cdot 108 = 25108.189\ MWh.$$

According geometrical symmetry of shape of façade sun can light one half of whole façade till will reach zenith point, after that time can light another remain half of it. Thus, calculus should be decreased to half amount of energy for both sides full day time lighting.

$$25108.189\ MWh \cdot 0.5 = 12554.09\ MWh$$

As already it is visible this amount of energy per hour is biggest comparing to previous aimed designs.

11.4. (Research Project 2: 7.3) Homotopic change of obtained helix shape at RP1, according its topological nature



As it was revealed at RP1, the naturally appeared (derived) floor perimeter is shaped like Nopmon mesh geometry. There are declared certain area of that floor geometry from the beginning of division on chosen radius of chosen base circle, (Fig.30).

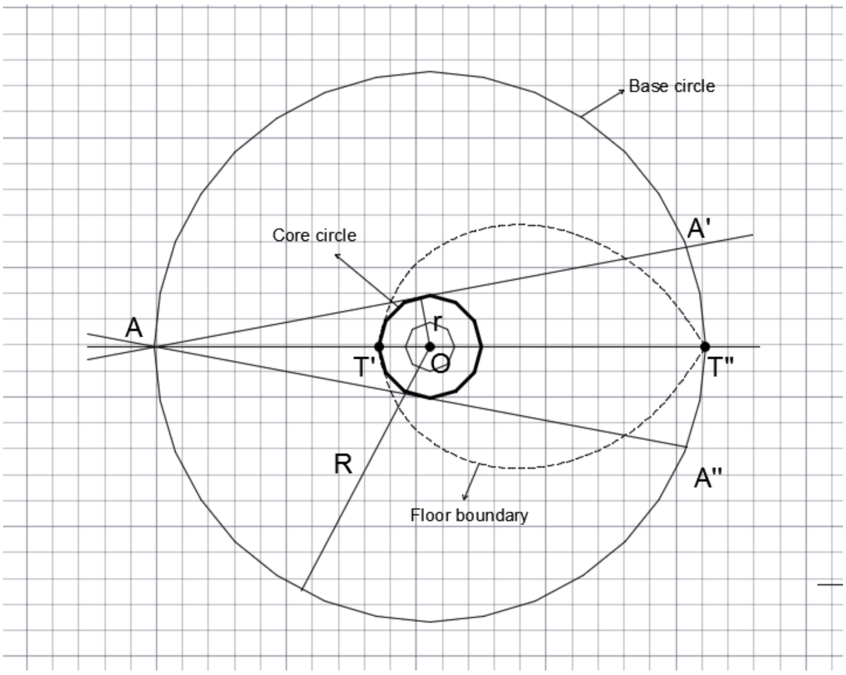


Figure.31: Naturally derived Floor shape boundary.

All design features and processes are linked with geometrical calculations and parametrically algorithmic design process which is in its own turn is linked also with geometrical theoretic fundaments. So, the evaluation of the designed towers will be held in hand according these rules. Parametric condition (Fig.31), of those formulas for floors' perimeters:

$$x = \frac{k+\theta-\theta v}{\theta v} R \cdot \cos\big(\theta(u+v-1)\big) + \left(1-\frac{k+\theta-\theta v}{\theta v}\right) r\cos(\theta(v-1)$$

$$y = \frac{k+\theta-\theta v}{\theta v} R \cdot sin\big(\theta(u+v-1)\big) + \left(1-\frac{k+\theta-\theta v}{\theta v}\right) r sin(\theta(v-1) \quad (11.4.1)$$

$[v \in (v_1(T); v_2(T))]$

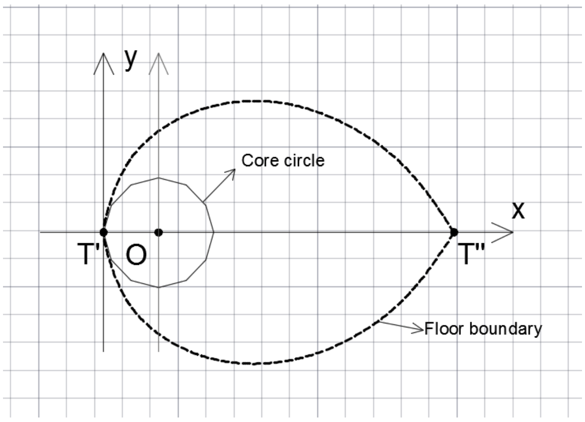


Figure.32: Floor curve placement in Cartesian

It was known the length of the curve on planymetric plane is being calculated by formula:

$$L = \int_a^b \sqrt{(x'(t))^2 + (y'(t))^2}\ dt. \tag{11.4.2}$$

The area of this figure is being counted by formula:

$$A = \int_a^b y(t) \cdot x'(t)\ dt. \tag{11.4.3}$$

Now the issue is that there should be connection between height of the tower and these parameters and through them all parametric connection to all possible parameters of decisive features.

Here tower reached height which is equal of tendril spirals rotation up to 5.26 (1) π.

As new case study for wider aspect on this helical towers, instead of circle on base, the Archimedes spiral will be substituted. Which in polar coordinate system being presented:

$$r = \alpha \cdot \varphi \tag{11.4.4}$$

Rotation angel now will affect simultaneously in two directions as it will grow – once it will narrow radius of upper floor parts and second it will rise helix in its constant pitch height. This fluent nature of these two geometric parameters allows for certain design. In spite of this fluent nature, the issue is slightly different than as we see its original state. Here it is needed to transfer spiral polar formula to opposite state where as the degree will increase the point on that and radius of that point respectively will approach to start point and radius will decrease. That is because of while helix will rise, it will be confused due to spiral also will get wider radius. There is need to find simple solution for this problem to prevent its such irrelevant growth. From this point appears idea to change simple Archimedes formula into new one which will decrease in same constant as it was growing.

In 11.4 tower, rotation is 947°, which corresponds to 2003.4m height.

Possible approach in shortest way is angel increase and radius decrease in one optimal way. As by logic if radius of spiral decreases there is need to present new formula in state of closed under certain rotation of some angel and deduct from that, the formula of Archimedes:

$$r = 2Z\pi - \alpha\varphi. \quad (11.4.5)$$

Here "Z" is representing how many times the spiral made circulation from origin point till closed one. That will be concerned as it is back twisting Archimedes spiral for this design aim (Fig.32). Otherwise in further research it may problems. Next step, there should be link between towers' height rising measures and twisting. And through that the formula should be gained which represents the mutually connection between radius of each floor base circle and height.

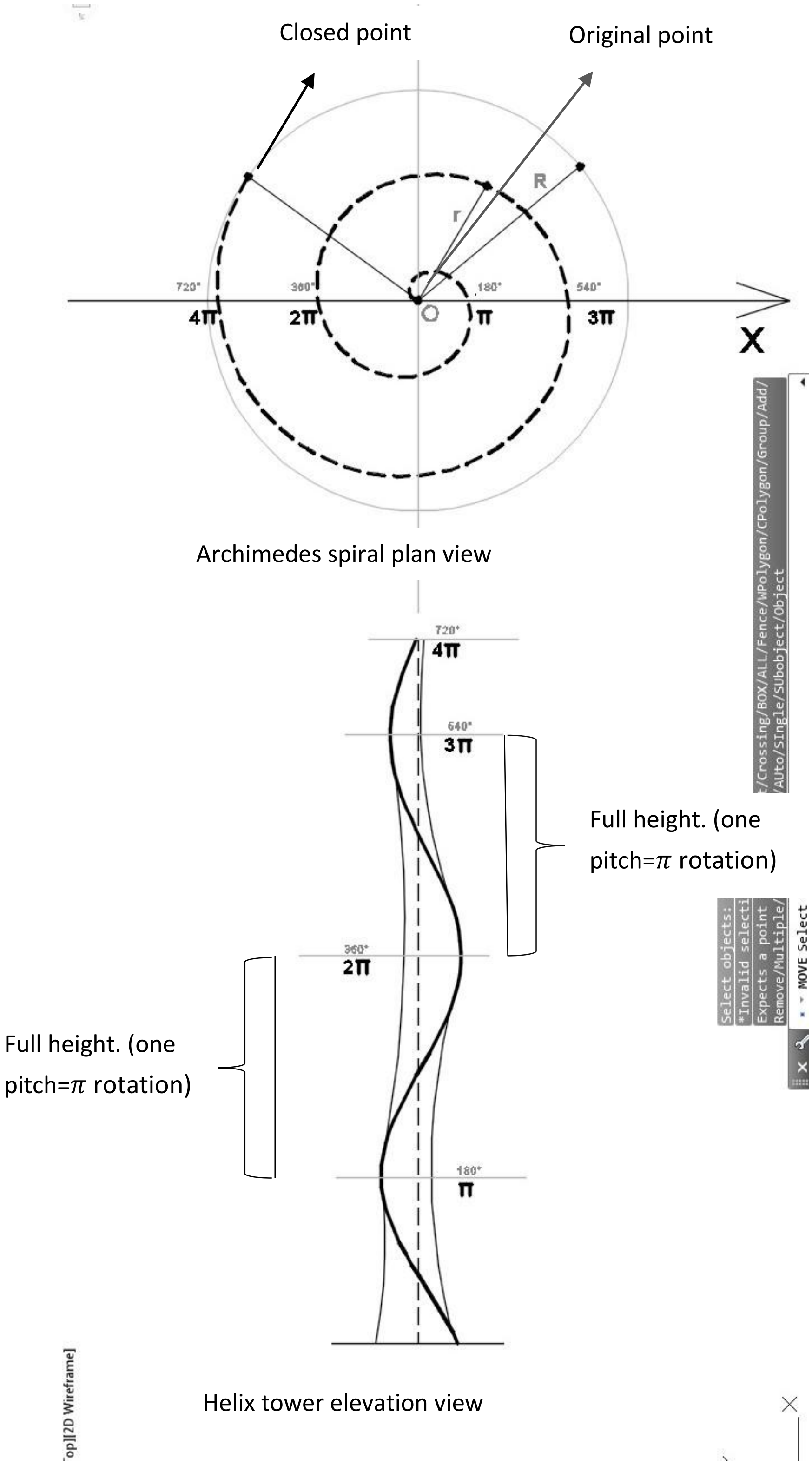


Figure.33: Archimedes spiral and 4.5 tower rise coherence.

Now, writing down common case equations.

Full rotation angel: $2Z\pi$

Full height (pitch): H

For unit rotation, equal height rise is: $\frac{H}{2Z\pi}$

Height in any twist: $$h = \varphi \cdot \frac{H}{2Z\pi} \tag{11.4.6}$$

From here let's turn back to formula of radius of circle:

$$R_2 = 2Z\pi - \alpha \cdot \varphi = 2\pi Z - \alpha \cdot \left(\frac{h \cdot 2Z\pi}{H}\right) = 2\pi Z \cdot \left(1 - \frac{\alpha \cdot h}{H}\right) \tag{11.4.7}$$

According RP1, T'T" is equal to r+R, where r-is core radius and R- is basic radius.

$$r = R \cdot \sin\frac{\alpha'}{2} \text{ (here } \alpha' \text{is one division arc angel, } \alpha' = A'A") \tag{11.4.8}$$

(30 – Research Project 1. Mathematical formulations. 2015. Page: 18).

$$T'T" = R_2 \cdot \left(1 + \sin\frac{\alpha'}{2}\right) = 2Z\pi \cdot \left(1 - \frac{\alpha \cdot h}{H}\right) \cdot \left(1 + \sin\frac{\alpha'}{2}\right) \tag{11.4.9}$$

Thus,

$$h = \frac{H}{\alpha} \cdot \left(1 - \frac{T'T"}{2Z\pi \cdot \left(1 + \sin\frac{\alpha'}{2}\right)}\right) \tag{11.4.10}$$

The height of the floor is presented under argumentation of T'T", from another side, area and perimeter measures of same floor should be presented under this argument too.

Next step is achieving the equations for area and perimeter of floors. For the simplicity T'T" will be here substituted with T.

The area is:

$$S = 2 \cdot \int_{v_2(T)}^{v_1(T)} \frac{1}{u^2\theta}((-z + (-1 + u + v)\theta)\sin[\theta[-1 + v]](M - 1.5\theta[-1 + v]) + (z + \theta - v\theta)\sin[\theta[-1 + u + v]](M - 1.5\theta[-1 + u + v]))(\cos[\theta[-1 + v]](M - 1.5\theta[-1 + v]) - \cos[\theta[-1 + u + v]](M - 1.5\theta[-1 + u + v]) - \frac{1.5(-z + (-1 + u + v)\theta)\cos[\theta[-1 + v]]\theta[-1 + v]}{\theta} - \frac{1.(-z + (-1 + u + v)\theta)\sin[\theta[-1 + v]](M - 1.5\theta[-1 + v])\theta[-1 + v]}{\theta} - \frac{1.5(z + \theta - v\theta)\cos[\theta[-1 + u + v]]\theta[-1 + u + v]}{\theta} - \frac{(z + \theta - v\theta)\sin[\theta[-1 + u + v]](M - 1.5\theta[-1 + u + v])\theta[-1 + u + v]}{\theta})\, dv \tag{11.4.11}$$

The perimeter is:

$$L = 2 \cdot \int_{v_2(T)}^{v_1(T)} \sqrt{(}\left(1 - \frac{k + \theta - v\theta}{2u\theta}\right)^2 (Z - 1.5\theta[-1 + v])^2 + \frac{m(k + \theta - v\theta)(1 - \frac{k + \theta - v\theta}{2u\theta})(Z - 1.5\theta[-1 + v])(Z - 1.5\theta[-1 + u + v])}{2u\theta} + \frac{(k + \theta - v\theta)^2 (Z - 1.5\theta[-1 + u + v])^2}{4u^2\theta^2})\, dv \tag{11.4.12}$$

The perimeter equation is significantly complex than one for area. However, compute able by professional calculators. These parametric functional equations are representing the connection between different parameters of helical tower. Only through such precise method it is high capability to manage any optimization problem in project. The first (min) interval value is:

$$v_1(T) = \frac{M - T}{1.5 \cdot \theta} + 1 - u \tag{11.4.13}$$

The interval value “$v_2(T)$” is quite longer expression. Even for exact full calculus by MATLAB software, that could take some extra pages to describe full output:

$$\begin{aligned} v_2(T) \to & \left(M-1.5(\theta(u+v-1))\right)^2 - 2\left(M-1.5(\theta(u+v-1))\right)T + T^2 = \\ & = \left(M-1.5(\theta(u+v-1))\right)^2 \left(\frac{k-\theta \mathrm{v}+\theta}{2\theta u}\right)^2 \\ & + \left(1-\frac{k-\theta \mathrm{v}+\theta}{2\theta u}\right)^2 \left(M-1.5(\theta(v-1))\right)^2 \\ & + \left(M-1.5(\theta(u+v-1))\right)\left(\frac{k-\theta \mathrm{v}+\theta}{2\theta u}\right)\left(1-\frac{k-\theta \mathrm{v}+\theta}{2\theta u}\right)\left(M \right. \\ & \left. - 1.5(\theta(v-1))\right)\cos[\mathrm{u}\theta] \end{aligned} \qquad (11.4.14)$$

The “$v_1(T)$” has shorter description, while “$v_2(T)$” is different, quite complex function in same parameters. They are corresponding to two “x” argument values, first to minimum and second to maximum, as respectively in both of them “y” equal to 0. $v_2(T)$‘s exact opening also is quite larger to express here, however, that is feasible to describe them in some defined forms.
Corresponding to those parameters:

M- is Full turn length which was described as “Z” above in this chapter
k- is certain height value according “z” axis
u- is number of base circle chord merging’s division point amount (regarding to rule of RP2: 7.2)
v- is variable, which represents division points’ numbers in circular motion.
θ- is parameter equal one division arc radian value
T- is a short written form of T’T” main axis length parameter.

1' circle is base circle of RP1 Helical-DNA structure as well here for 8.2, the 2' is 11.4's base circle. It is visible there is just one core and base circle in 1' one, while there are four base ones and one core in 2' one.

That is because of each height has different base circle and respectively different radius in 11.4, (Fig.33). Underneath them, there are two arcs: upper one is envelop of 1' helicoid curvature, second down one envelop for 2' helicoid curvature. These are very important parts of towers' shape to analyze and get conclusion.

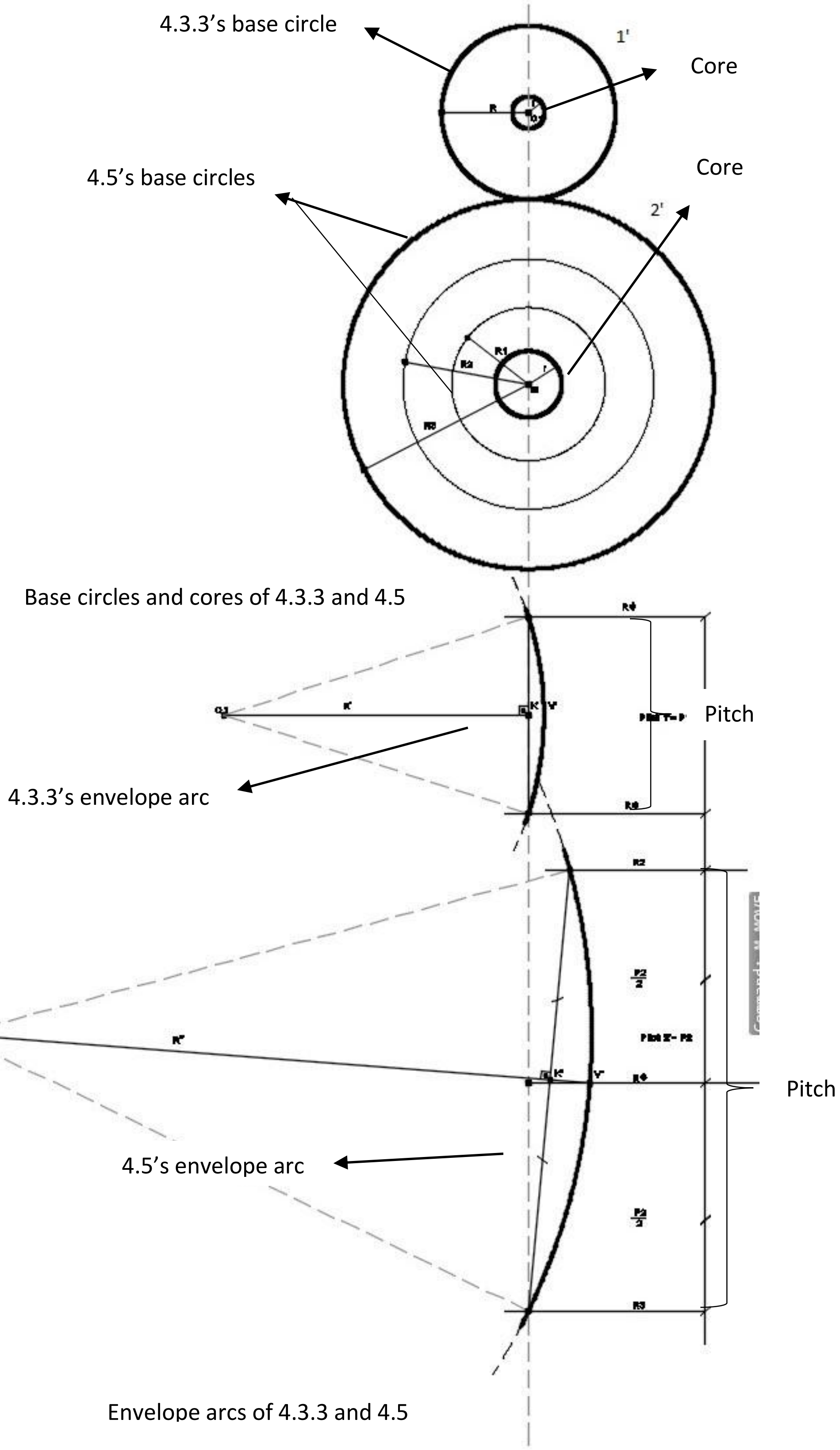


Figure.34. Floor curve placement in Cartesian.

In 11.4, there are endless radiuses as above was explained. Now here just three of them which ones are on one envelope of one pitch should be concerned. Two at the ends and one in the middle. In picture, there is K" V" is piece which is vital to find envelope radius. In spite of, it would be hard to understand directly, it will be written in shortest way for equations' transformations to save more volume of this text.

$$KV = \left(\sqrt{\left(R_3 - R_\varphi\right)^2 + \left(\frac{P_2}{2}\right)^2}\right)^2 - \left(\frac{\sqrt{{P_2}^2 + (R_3 - R_2)^2}}{2}\right)^2 =$$

$$= \left(\frac{P_2}{2}\right)^2 + (R_3 - R_2)^2 - \frac{(R_3 - R_2)^2}{4} - \left(\frac{P_2}{2}\right)^2 = \left[\frac{2 \cdot \left(R_3 - R_\varphi\right) + R_3 + R_2}{2}\right] \cdot \qquad (11.4.15)$$

$$\cdot \left[\frac{2 \cdot \left(R_3 - R_\varphi\right) - R_3 + R_2}{2}\right] = \frac{\left(3 \cdot R_3 + R_2 - R_\varphi\right) \cdot \left(R_3 + R_2 - 2 \cdot R_\varphi\right)}{4}.$$

Thus,

$$(R")^2 = \left[R" - \frac{\sqrt{\left(3 \cdot R_3 - R_2 - R_\varphi\right) \cdot \left(R_3 + R_2 - 2 \cdot R_\varphi\right)}}{2}\right]^2 + \left[\frac{P_2^2 + (R_3 - R_2)}{2}\right]^2$$

$$R" = \frac{\sqrt{\left(R_3 - 2 \cdot R_\varphi + R_2\right) \cdot \left(3 \cdot R_3 - 2 \cdot R_\varphi - R_2\right)}}{4} + \frac{P_2^2 + (R_3 - R_2)^2}{4 \cdot \sqrt{\left(R_3 - 2 \cdot R_\varphi + R_2\right) \cdot \left(3 \cdot R_3 - 2 \cdot R_\varphi - R_2\right)}} \qquad (11.4.16)$$

So, this is formula for 11.4 curvature envelop radius. As it is visible, there are three different radiuses playing role as parameters, while the one which R_φ is certainly representing the any radius relevant to its exact helix and spiral rotation angel. Same time there at above we found formula for that type of radius depending on parameter of rotation angel. That radius has been connected with altitude and even floor radius and perimeter. So, after all we see here excellent coherence in, outer and inner resolutions parameterized link.

12. Description and Justification of the design solutions.

Same methodic consideration (as in 11.4) should consduct on those three designs which ones aimed for ecological point of views.

First aimed design solution:

This design is done by conventional dimensions matching and according that randomly preserving boundary line adjusting to inner design. Let's say typical Architect work.

So, as it was designed only by adjusting and randomly drawing there is no certain curvature parameters which could play decisive role of its whole concept.

And just is because that, there is no coherence between in all parts of design. Parameterization here is failing to low level, there are part by part cut connections between different measurements. Most of them are in chaotic condition (it means there is in some significant parts no connection at all, and it stands out of our methodology even out of common parametrization).

Second aimed design solution:

This one is not in unknown chaotic structure but also not in our case study method structure. Here in this one, the floor form replaced by similar form (elliptic curve). This curve has different mathematic presentation than our case study one (4.5)

$$y = \sqrt{t^6 - 4 \cdot t^2}$$
$$x = t^2 \qquad t \in \left(0: -\sqrt{T'T''}\right) \tag{12.1}$$

Such form is very closer by outlook shape to Nopmon mesh but, it is not in the same parametrization as I did till 11.4 through all RP series.

Third aimed design solution:

In aimed design for solar panel settlement, there is everything is in same functions from first division strategy till whole research fulfillment as was in RP1 chapter-5 and in chapters of RP2 7.1 and 7.2. The difference in that project is only T'T" and the second is there is no change in base radius as the helical altitude and pitch is not changing. But, the method I elaborated in 11.4 is the same in this one for floor area and perimeter and for any same pieces.

And finally there is slightly difference in outer surface curvature of envelop comparing to 11.4, as it is here:

$$(R' - R + r)^2 + \left(\frac{P_1}{2}\right)^2 = (R')^2 \tag{12.2}$$

$$-2 \cdot R' \cdot (R - r) + (R - r)^2 + \frac{P_1^2}{4} = 0 \tag{12.3}$$

$$R' = \frac{R - r}{2} + \frac{P_1^2}{8 \cdot (R - r)} \tag{12.4}$$

Note: these parameters are illustrated at page 68 above.

Where R'- is radius of envelope here, and R- is constant base radius meanwhile r- is core radius (it matches in 11.4 with R_φ, that is because of here the radius is constant while there it is changing. Mid-point there cannot match all the time on r- core radius level, but on any closer small corresponded rotation angel).

If it will be replaced P_2 with P_1, R_2 and R_3 with R, and R_φ with r, in (11.4.16) formula above for R'' at page 69, that would be gained again R' in (12.4) formula as it is here. It means their outer linear surface structures have such fluent link of common geometrical features. It is homotopical transformation between two surfaces structures. Exactly according to this, characteristic, I can confirm that, the design solution 11.4 is an evolution version of design solution 8.2. And those solar panels settlement could be applied to 11.4 design solution too, because of they are done according 8.2's parameters. All same type of geometric designing parametric features of 8.2, exactly could be applied in 11.4, or vice versa.

So, once again it is noticeable the correlation between 8.2 and 11.4 design solutions. The 11.4 is general state of all same methodology products, as 8.2 is included in that. That is a true beauty of geometric parameterization designing in architecture.

Conclusion of Research Project 3.
(Evaluation of the results of the experimental project)

Conclusion of this experimental project is that, the 8.2 is the most suited aimed design solution to our methodical case study. And beside this our impartially compute over aimed designs energy generation is showing that 8.2's productivity is more approximately 6.12 times than second aimed one and 84,28 times than first aimed one.

General Conclusion.

Note: Graphical illustrations for general conclusion are presented in wide scale at graphical part.

1- The motif and its reason for starting under such title name research projects: First of all, the necessity and importance of geometry in architecture is quite well known, even it could be said like "architecture is a plant which grows by components of geometry". The second motif is coming from newly known methods called "Generative modelling (designing)", "Parametric architecture" and "Computational designing".

"Generative design is a form finding process that can mimic nature's evolutionary approach to design. It can start with design goals and then explore innumerable possible permutations of a solution to find the best option. The process can enable designers to generate brand new options, beyond what a human alone could create, to arrive at a most effective design." (31- *Definition adapted from a product developed by Autodesk named Generative Design*. Retrieved 30 March 2017.)

"Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response." (32- Woodbury, Robert. *Elements of Parametric Design*. Routledge. 2010.)

"The term *parametric* originates from mathematics (parametric equation) and refers to the use of certain parameters or variables that can be edited to manipulate or alter the end result of an equation or system." (33- Frazer, John. "Parametric Computation: History and Future". *Architectural Design 2016* March/April.)

"What is Computational Design? Computational design is the application of computational strategies to the design process. While designers traditionally rely on intuition and experience to solve design problems, computational design aims to enhance that process by encoding design decisions using a computer language." (34- ArchDaily 2008-2017.)

These citations are significant to attach in this conclusion part in order to describe basic principles and relevance between this project and mentioned architectural fields. The whole work procedure have been done basically closer to generative modelling procedure sequence, but distinguishes in particular branches. Those particular branches in this research, are extra analysis of object in order to learn its natural geometric features and according to them starting to formalization and parameterization. In spite of the computational designing citation above, that had been elaborated in this research once according special theories rather than referring to help of any software, as mentioned in parametric design citation (The term *parametric* originates from mathematics (parametric equation) and refers to the use of certain parameters or variables that can be edited to manipulate or alter the end result of an equation or system), whole research project series have been constructed through parametric equations. For example, the most initial found parameter (T'T") came at the end to play important role in area and perimeter calculations and same time it made contact between those parameters and height parameter in last generated design solution. Via relying all these stuff work only on software, wouldn't allow to gain such precise result. That is one of the major difference between this method and simple computational designing.

2- In all research series text part title pages were written a phrase: "Geometry lies at the core of the Architectural design process. It is omnipresent, from the initial form-finding stages to the final construction. Modern Geometric computing provides a variety of tools for the efficient design, analysis, and manufacturing of complex shapes. On the one hand this opens up new horizons for Architecture. On the other hand, the Architectural context also poses new problems to Geometry. Around these problems the research area of Architectural Geometry has emerged. It is located at the common border of applied Geometry and Architecture." (35-Architectural Geometry Hardcover – Helmut Pottmann , Michael Hofer , Axel Kilian and Daril Bentley. October 1, 2007). The whole research work at the end responded to this phrase. More clearly saying, the given promise at start of hypothetical step has been fulfilled at the experimental stage. Exactly after all surveys, were found new equations and theoretical explanations of new geometric shapes, which explicitly responds to sentence "On the other hand, the architecture context also poses new problems to geometry".

3- Similar work has been conducted at Canton tower's form modelling process. In spite of the difference between Canton tower's and this research project work algorithmic modelling procedures, the whole general concept of both works are established on alike principles. One of the major differences is that, in Canton tower AAD (Algorithmic Aided Design) method has been applied, while in this research project has been implemented the base steps combination of PA (Parametric Architecture) and GD (Generative Design) methods.

In such a way the design results also slightly distinguishes of each other, despite the main basic principles stays similar. From generative design aspect, Canton tower's base source codes are two ellipses at different altitudes, also their 45 degree twist positions relatively to each other plays a source code role as well. In such a case, this research and Canton tower's design work principles are the same, starting from some similar source codes till modelling. Although, in this research project has been conducted much more deeply geometrical analysis than Canton tower case, which in its own turn allows for more precisely manipulation and optimization capabilities.

Additional foundings.

1-Why helix? Helix is a smooth space curve, in its parametric Cartesian equations, this curve presents basic trigonometrical functions and they are in mathematics are accepted as functions of nature harmony. Such a geometrical object like helix has features to be concerned and elaborated for generating into more complex models.

2- Architectural point of view obtained most suitable helical shape: According above citation of generative design concept, it has been made analysis over nearly five DNA helical structures in order to find out most suitable to further advancement of that and design appliance into building construction. That was triple-helical DNA, just taking out its one helix as tuning to alpha DNA presumably that structure compatibles helical body. Only that alpha DNA and triple-helical DNA structures have interior volume and core part and these are important factors to analyze and implement into architectural design.

3- T'T" length parameter and its essence: T'T" length is decisive factor parameter found and named for long axis distance in almond shaped cut-section of helicoid body (supposed to be floor placement in ahead design procedure). The equation for T'T":

$$T'T" = r + R = R \cdot (1 + \sin\frac{\alpha}{2})$$

Here "r" parameter is core section radius, "R" is base circle radius "α" is division angel. This is an important parameter for area and perimeter calculus ahead in RP 3, where substituted with "T".

Area equation:

$$S = 2 \cdot \int_{v_2(T)}^{v_1(T)} \frac{1}{u^2\theta}\Big(\big((-z + (-1 + u + v)\theta) \sin\big[\theta[-1 + v]\big]\,(M - 1.5\theta[-1 + v])$$
$$+ (z + \theta - v\theta) \sin\big[\theta[-1 + u + v]\big]\,(M - 1.5\theta[-1 + u + v])\big)\Big(\cos\big[\theta[-1 + v]\big]\,(M$$
$$- 1.5\theta[-1 + v]) - \cos\big[\theta[-1 + u + v]\big]\,(M - 1.5\theta[-1 + u + v])$$
$$- \frac{1.5(-z + (-1 + u + v)\theta) \cos\big[\theta[-1 + v]\big]\,\theta[-1 + v]}{\theta}$$
$$- \frac{1.(-z + (-1 + u + v)\theta) \sin\big[\theta[-1 + v]\big]\,(M - 1.5\theta[-1 + v])\theta[-1 + v]}{\theta}$$
$$- \frac{1.5(z + \theta - v\theta) \cos\big[\theta[-1 + u + v]\big]\,\theta[-1 + u + v]}{\theta}$$
$$- \frac{(z + \theta - v\theta) \sin\big[\theta[-1 + u + v]\big]\,(M - 1.5\theta[-1 + u + v])\theta[-1 + u + v]}{\theta}\Big)\,dv$$

Perimeter equation:

$$L = 2 \cdot \int_{v_2(T)}^{v_1(T)} \surd(\Big(1 - \frac{k + \theta - v\theta}{2u\theta}\Big)^2\,(Z - 1.5\theta[-1 + v])^2$$
$$+ \frac{m(k + \theta - v\theta)(1 - \frac{k + \theta - v\theta}{2u\theta})(Z - 1.5\theta[-1 + v])(Z - 1.5\theta[-1 + u + v])}{2u\theta}$$
$$+ \frac{(k + \theta - v\theta)^2(Z - 1.5\theta[-1 + u + v])^2}{4u^2\theta^2})\,dv$$

4- Found equations and theoretically principles of geometrical resolutions at research project 2.

1. Gained helical body's linear surface feature and its line families description:

$$\frac{\mathrm{x} - \mathrm{R} \cdot \cos(\mathrm{v} - 1)\,\theta}{\mathrm{R} \cdot (\cos\big((\mathrm{u} + \mathrm{v} - 1)\theta\big) - \cos\big((\mathrm{v} - 1)\theta\big))} = \frac{\mathrm{y} - \mathrm{R} \cdot \sin(\mathrm{v} - 1)\,\theta}{\mathrm{R} \cdot (\sin((\mathrm{v} - 1)\,\theta) - \sin((\mathrm{u} - 1)\theta))}$$
$$= \frac{z - (v - 1)\theta}{u\theta}$$

Necessity: making sure it is linear segmented object for solar energy aimed design solution, panel cells placement.

2. Gained equation for normal helical body generation:

$$\frac{\sqrt{1 - \cos 20°^2}}{\sqrt{2(1 + \cos 20°)}} = \sqrt{\frac{1}{2}\frac{(1 - \cos 20°)(1 + \cos 20°)}{(1 + \cos 20°)}} = \sqrt{\frac{1}{2}(1 - \cos 20°)}$$

Necessity: deciphering unique nature of obtained helical body.

3. Gained parametric equations of new generated and research project 1 helical bodies:

   Research project 1 helicoid (former body):

   $$x = p\big(R \cdot \cos\big((u+v-1)\cdot\theta\big) - R\cdot\cos\big((v-1)\cdot\theta\big)\big) + R\cdot\cos((v-1)\cdot\theta)$$
   $$y = p\big(R \cdot sin\big((u+v-1)\cdot\theta\big) - R\cdot sin\big((v-1)\cdot\theta\big)\big) + R\cdot\sin\big((v-1)\cdot\theta\big)$$
   $$z = p\cdot u\cdot\theta + (v-1)\cdot\theta$$

   New generated helical body (Archimedes spiral combined):

   $$x = R\cdot p\cdot\cos\big(\theta\cdot(u+v-1)\big) + (1-p)\cdot r\cdot\cos\big(\theta\cdot(v-1)\big)$$
   $$y = R\cdot p\cdot sin(\theta\cdot(u+v-1)) + (1-p)\cdot r\cdot sin(\theta\cdot(v-1))$$
   $$z = \theta\cdot(u\cdot p + v - 1)$$

   Necessity: proving homotopic relationship of new generated and former bodies.

5- There are three ecological energy conversion aimed design solutions. These ecological energy conversion concepts have been added to research project survey later at research project 2. They are on second level importance in research series comparing its main concept (geometrical resolutions).

Bahrain World Trade Center, Razor skyscraper and other similar ones are an example to integration of ecological energy conversion aimed techs with big scale tower structures. However, here in research case, they are intended to be integrated with geometrical forms of towers. In order to adjust those design solutions energy conversion features to geometrical resolutions, two of them have been modelled by typical computational designing method out of generative modelling principles. Only third one, solar energy conversion aimed design solution was modelled according research project 1's best evaluated helical body geometrical resolutions as mentioned here at fifth section.

1. Energy outcome result of first aimed design solution (INVELOX air-pressure and velocity conversion system):

   $$E_1 + E_2 + E_3 + E_4 + E_5 = 24.178\ kW + 12.465\ kW + 4.221\ kW + 0.2041\ kW + 0.0003086\ kW = 41.37678749 kW/s$$

   $$\frac{41.37678749kW}{s} = \frac{148956.4332kW}{h} = \frac{148.956MW}{h}$$

2. Energy outcome result of second aimed design solution (air-pressure and velocity conversion by artificial hurricane in top-roof fan):

   $$E_{pro1} + E_{pro2} + E_{pro3} + E_{pro4} + E_{pro5} + E_{pro6} + E_{pro7} + E_{pro8} + E_{pro9} + E_{pro10} + E_{pro11} = 2643.066\ KW$$

   $$E_{Total} - E_{Fan} = 569.842\ kW$$

   $$569.842\frac{kW}{s\cdot 3600}\cdot 3600 = \frac{2051431.200kW}{h} = \frac{2051.431MW}{h}$$

3. Energy outcome result of third aimed design solution (solar energy photovoltaic conversion by solar panel cells):

   $E_{wing\ panel} = {}^{E}/_{N_p} \cdot A_{wing\ panel} \cdot \sin 51° = 1\,309.77 \cdot 247.17 \cdot \sin 51° = 232.483\ MWh$

   $232.483\ MWh \cdot 108 = 25108.189\ MWh.$

   $25108.189\ MWh \cdot 0.5 = 12554.09\ MWh$

Despite amount of energy conversion comparison, in any way this solution would be evaluated as best one, just because it is generative design procedure product, those mentioned new derived body and such other several ones could be adjusted to such solar panel cells placement requirements and their technical stuff settlements, because all of them are new born forms of research project 1 helical body as this solar energy design solution, all their parametric features are in common state and in equality between each other. Here once again it flows out the difference in methods between known typical generative algorithmic designing and such one as I have done in my research. The helices or solar energy panel cells are not the exact message of this research, the exact message here is adjustment of various types of requirements with different types of architectural requirements under geometrical and mathematical related analysis combination with generative modelling technics.

6- Achieved envelope radiuses for making exact certainty of homotopic relationship between new generated body and research project 1 best evaluated helical body.

Research project 1 helicoid (former body):

$$R' = \frac{R-r}{2} + \frac{P_1^2}{8 \cdot (R-r)}$$

New generated helical body (Archimedes spiral combined):

$$R'' = \frac{\sqrt{(R_3 - 2 \cdot R_\varphi + R_2) \cdot (3 \cdot R_3 - 2 \cdot R_\varphi - R_2)}}{4} + \frac{P_2^2 + (R_3 - R_2)^2}{4 \cdot \sqrt{(R_3 - 2 \cdot R_\varphi + R_2) \cdot (3 \cdot R_3 - 2 \cdot R_\varphi - R_2)}}$$

RP3 11.3 (RP2 8.2) design solution is most responsive and initial form of mentioned methodical sides of views in accordance with prescribed equations here.

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Figure. 1: Guggenheim Museum. Photo from main entrance direction. (Guggenheim Architecture...2003) Retrieved from: https://www.guggenheim.org/

Figure. 2: Solomon R. Guggenheim Museum floor plan… 2009. Retrieved from: https://www.guggenheim.org/arts-curriculum/topic/form-follows-function

Figure. 3: Agora Garden tower. Downside view 2015. Retrieved from: http://www.skyscrapercity.com/showthread.php?p=136622731

Figure. 4: Canton tower. Construct view and downstairs position view. Retrieved from: http://www.architravel.com/architravel/building/canton-tower/

Figure.5: Metamorphosis of the Canton Tower from cylindrical to twisted lattice. ©2011 Information Based Architecture (IBA). Retrieved from: http://www.solaripedia.com/13/342/4260/canton_tower_metamorphosis.html

Figure. 6: This is a particularly useful figure for getting a clearer idea of the structure of the double helix since both side views and views looking top down along the helical axis are shown. © 2009. Retrieved from: http://www.bio.miami.edu/tom/courses/bil255/bil255goods/09_dna.html

Figure. 7: Helical Wheel for the model peptide system, where hydrophobic (yellow), basic (blue) and acidic (red) are highlighted. © 2009. Retrieved from: http://www.mdpi.com/1422-0067/12/3/1431/htm

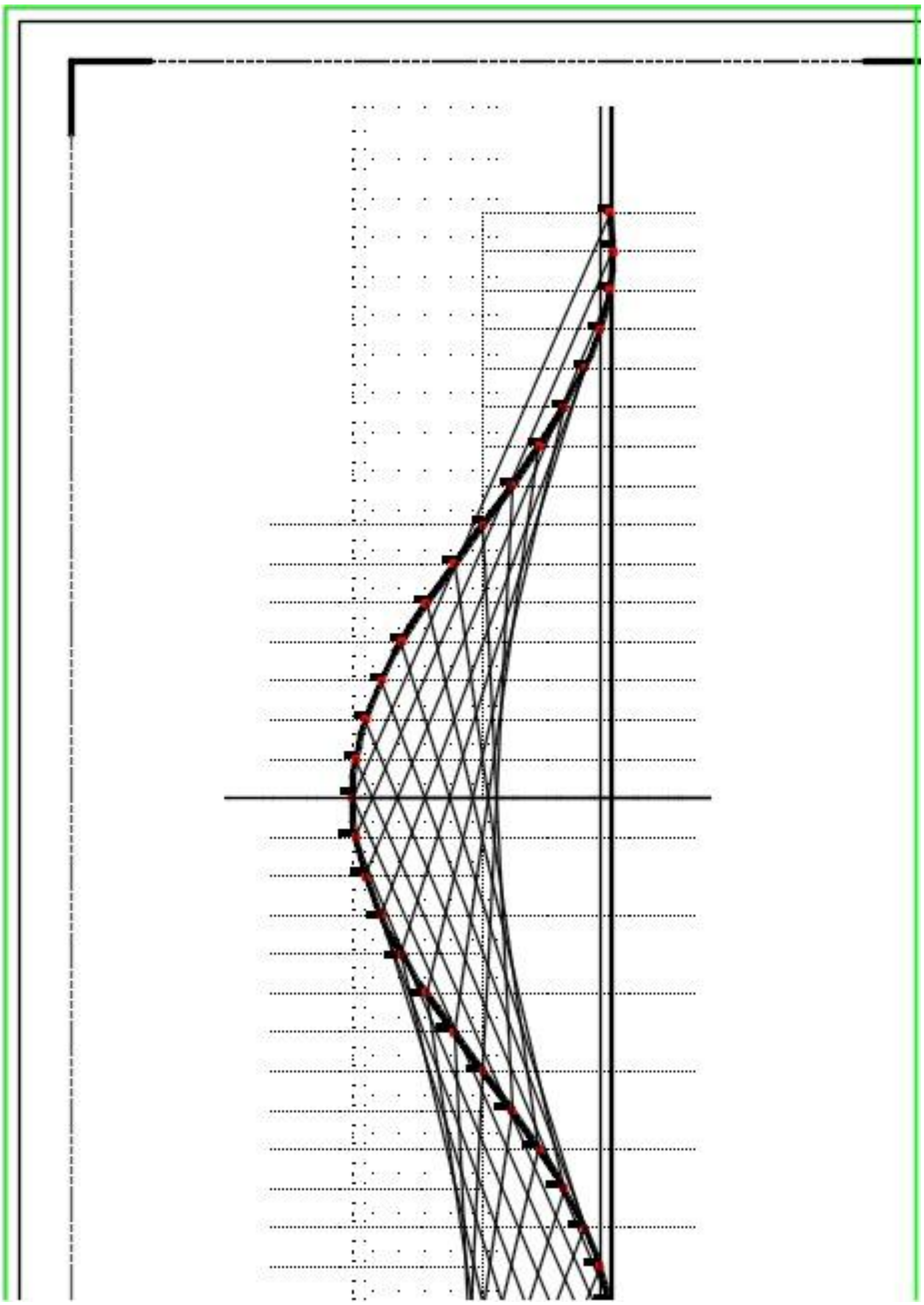
Figure. 8: Helical wheel projections for the lytic peptide of NSP4 protein of Rotavirus and the carboxy-terminal half of Ebola virus delta peptide. An online utility was used to project NSP4 and carboxyl terminal amino acids of EBOV delta peptide as an alpha helix. The applet also computes the value and angular direction of hydrophobic moment of each peptide. For emphasis, lysine and arginine residues are circled in blue, cysteine residues in yellow, and aromatic residues in black. © 2015. Retrieved from: http://www.mdpi.com/1999-4915/7/1/285/htm

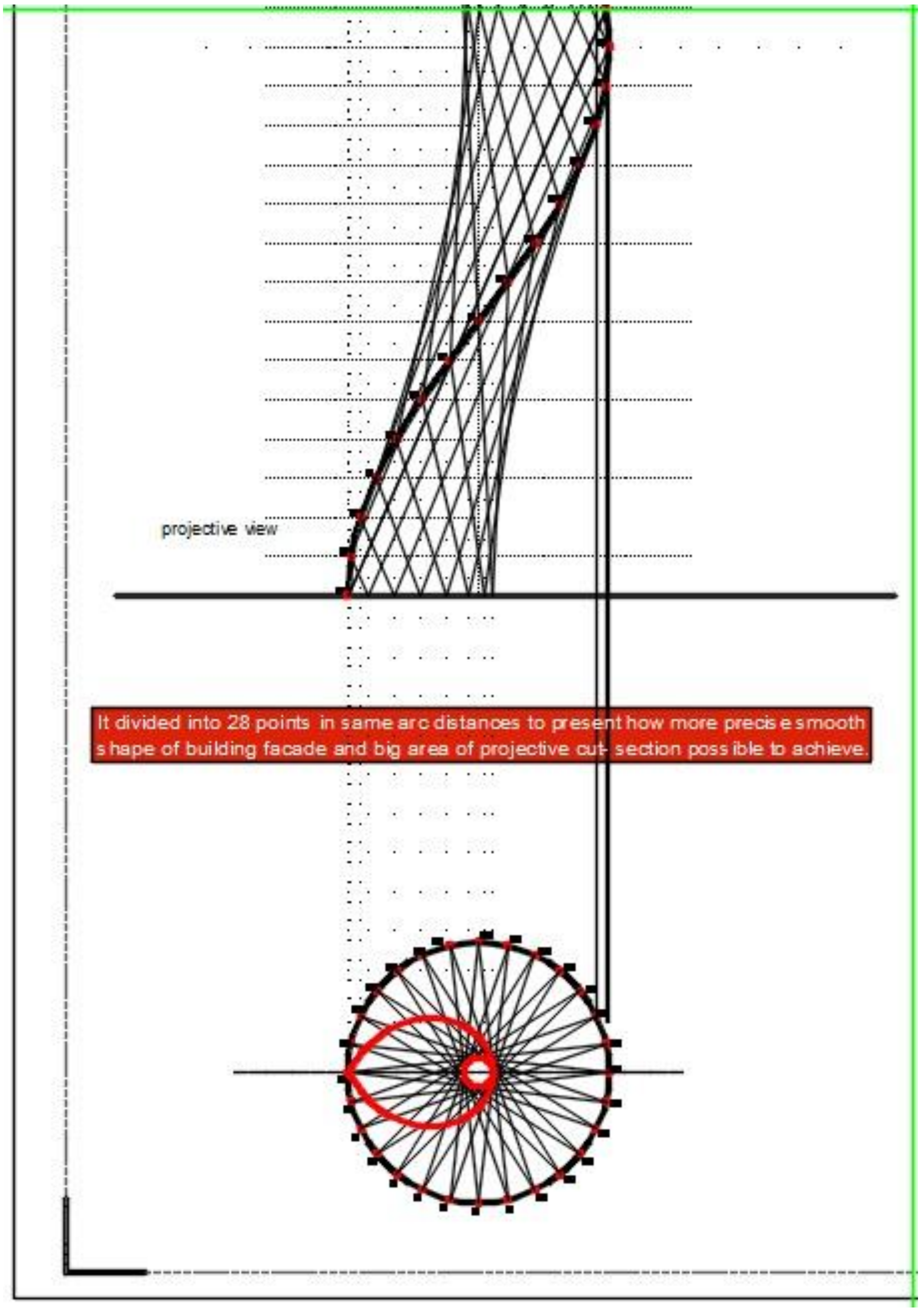
Figure. 18: Schematic of the INVELOX wind delivery system with its key components. © 2014. Retrieved from: http://breakingenergy.com/2014/12/12/energy-startup-series-sheerwind/

Figure. 25: Building-site is marked by red circle in both maps. 2016. Retrieved from: https://www.google.co.uk/maps/@40.337144,49.8411082,15.5z

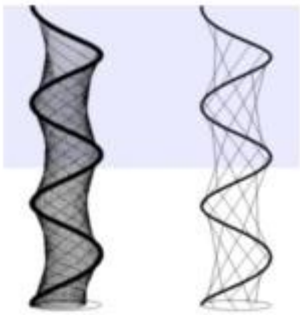
Note: Illustrative sketch figures without source indication, are drawn by author of this report (by me). They are intended to properly deliver the ideas of some special technical forms or schemes throughout the text report.

Annexes

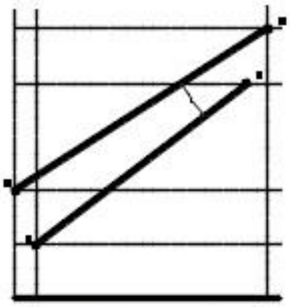



projective view
It divided into 28 points in same arc distances to present how more precise smooth shape of building facade and big area of projective cut- section possible to achieve.

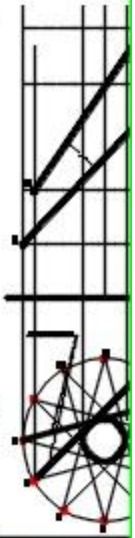
7.1-Helicoid surface could be implemented and included as contemporary linear double-curved building façade surfaces.



Example illustration for 1.Principle



Example illustration for 2.Approach: Orthogonal side view of Helicoid's base chord lines.



Example illustration f
Plan and Orthogonal
Helicoid's base chord

1.Principle: In any type of division there is constant rotated chord lines, which ones are turning around core section circle in condition of tangent to it. In every turn, there are two of them side to side. They represent also constructive tubes which joining tendril.

2.Approach: The principle is coming out here by analysing the orthogonal frontal view on these chords. There are, these chords are intersecting each other a little away of central axis over top viewand their end and start points have same distance respectively between each other: 1"-2" = 8"-9".

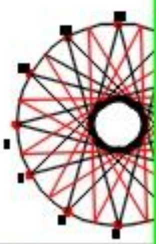
3.Formulation: The underneath equations represent the research project1's helical body surface in Cartesian system:

$$x = p(R \cdot (\cos((u+v-1)\cdot\theta) - R\cdot\cos((v-1)\cdot\theta)) + R\cdot\cos((v-1)\cdot\theta)$$
$$y = p(R \cdot (\sin((u+v-1)\cdot\theta) - R\cdot\sin((v-1)\cdot\theta)) + R\cdot\sin((v-1)\cdot\theta)$$
$$z = p\cdot u\cdot\theta + (v-1)\cdot\theta$$

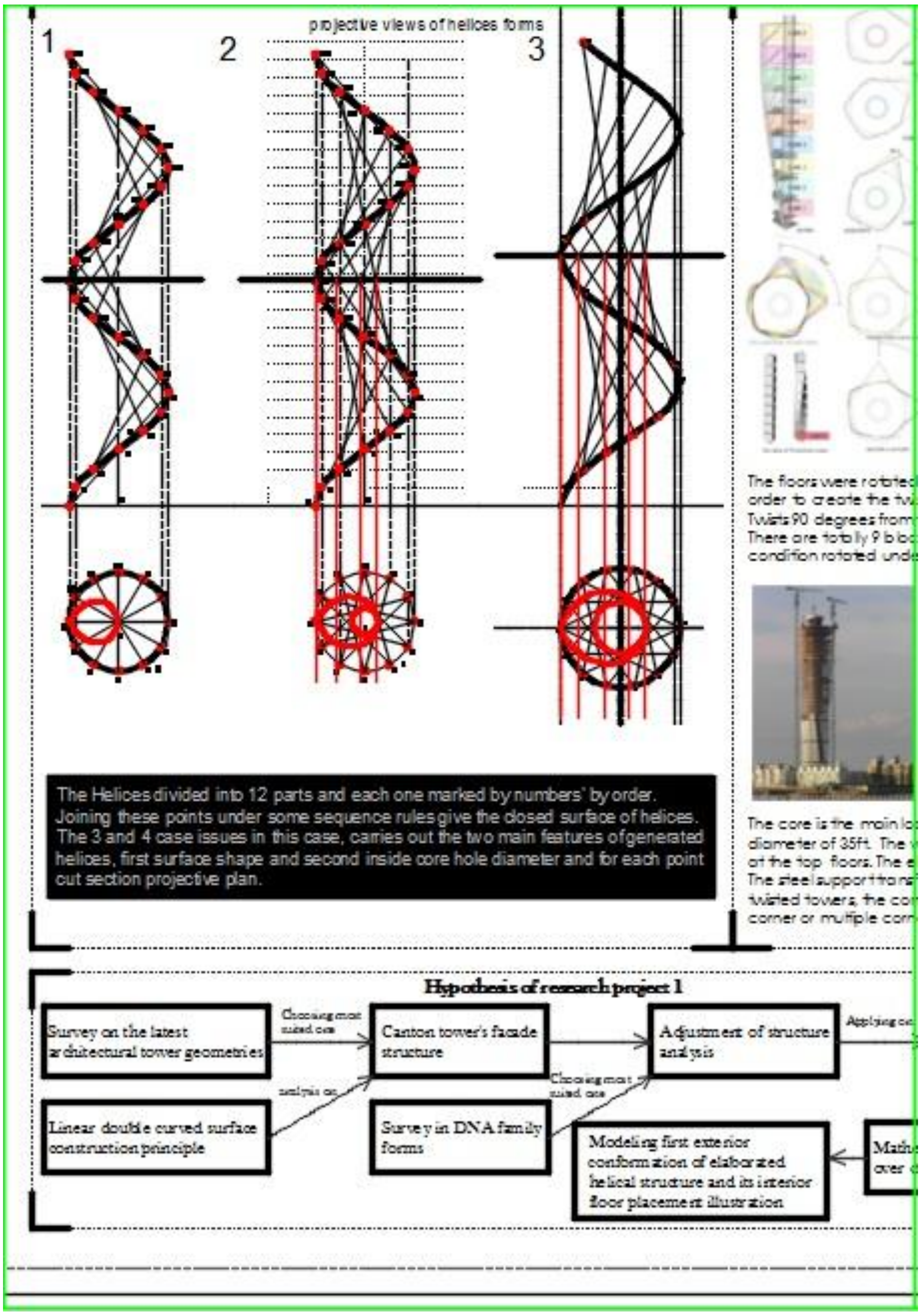
Parameter "p" is changing between 0 and 1, it means its oriented interval is: [0;1].

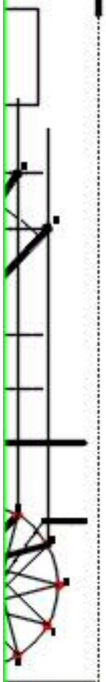
4.Determination: For determination of line families over surface is needed to generate formula in bilateral equality state between all coordinate arguments.

$$\frac{x - R\cdot\cos(v-1)\theta}{R\cdot(\cos((u+v-1)\theta) - \cos((v-1)\theta))} = \frac{x - R\cdot\sin(v-1)\theta}{R\cdot(\sin((u+v-1)\theta) - \sin((v-1)\theta))} = \frac{z-(v-1)\cdot\theta}{u\cdot\theta}$$

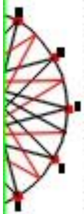


Example illustration for 4.D
First family chords placeme
body surface.


projective views of helices forms
1
2
3
The Helices divided into 12 parts and each one marked by numbers' by order.
Joining these points under some sequence rules give the closed surface of helices.
The 3 and 4 case issues in this case, carries out the two main features of generated helices, first surface shape and second inside core hole diameter and for each point cut section projective plan.
Hypothesis of research project 1
Survey on the latest architectural tower geometries
Choosing most suited one
Canton tower's facade structure
Adjustment of structure analysis
Linear double curved surface construction principle
analysis on
Survey in DNA family forms
Choosing most suited one
Modeling first exterior conformation of elaborated helical structure and its interior floor placement illustration

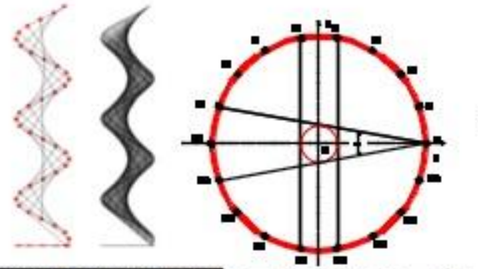


r 2.Approach: ront view of ines.



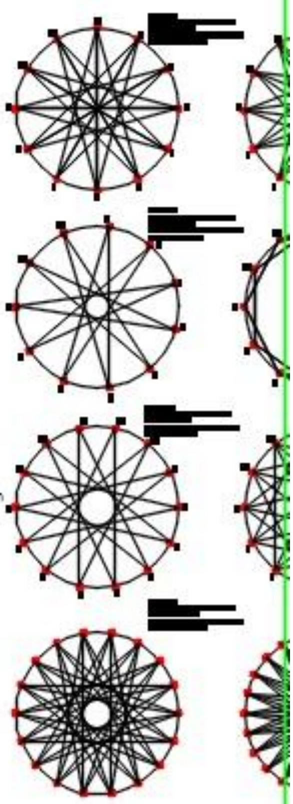
etermination: t on helical

7.2-It is not possible to obtain DNA shape always helix as it was revealed at Research Project 1. are some geometric-mathematical related conditio which ones are vital to find out, in order decla much the project real and applicable.



Example illustration for 5.Exception

Example illustration for 3.Formulation



1.Principle: From helix line possible to gain helicoid volume which will be suitable to be designed into building construction. Although, there is problem in proper transformation procedure. That problem is linked in initial stage of base circle division and chord merging.

2.Approach: So, the shortest distance of center till this line (the perpendicular from center point till this line) should be constant. And it should be proved it doesn't interest into core section.

3.Formulation: For this survey analyze is being taken the circle with 18 division parts. And radius of circle by 1 (this is for easily implementation of complex figures in forward).

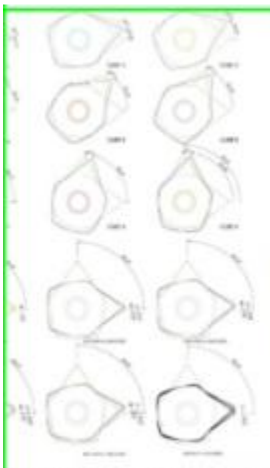
$$z = -\frac{i \sin 20^\circ}{-1 - \cos 20^\circ + i \sin 20^\circ}$$

4.Determination: The cousins is a trigonometric function for which doesn't matter argument's negative or positive value and according to that we can say like this: in any division portions, there should be same degree joint according to each point relatively that diameter which crosses it.

[illegible]

5.Exception: In spite of 4.Determination, there is one more issue, chord merging procedure depends on helix, as it is right-handed or left-handed. In each case, chord merging should happen in same direction.

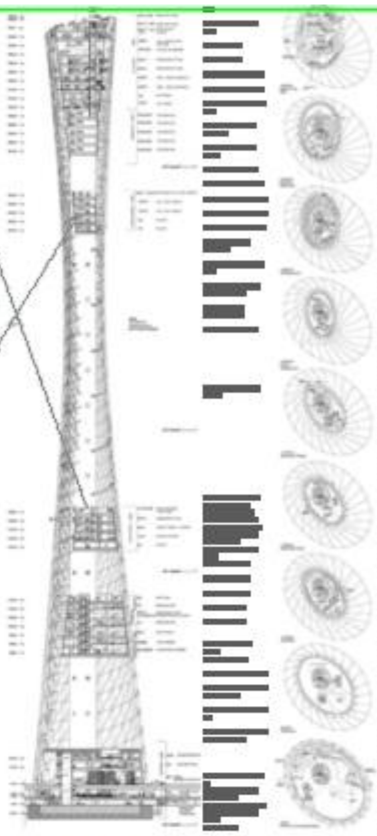
Example illustration for 1.Principle



Captured photo at top of C block's in highest floor towards to D blocks underneath. At 168.11 m altitude.

Captured photo at D block's 2nd lowest floor towards downward to C block. 339.6 m altitude.

under 1.6 degrees for each floor in
st characteristic of the building.
the ground level to the top floor.
ks and each one in common
r 10 degree.

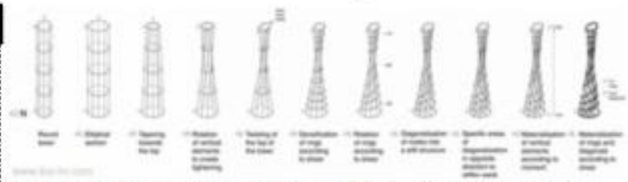


ad-bearing structure with large concrete pipe, with an inner
walls are 8ft thick at the bottom, gradually shifting to 1ft thick
levator shafts and staircases are located inside the core.
fers shear forces to the supporting concrete core. In all such
mmunal systems wires and tubes are going through in one
ers of core section.

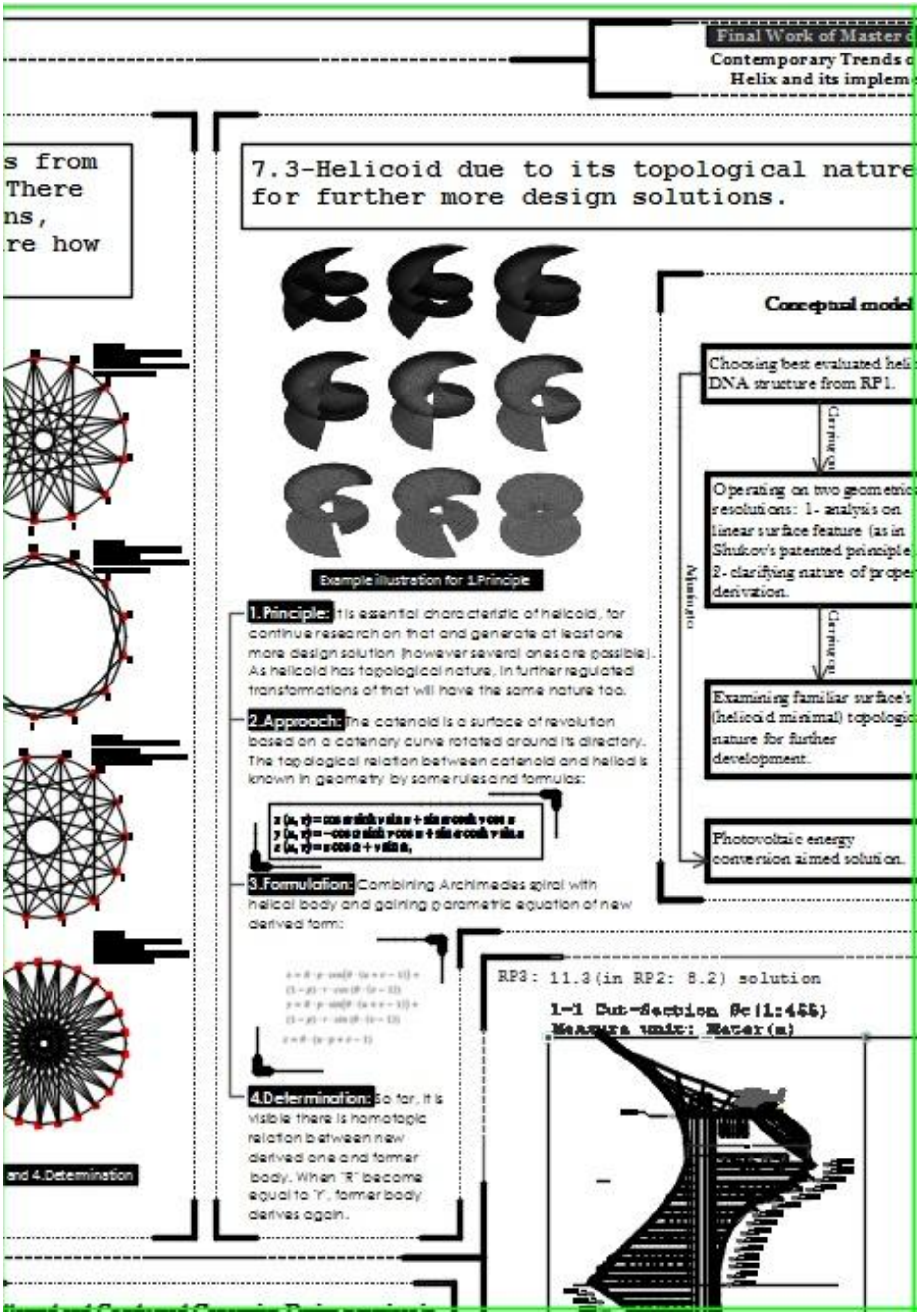
Building layouts: Hollowspace with spiral staircase. •Section A : Two floors lobby, exhibition, public service, connections to underground. •Section B : 4d cinema . •Section C : leisure places observation hall snack shop.

Helix line geometry

ematical formulations
btained geometry



The structure formation of Canton tower. Analysis on several cases for optimum solution. Analysis over tower's parametrically geometric resolution features for most suited shape detection. Base source codes of object are two ellipses (one at bottom and another at 450m altitude) geometrical positions and division parametric values according Vladimir Shukov's hyperbolic stucture premises.

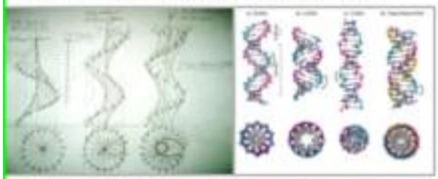

Final Work of Master
Contemporary Trends
Helix and its impleme
s from
There
ns,
re how
7.3-Helicoid due to its topological nature
for further more design solutions.
Example illustration for 1.Principle
1.Principle: It is essential characteristic of helicoid, for continue research on that and generate at least one more design solution (however several ones are possible). As helicoid has topological nature, in further regulated transformations of that will have the same nature too.
2.Approach: The catenoid is a surface of revolution based on a catenary curve rotated around its directory. The topological relation between catenoid and heliod is known in geometry by some rules and formulas:
3.Formulation: Combining Archimedes spiral with helical body and gaining parametric equation of new derived form:
4.Determination: So far, it is visible there is homotopic relation between new derived one and former body. When "R" become equal to "r", former body derives again.
and 4.Determination
Conceptual model
Choosing best evaluated heli
DNA structure from RP1.
Operating on two geometric
resolutions: 1- analysis on
linear surface feature (as in
Shukov's patented principle)
2- clarifying nature of proper
derivation.
Examining familiar surface's
(helicoid minimal) topologic
nature for further
development.
Photovoltaic energy
conversion aimed solution.
RP3: 11.3(in RP2: 8.2) solution
1-1 Cut-Section Sc(1:455)
Measure unit: Meter(m)

llowed and Conducted Generative Design processes in research projects.

ign Schema — Means of Creating Variations — Means of selecting desirable outcomes

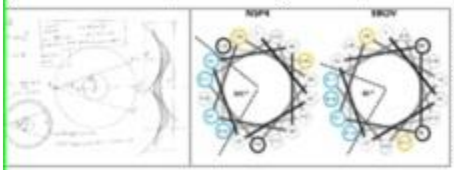
llowing natural design process algorithm.

—Analyzing DNA family stuctures for case study.



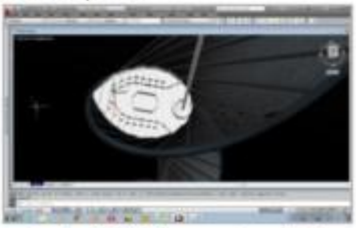
Genetic variations through mutation and crossovers.

Research project 1: Imitating DNA family structures' geometric helical shapes and their geometric parameters.

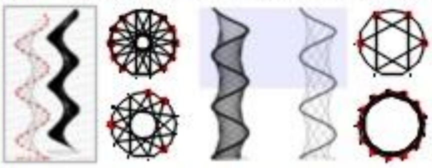


Desirable outcome.

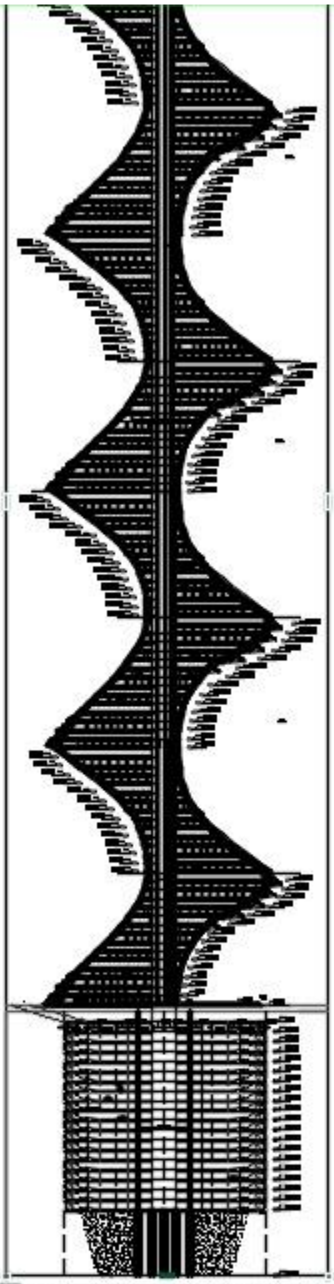
—Means to choose desirable outcome are linked to constructive build-abile geometry as well architectural functionality trends.

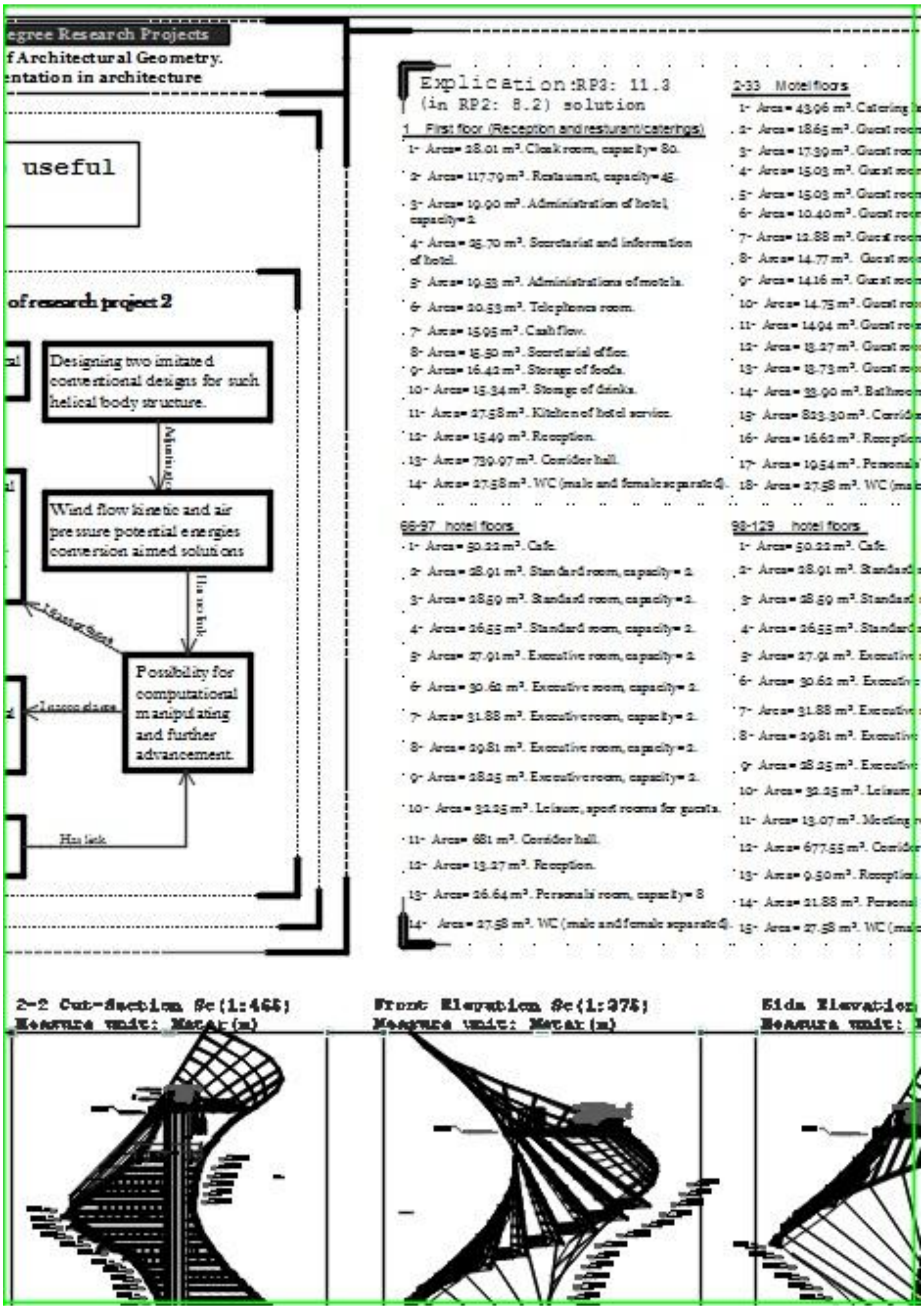


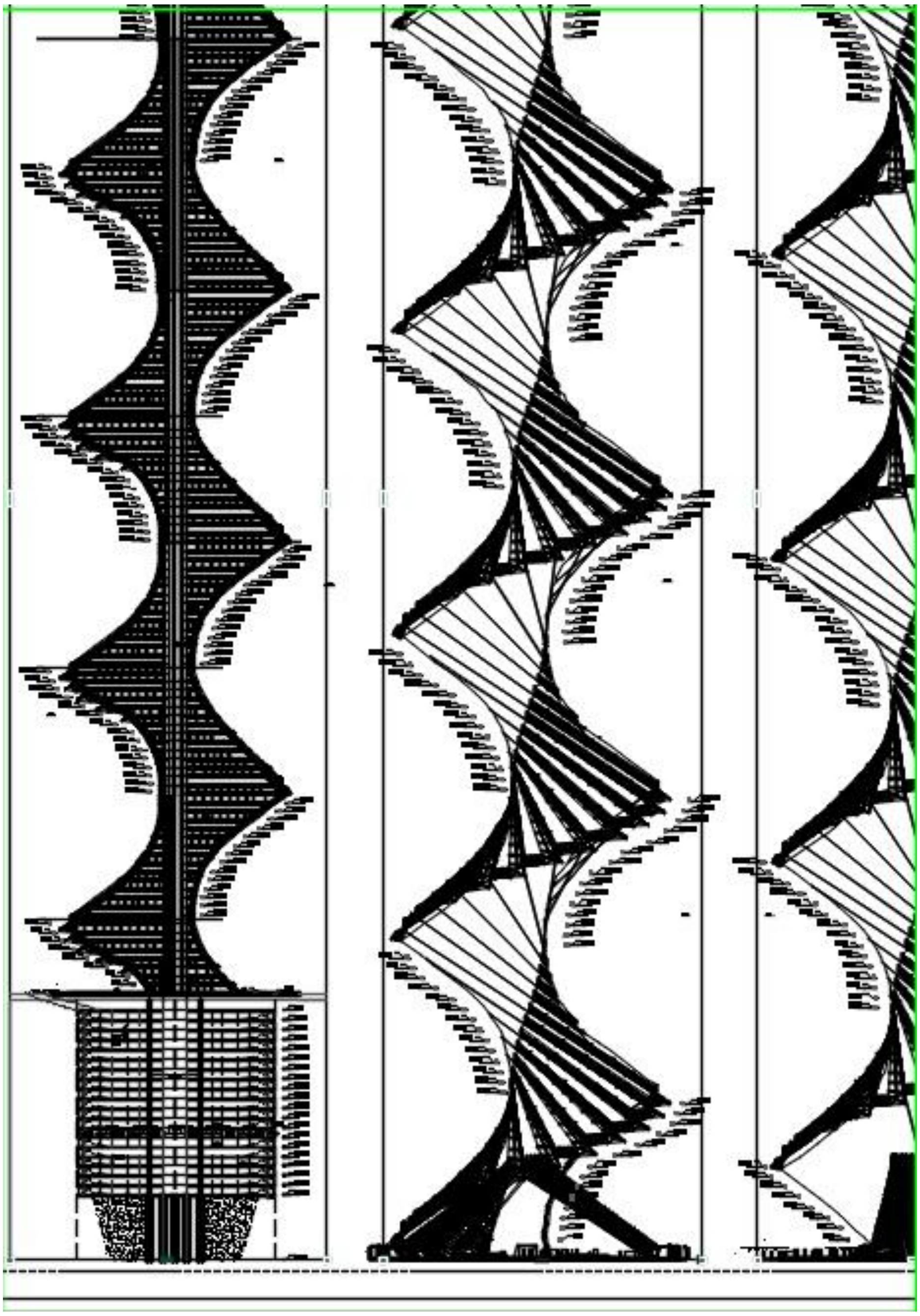
Research project 2- 7.2: After research project 1 analyzing and examining most desirable outcome's variations through mutations according its geometric-mathematical features.

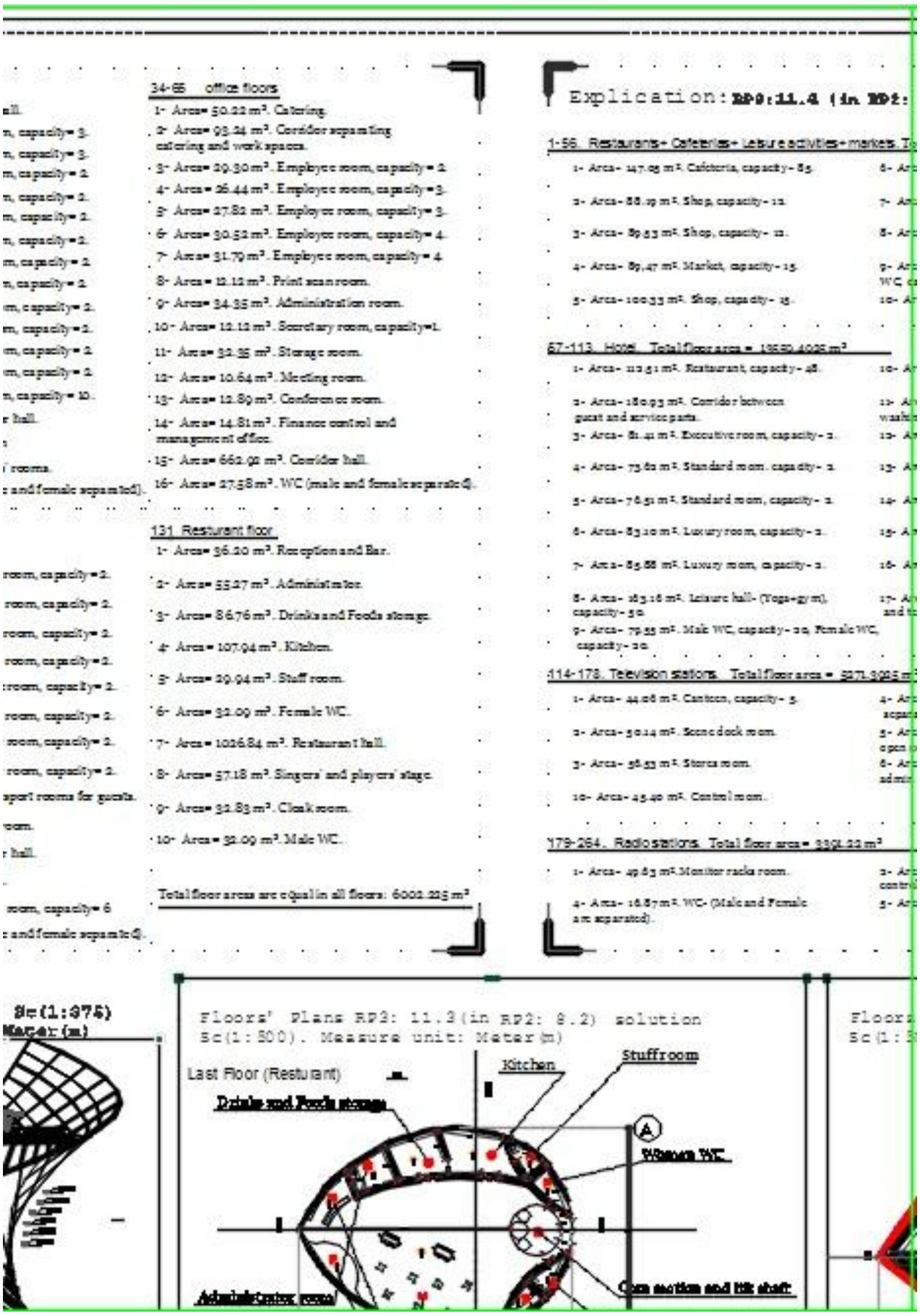


Combining Archimedes spiral with most desirable outcome esearch project1 in order to gain more advanced rametric design solution according to subjective of research.

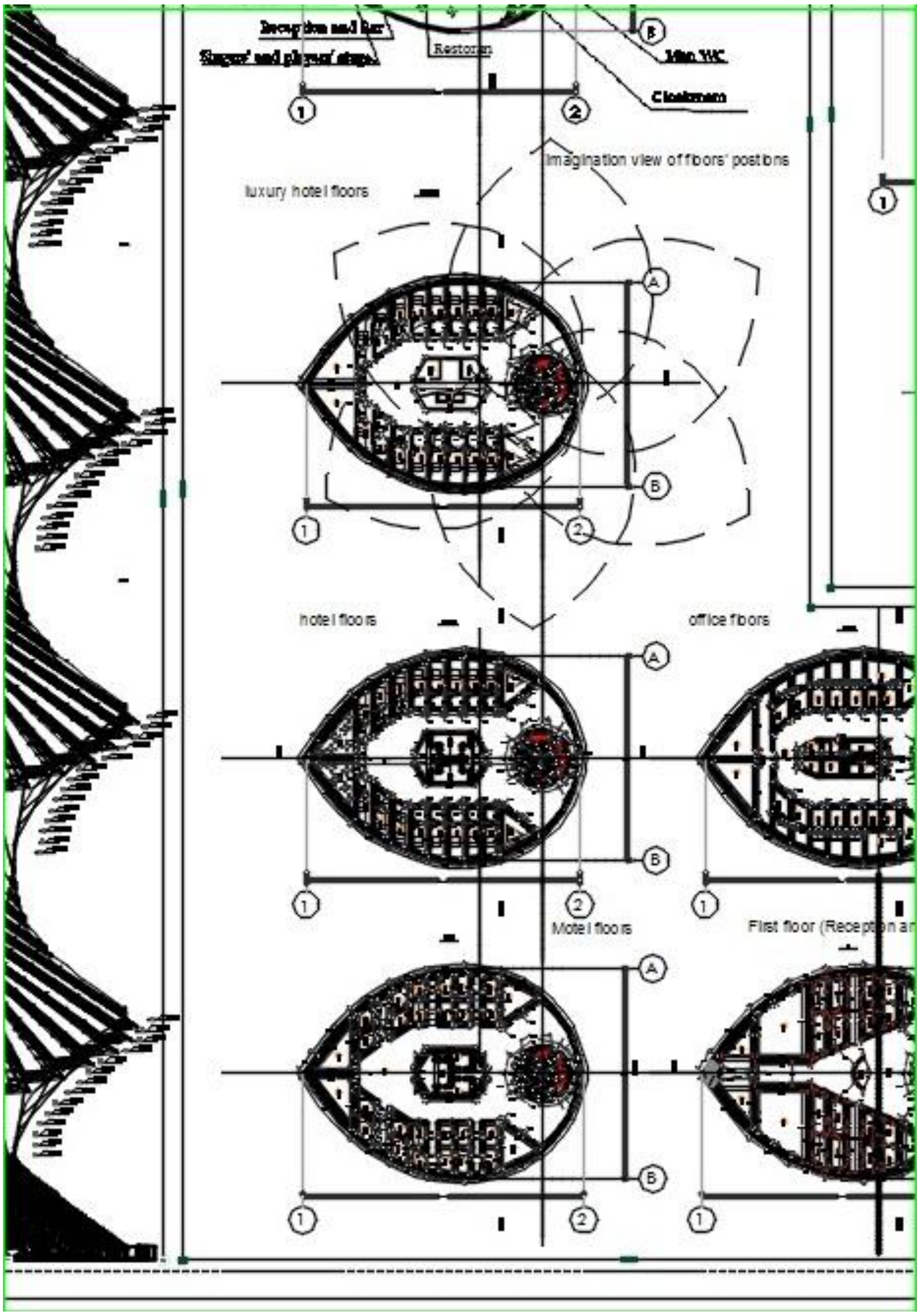


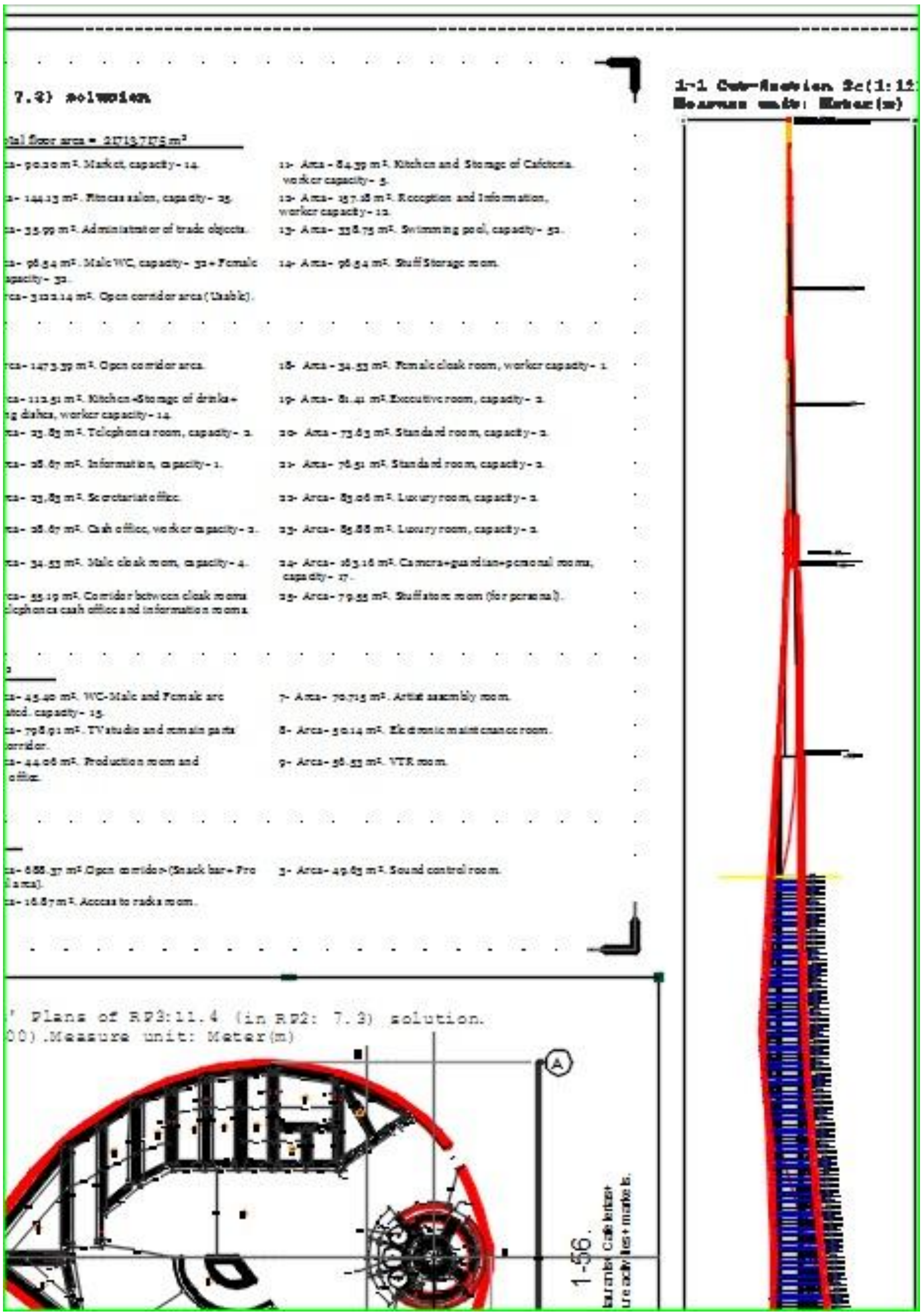

egree Research Projects
f Architectural Geometry.
entation in architecture
useful
of research project 2
Designing two imitated conventional designs for such helical body structure.
Wind flow kinetic and air pressure potential energies conversion aimed solutions
Possibility for computational manipulating and further advancement.
Has link
Explication:RP3: 11.3
(in RP2: 8.2) solution
1 First floor (Reception and resturant/caterings)
1- Area= 28.01 m². Cloak room, capacity= 80.
2- Area= 117.79 m². Restaurant, capacity= 45.
3- Area= 19.90 m². Administration of hotel, capacity= 2.
4- Area= 25.70 m². Secretariat and information of hotel.
5- Area= 19.33 m². Administrations of motels.
6- Area= 20.53 m². Telephones room.
7- Area= 15.95 m². Cash flow.
8- Area= 15.50 m². Secretarial office.
9- Area= 16.42 m². Storage of foods.
10- Area= 15.34 m². Storage of drinks.
11- Area= 27.58 m². Kitchen of hotel service.
12- Area= 15.49 m². Reception.
13- Area= 739.97 m². Corridor hall.
14- Area= 27.58 m². WC (male and female separated).
66-97 hotel floors
1- Area= 50.22 m². Cafe.
2- Area= 28.91 m². Standard room, capacity= 2.
3- Area= 28.59 m². Standard room, capacity= 2.
4- Area= 26.55 m². Standard room, capacity= 2.
5- Area= 27.91 m². Executive room, capacity= 2.
6- Area= 30.62 m². Executive room, capacity= 2.
7- Area= 31.88 m². Executive room, capacity= 2.
8- Area= 29.81 m². Executive room, capacity= 2.
9- Area= 28.25 m². Executive room, capacity= 2.
10- Area= 32.25 m². Leisure, sport rooms for guests.
11- Area= 681 m². Corridor hall.
12- Area= 13.27 m². Reception.
13- Area= 26.64 m². Personals room, capacity= 8
14- Area= 27.58 m². WC (male and female separated).
2-33 Motel floors
98-129 hotel floors
2-2 Cut-Section Sc(1:466)
Measure unit: Meter(m)
Front Elevation Sc(1:275)
Measure unit: Meter(m)
Side Elevation
Measure unit:



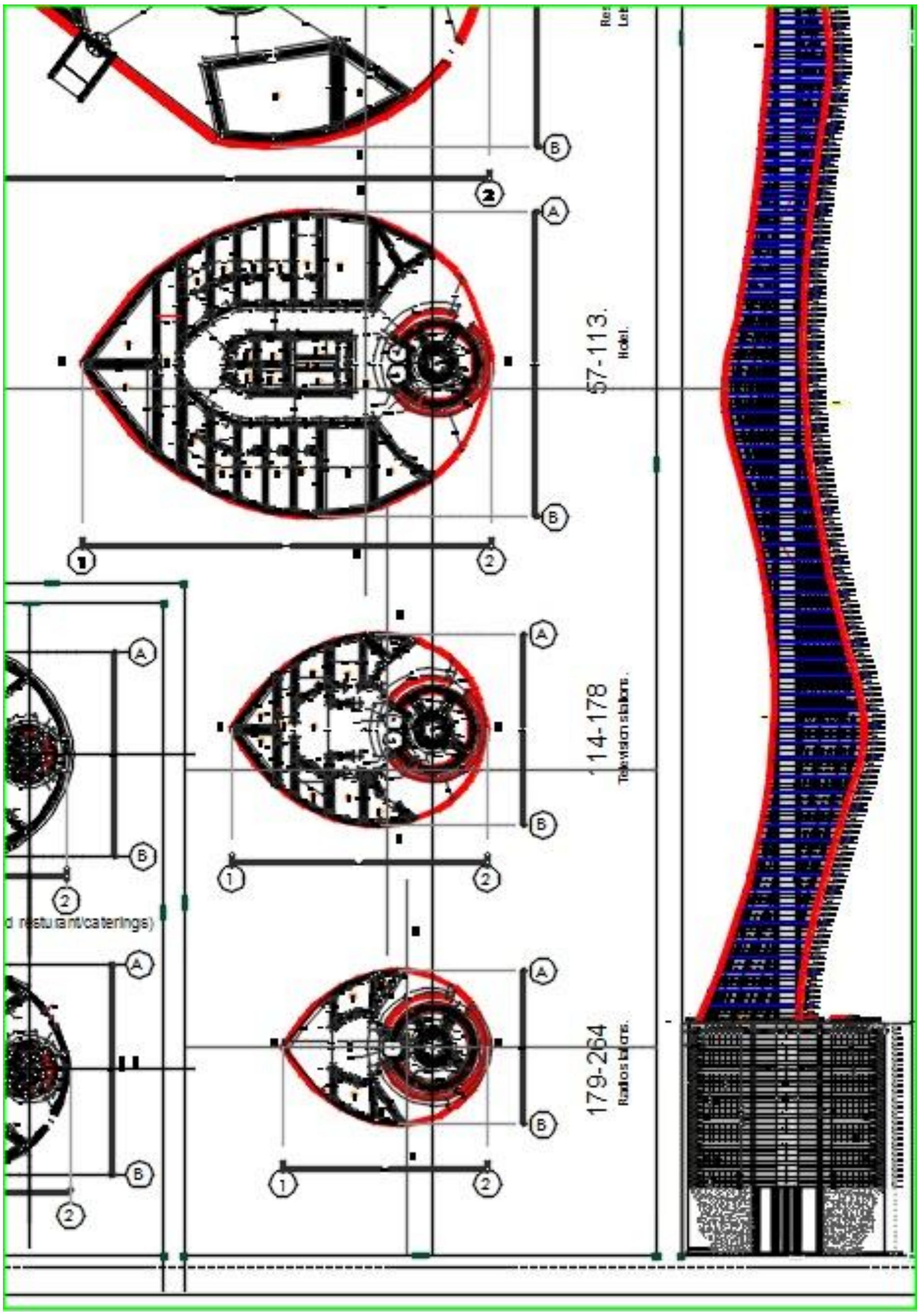


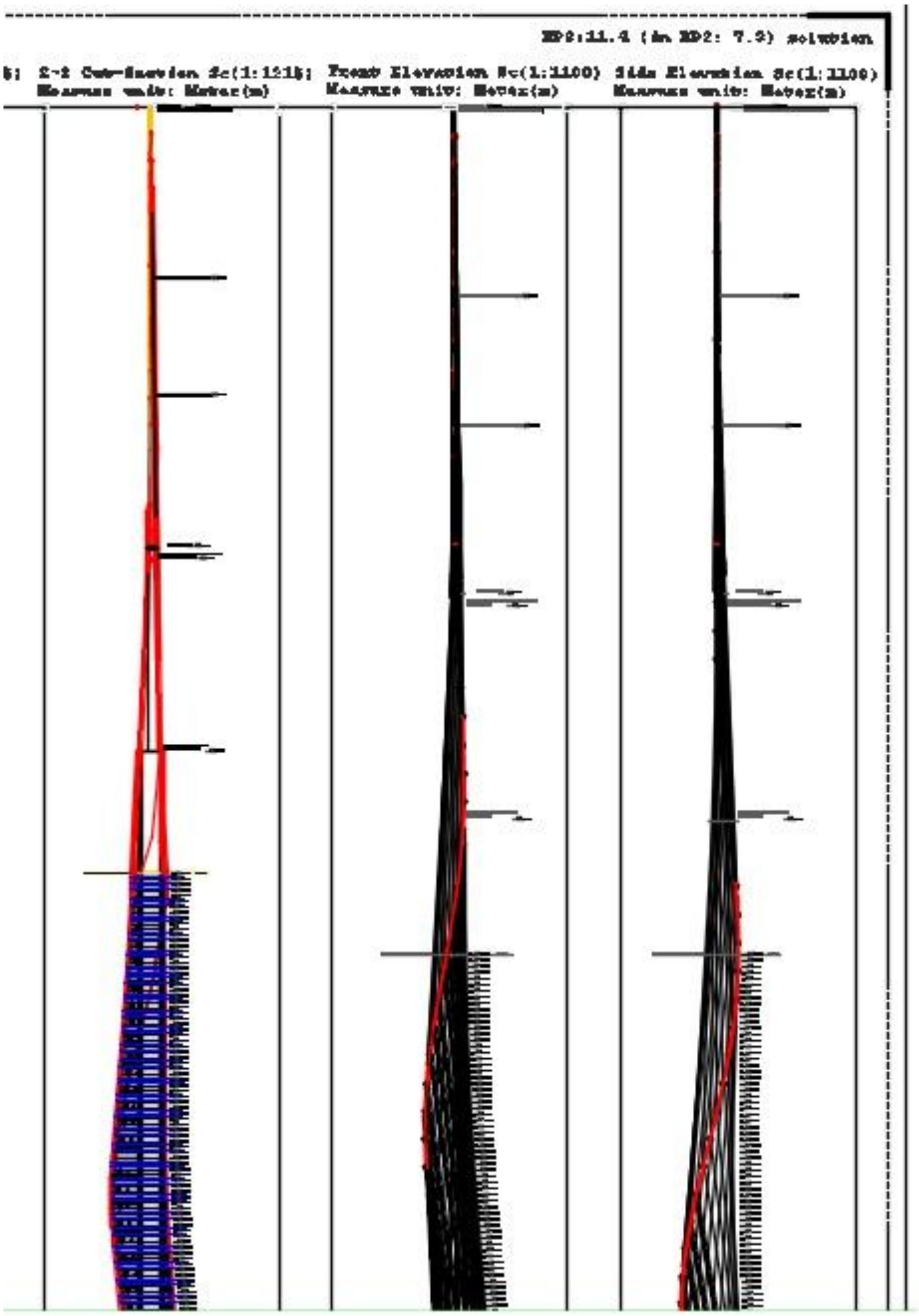
34-66 office floors
1- Area= 50.22 m². Catering.
2- Area= 93.24 m². Corridor separating catering and work spaces.
3- Area= 29.30 m². Employee room, capacity= 2.
4- Area= 26.44 m². Employee room, capacity= 3.
5- Area= 27.82 m². Employee room, capacity= 3.
6- Area= 30.52 m². Employee room, capacity= 4.
7- Area= 31.79 m². Employee room, capacity= 4.
8- Area= 12.12 m². Print scan room.
9- Area= 34.35 m². Administration room.
10- Area= 12.12 m². Secretary room, capacity=1.
11- Area= 32.35 m². Storage room.
12- Area= 10.64 m². Meeting room.
13- Area= 12.89 m². Conference room.
14- Area= 14.81 m². Finance control and management office.
15- Area= 662.92 m². Corridor hall.
16- Area= 27.58 m². WC (male and female separated).
131 Resturant floor
1- Area= 36.20 m². Reception and Bar.
2- Area= 55.27 m². Administrator.
3- Area= 86.76 m². Drinks and Foods storage.
4- Area= 107.94 m². Kitchen.
5- Area= 29.94 m². Staff room.
6- Area= 32.09 m². Female WC.
7- Area= 1026.84 m². Restaurant hall.
8- Area= 57.18 m². Singers' and players' stage.
9- Area= 32.83 m². Cloak room.
10- Area= 32.09 m². Male WC.
Total floor areas are equal in all floors: 6002.225 m²
Explication:
1-56. Restaurants+ Cafeterias+ Leisure activities+ markets.
1- Area- 147.05 m². Cafeteria, capacity- 85.
2- Area- 88.19 m². Shop, capacity- 12.
3- Area- 89.53 m². Shop, capacity- 12.
4- Area- 89.47 m². Market, capacity- 15.
5- Area- 100.33 m². Shop, capacity- 15.
57-113. Hotel.
1- Area- 112.51 m². Restaurant, capacity- 48.
2- Area- 180.93 m². Corridor between guest and service parts.
3- Area- 81.41 m². Executive room, capacity- 2.
4- Area- 73.62 m². Standard room. capacity- 2.
5- Area- 76.51 m². Standard room, capacity- 2.
6- Area- 83.10 m². Luxury room, capacity- 2.
7- Area- 85.88 m². Luxury room, capacity- 2.
8- Area- 183.16 m². Leisure hall- (Yoga+gym), capacity- 50.
9- Area- 79.55 m². Male WC, capacity- 20, Female WC, capacity- 20.
114-178. Television stations.
1- Area- 44.08 m². Canteen, capacity- 5.
2- Area- 50.14 m². Scene dock room.
3- Area- 56.53 m². Stores room.
10- Area- 45.40 m². Control room.
179-264. Radio stations.
1- Area- 49.83 m². Monitor racks room.
4- Area- 16.87 m². WC- (Male and Female are separated).
Floors' Plans RP3: 11.3 (in RP2: 8.2) solution
Sc (1: 500). Measure unit: Meter (m)
Last Floor (Resturant)
Kitchen
Stuffroom
Drinks and Foods storage
Women WC
Core section and lift shaft
Administrator room

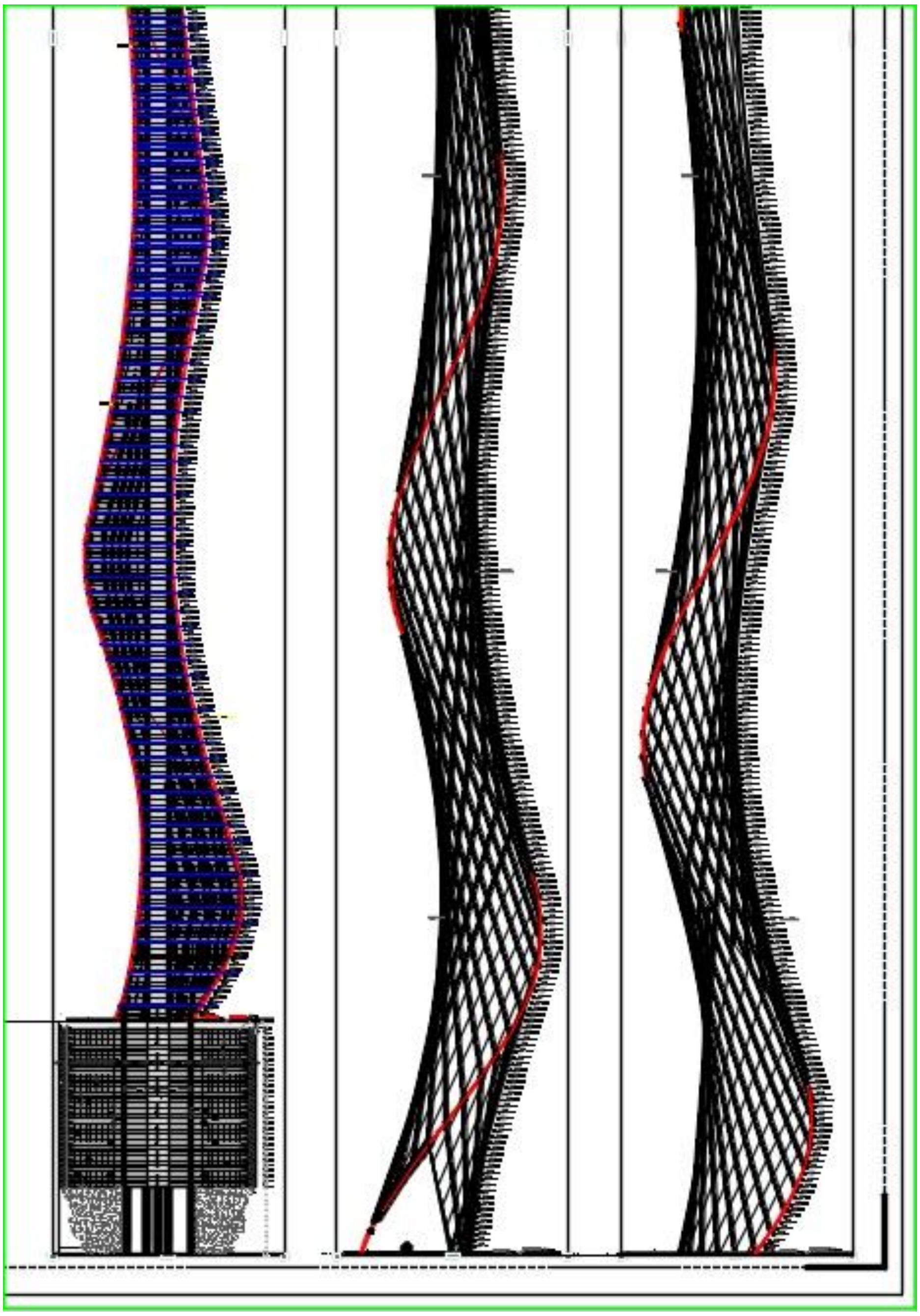

Reception and bar
Singers' and players' stage.
Restoran
Man WC
Cloakroom
Imagination view of floors' positions
luxury hotel floors
hotel floors
office floors
Motel floors
First floor (Recept

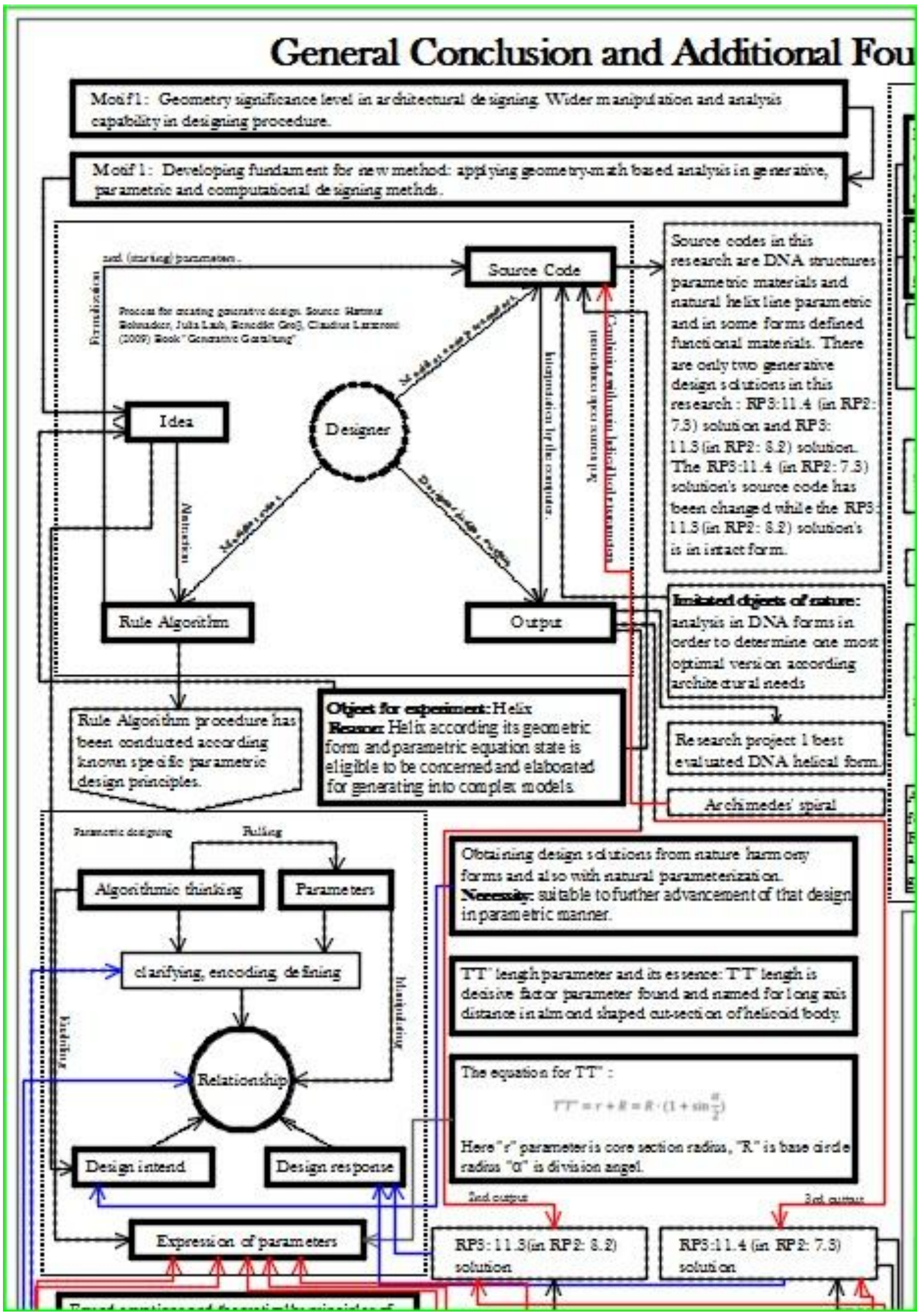


7.3) solution
tal floor area = 21713.7175 m²
ea- 90.20 m². Market, capacity- 14.
11- Area- 84.39 m². Kitchen and Storage of Cafeteria. worker capacity- 5.
a- 144.13 m². Fitness salon, capacity- 25.
12- Area- 157.18 m². Reception and Information, worker capacity- 12.
ea- 35.99 m². Administrator of trade objects.
13- Area- 338.75 m². Swimming pool, capacity- 52.
ea- 98.54 m². Male WC, capacity- 32+Female capacity- 32.
14- Area- 98.54 m². Stuff Storage room.
rea- 3122.14 m². Open corridor area (Usable).
rea- 1473.39 m². Open corridor area.
18- Area- 34.53 m². Female cloak room, worker capacity- 1
ea- 112.51 m². Kitchen+Storage of drinks+ g dishes, worker capacity- 14.
19- Area- 81.41 m². Executive room, capacity- 2.
ea- 23.83 m². Telephones room, capacity- 2.
20- Area- 73.63 m². Standard room, capacity- 2.
ea- 28.67 m². Information, capacity- 1.
21- Area- 76.51 m². Standard room, capacity- 2.
ea- 23,83 m². Secretariat office.
22- Area- 83.06 m². Luxury room, capacity- 2.
ea- 28.67 m². Cash office, worker capacity- 2.
23- Area- 85.88 m². Luxury room, capacity- 2.
ea- 34.53 m². Male cloak room, capacity- 4.
24- Area- 183.16 m². Camera+guardian+personal rooms, capacity- 17.
ea- 55.19 m². Corridor between cloak rooms elephones cash office and information rooms.
25- Area- 79.55 m². Stuff store room (for personal).
ea- 45.40 m². WC-Male and Female are ated. capacity- 15.
7- Area- 70.715 m². Artist assembly room.
ea- 798.91 m². TV studio and remain parts orridor.
8- Area- 50.14 m². Electronic maintenance room.
ea- 44.08 m². Production room and office.
9- Area- 58.55 m². VTR room.
ea- 688.37 m². Open corridor (Snack bar+ Pro l area).
3- Area- 49.85 m². Sound control room.
ea- 16.87 m². Access to racks room.
Plans of RP3:11.4 (in RP2: 7.3) solution.
00). Measure unit: Meter (m)
A
1-56.
1-1 Cut-Section 2c(1:1
Measure unit: Meter (m)


57-113.
Hotel.
14-178
Television stations.
179-264
Radios stations.
d resturant/caterings)






General Conclusion and Additional Fou
Motif 1: Geometry significance level in architectural designing. Wider manipulation and analysis capability in designing procedure.
Motif 1: Developing fundament for new method: applying geometry-math based analysis in generative, parametric and computational designing methds.
Source Code
Idea
Designer
Rule Algorithm
Output
Formalization
Notation
Interpretation by the computer
Source codes in this research are DNA structures parametric materials and natural helix line parametric and in some forms defined functional materials. There are only two generative design solutions in this research: RP3:11.4 (in RP2: 7.3) solution and RP3: 11.3 (in RP2: 8.2) solution. The RP3:11.4 (in RP2: 7.3) solution's source code has been changed while the RP3: 11.3 (in RP2: 8.2) solution's is in intact form.
Imitated objects of nature: analysis in DNA forms in order to determine one most optimal version according architectural needs
Research project 1 best evaluated DNA helical form.
Archimedes' spiral
Rule Algorithm procedure has been conducted according known specific parametric design principles.
Object for experiment: Helix
Reason: Helix according its geometric form and parametric equation state is eligible to be concerned and elaborated for generating into complex models.
Parametric designing
Ruling
Algorithmic thinking
Parameters
clarifying, encoding, defining
Relationship
Design intend
Design response
Expression of parameters
Obtaining design solutions from nature harmony forms and also with natural parameterization.
Necessity: suitable to further advancement of that design in parametric manner.
TT' length parameter and its essence: TT' length is decisive factor parameter found and named for long axis distance in almond shaped cut-section of helicoid body.
The equation for TT' :
Here "r" parameter is core section radius, "R" is base circle radius "α" is division angel.
2nd output
3rd output
RP3: 11.3 (in RP2: 8.2) solution
RP3:11.4 (in RP2: 7.3) solution

Found equations and theoretically principles of geometrical resolutions at research project 2

1.Gained helical body's linear surface feature and its line families description:

$$\frac{x - r \cdot \cos(u-1)\theta}{r \cdot (\cos(v-1)\theta - \cos(u-1)\theta} = \frac{y - r \cdot \sin(u-1)\theta}{r \cdot (\sin(v-1)\theta - \sin(u-1)\theta} = \frac{z - (u-1)\cdot\theta}{(v-1)\cdot\theta - (u-1)\cdot\theta}$$

Necessity: making sure it is linear segmented object for solar energy aimed design solution, panel cells placement.

2.Gained equation for normal helical body generation:

$$\frac{\sqrt{1-\cos 20^{\circ 2}}}{\sqrt{2(1+\cos 20^\circ)}} = \sqrt{\frac{1}{2}\frac{(1-\cos 20^\circ)(1+\cos 20^\circ)}{(1+\cos 20^\circ)}} = \sqrt{\frac{1}{2}(1-\cos 20^\circ)}$$

Necessity: deciphering unique nature of obtained helical body.

3.Gained parametric equations of new generated and research project 1 helical bodies:

Research project 1 helicoid (former body):

$$x = p(R\cdot(\cos((u+v-1)\cdot\theta) - R\cdot\cos((v-1)\cdot\theta)) + R\cdot\cos((v-1)\cdot\theta)$$

$$y = p(R\cdot(\sin((u+v-1)\cdot\theta) - R\cdot\sin((v-1)\cdot\theta)) + R\cdot\sin((v-1)\cdot\theta)$$

$$z = p\cdot u\cdot\theta + (v-1)\cdot\theta$$

New generated helical body (Archimedes spiral combined):

$$x = R\cdot p\cdot\cos(\theta\cdot(u+v-1)) + (1-p)\cdot r\cdot\cos(\theta\cdot(v-1))$$

$$y = R\cdot p\cdot\sin(\theta\cdot(u+v-1)) + (1-p)\cdot r\cdot\sin(\theta\cdot(v-1))$$

$$z = \theta\cdot(u\cdot p + v - 1)$$

Necessity: proving homotopic relationship of new generated and former bodies.

7- Achieved envelope radiuses of generated body and research project 1 best evaluated helical body.

New generated helical body (Archimedes spiral combined):

$$R' = \frac{\sqrt{(R_1 - 2\cdot R_\varphi + R_2)\cdot(3\cdot R_1 - 2\cdot R_\varphi - R_2)}}{4} + \frac{P_1^2 + (R_1 - R_2)^2}{4\cdot\sqrt{(R_1 - 2\cdot R_\varphi + R_2)\cdot(3\cdot R_1 - 2\cdot R_\varphi - R_2)}}$$

Research project 1 helicoid (former body):

$$R' = \frac{R-r}{2} + \frac{P_1^2}{8\cdot(R-r)}$$

Necessity: making exact certainty of homotopic relationship.

Perimeter equation:

$$L = 2\cdot\int_{v_2(T)}^{v_1(T)} \sqrt{}(\left(1 - \frac{k+\theta-v\theta}{2u\theta}\right)^2 (Z - 1.5\theta[-1+v])^2 + \frac{m(k+\theta-v\theta)(1-\frac{k+\theta-v\theta}{2u\theta})(Z-1.5\theta[-1+v])(Z-1.5\theta[-1+u+v])}{2u\theta}$$

Area equation:

$$S = 2\cdot\int_{v_2(T)}^{v_1(T)} \frac{1}{u^2\theta}((-1.z + (-1.+u+v)\theta)\mathrm{Sin}[\theta[-1+v]](M - 1.5\theta[-1+v]) + (z+\theta-1.v\theta)\mathrm{Sin}[\theta[-1+u+v]](M-1.5\theta[-1+u+v]))(\mathrm{Cos}[\theta[-1+v]](M-1.5\theta[-1+v]) - 1.\mathrm{Cos}[\theta[-1+u+v]](M-1.5\theta[-1+u+v]) - \frac{1.5(-1.z+(-1.+u+v)\theta)\mathrm{Cos}[\theta[-1+v]]\theta'[-1+v]}{\theta} - \frac{1.(-1.z+(-1.+u+v)\theta)\mathrm{Sin}[\theta[-1+v]](M-1.5\theta[-1+v])\theta'[-1+v]}{\theta} - \frac{1.5(z+\theta-v\theta)\mathrm{Cos}[\theta[-1+u+v]]\theta'[-1+u+v]}{\theta} - \frac{(z+\theta-v\theta)\mathrm{Sin}[\theta[-1+u+v]](M-1.5\theta[-1+u+v])\theta'[-1+u+v]}{\theta})\,dv$$

ndings

Canton tower's algorithmic aided design case

Motif: Architect Mark Hemel has got idea about erecting female body symbolizing form tower, as he considered many precedent have been erected owers resembling male body forms.

Inspiration: Architect Mark Hemel has interested in wrapping cylindrical path wire connected object and gaining one-sheeted hyperbolic surface.

Shukov's linear double-curved surface principle.

Applied

Idea

Achievement

The formation of one-sheeted hyperbola by ubstituting base pair circles with ellipses (in certain parameters).

Improving

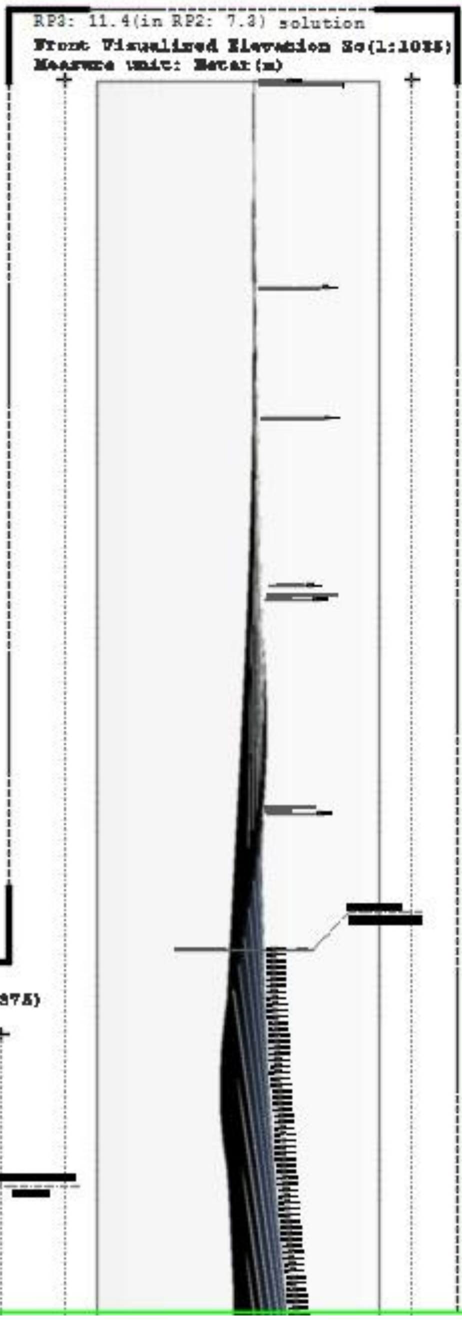
Applying columns, rings and braces.

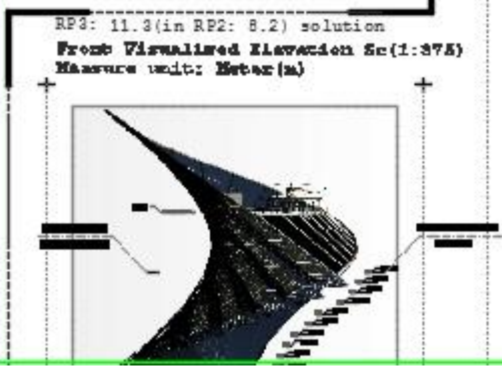
Output

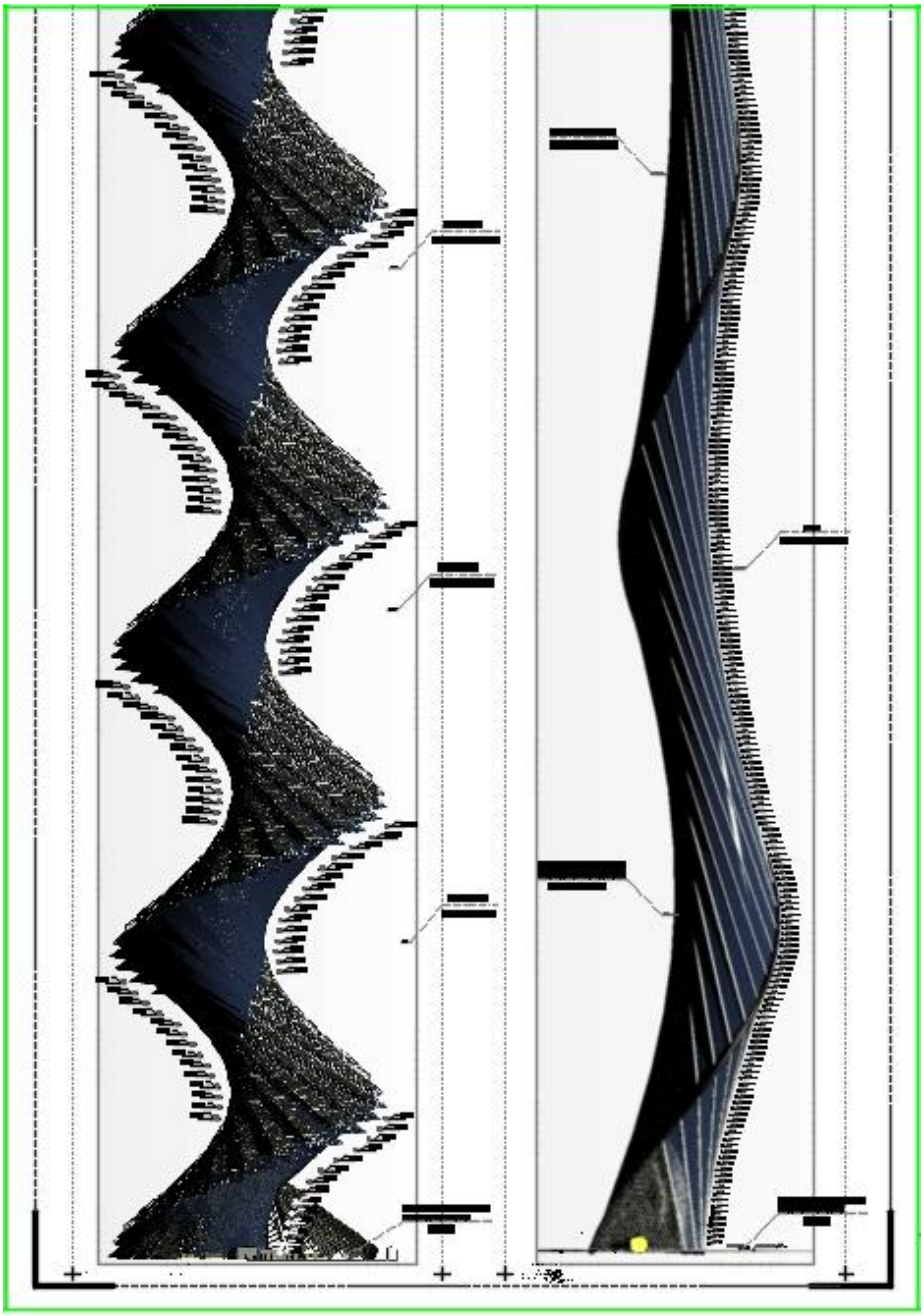
The open lattice-structure, built up from 1100 nodes and the same amount of connecting ring and bracing pieces. Basically the tower can being seen as a giant 3 dimensional puzzle of which all 3300 pieces are totally unique.

Comparison of methodic design principles of Canton tower and current research project

lgoritmic aided modelling premises are being ollowed at Can.tow. design work while in current P much wider aspect of complex geometries nalysis and advancements has been applied through enerative and parametric designs' principles.





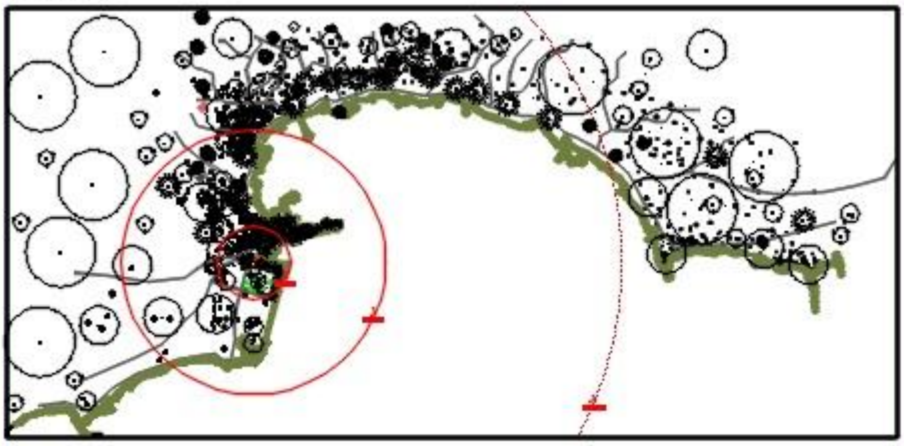


Exterior views of RP3: 11.3(in RP2: 8.2) solution

Exterior views of RP3:11.4 (in RP2: 7.3) solution

Situation plan of towers' building-site in the Baku city's Center (shore-side)

Sc(1:6100)



Explication of land area marks:

Central part of Baku is very modernistic town. In last two decades there were built enormously many modern towers and other activity facilities. Beside that, there is preservation of some ancient monuments, castles and small living towns. Our four design towers' building-site is located enough far away from those historical places There is no any historical place in its 39 km around).

1M- State Carpet Museum
2M- Mugham Center
3M- State Conference Building.
4M- Haydar Aliyev Foundation.
5M- Four Seasons Hotel.
6M- Hilton Baku Hotel.
7M- Baku Crescent Hotel.
8M- 28 Mall.
9M- Baku Entertainment Center.
10M- Excelsior Hotel.
11M- Nobel ave. Spine Bridge.
12M- Central Business district.
13M- Asiman Palace.
14M- SAGA Ship repair company.
15M- Mirvari Plaza.
1F- National flag square.
2F- Crystal Hall Baku.
3F- Flame Towers.
4F- JW Marriot Hotel Baku.
5F- Dede gorgud park.
6F- BWC Office Building.
7F- Haydar Aliyev Cultural Center.
8F- Bakmil M.Station.
9F- Maiden Towerv.
10F- Caspian Palace.
11F- Icheri Sheher M.Station.
12F- Haydar Aliyev Palace.
13F- Nizami M.Station.
14F- Baku White city complex.
15F- 28 May M.Station.
2P Icheri Sheher- 7th century's castle.Inside still living areas in that.Accepted Baku's oldest part ever.

Indications and their designations:

Green are(R=2.501 km) -
Small Populated area - (R=5.279 km) Population=1060
Productive facility-
Green are (R=462 m)-
Industrial complex-
Green are (R=995.33 m)-
Small Populated area - (R=2.455 km) Population= 230
Small Populated area - (R=9.505 km) Population= 3440

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