

Computational Strategy Research on the Development of Kiruna, in Sweden

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Abstract

In Kiruna, nearly all the residents support the migration plan in order to make LKAB able to continue the mining process. Based on current condition, a larger part of this town will be demolished by the sinking land caused by iron ore mining processing operated by LKAB. Since then, most of the buildings in the sinking district will be relocated in another district. However, the situation in Kiruna is not quite the same as when this kind of migration happens in another place. In other place, while migration happens, even if not most, a large part of the local residents will resist and fight for their house and properties. Concentrated on the ownership of different buildings and tried find the relationship between the public and private buildings to discover some issue that will help to work on the computational urban design.

Keywords: *Iron Mine; Economic; Public; Private; Property; Ownership; Transportation; Employment; Economical System; Development History; Swarm Intelligence Logic; Processing*

1 INTRODUCTION

Kiruna is the northernmost city in Sweden, situated in the province of Lapland. It had 18,154 inhabitants in 2005 and is the seat of Kiruna Municipality in Northern County. It is a very special case for urban design study because of the subsidence of the city.

As being a mining city, Kiruna was founded by mining company LKAB in 1900s, at the beginning of the city, the major composition of the city was the workers working in the iron mine. After decades of development, this city has grown into a city composed with varies of industries, which has more than 18000 inhabitants in total. However, along with the development of the city, the exploitation of iron mine also created a huge void under Kiruna city which led to a graduate subsidence towards Kiruna city. Since the economy of Kiruna is very dependent on the income from the mining company LKAB, the mining process cannot be stopped, however, as the mining process moving on, the major part of the urban area will face the danger of subsidence. With the consideration of that, the aim of our research is to find out a suitable relocation strategy for current Kiruna. This strategy should both consider about avoiding the area of subsidence and also the extreme weather condition in Kiruna.

2 BACKGROUND STUDY

2.1 Developing History of Kiruna

As the beginning of Kiruna was based on the mining company, they first build up the illegal residential buildings for their workers and along with the provisional public buildings such church, school, hospital, hotel and police station. Then these illegal and provisional buildings were demolished and replaced by the company as railway opened. At that time, the Kiruna government did not exist, and LKAB company was still a company that 100% belongs to personal. So, it is reasonable to draw the conclusion that most, or the entire properties in that area belongs to LKAB company, which means they are all individual properties.

After the world war II, Kiruna gained city rights and started to receive large amounts of city from the mine, however, LKAB no longer belongs to some individuals but switched into 100% state owned company. In addition, after world war II, most of the buildings were demolished due to the war or some other reasons, and then replaced by the

government. This situation even more weaken the LKAB's right in Kiruna city and make the company lost their property ownership.

The conclusion about the ownership of properties in this city, which is, even though LKAB owned the most part of this town at the beginning of Kiruna history, however, as the city developing, the government got city rights and steadily took the ownership back due to some important event, such as becoming a municipality and World War II.

2.2 Kiruna Government

The Kiruna government was established as a municipality government and this government has its own right and economical system. This made the properties that belongs to the government has no relationship with Swedish government and also LKAB company. Which means LKAB needs to pay the full amount for the lost to any properties lost caused by its mining process.

2.3 LKAB Mining Company

The LKAB belongs to Swedish government and relies on the iron mine in Kiruna which means the company needs to continue their mining process in Kiruna in order to keep the company's operation. Also, the ownership of this company makes this company related to the state government, however, even though the government of Kiruna municipality and the state government were separated, they still have some connections on some beneficial aspect, which made the situation in Kiruna quite complicated.

2.4 The Relationship between the Government and LKAB

There comes questions, as what we have found out, most of the buildings belongs to individuals or Kiruna government, instead of what we thought before, belongs to LKAB, and also, the government of Kiruna is also an isolated government which is not directly controlled by Swedish government, which means they have different beneficial consideration compared with LKAB.

Based on the information and sequitur based on those information, we can generate these conclusions. These conclusions will be the basic principles for future research development, since I think future transformation process will relies on the relationship between them.

The history of Kiruna is very much interlaced with the history of the LKAB mine. In fact, the city was planned and founded by the first director of the mine 100 years ago. LKAB is an international high-tech minerals group, and the mine has become the world's largest underground mine. Even though other trades have become increasingly important for the region, the mine still provides the basis of the local economy.

2.5 Land Use

In Kiruna, the mining area locate in the southwest of Kiruna city. Residential district took the major portion of the city and they are separated into three major district which located in the south, northwest and east. In the central part of Kiruna which will be mostly affected by sinking is the commercial, government and some other public buildings. To the east of the central part, located the industrial area with different companies.



FIGURE 1 LAND USE MAP, BY AUTHOR

1.6 Private Buildings Proportion

After drawing the land use map, it clearly told us that residential district takes the largest proportion in land use aspect which is approximately 60%. According to previous research, we can learn that most of the residential district belongs to individuals which means these are private properties.

However, the industrial district locates in the east part of the city. It is really hard to define whether they are private properties or public properties. Since some of the companies are the subsidiary companies of LKAB and some of them belongs to private owners. Since after the world war II, the descending of mining production made both the government and LKAB company to diversify the industry and also the economy in Kiruna. The municipality government lent money to individuals to open their own company, and LKAB invest a large amount of money to relative areas to diversify its industrial economy. Most of the company opened during that period located in this industrial district which made it extremely hard to define each company's ownership in this area.



FIGURE 2 PRIVATE PROPERTIES, BY AUTHOR

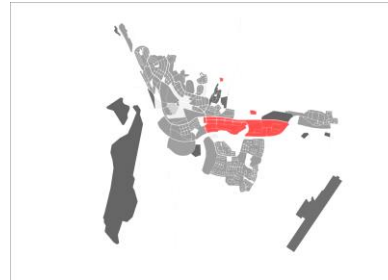


FIGURE 2 UNCERTAIN PROPERTIES, BY AUTHOR

2.7 Subsidence

In order to make this research useful to our future design, subsidence processes were also studied in order to know how many private will be affected by mining process and what is the time? I draw the subsidence map of Kiruna to depict the sinking range and the private property district in that range.

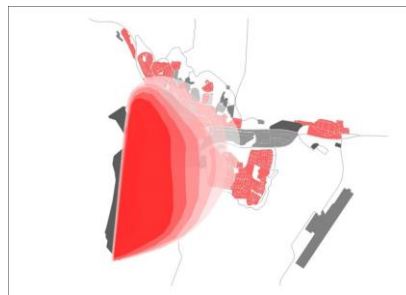


FIGURE 3 DEFORMATION AFFECTION RANGE, BY AUTHOR

The first dwellings to be affected in Kiruna are in an area known as Ullspiran. LKAB owns the land and the buildings there. The railway track that lies between Ullspiran and the mine can be used until 2012, when the new line is ready, and the buildings will remain in place for at least as long.



FIGURE 4 2013 AFFECTION RANGE 1, BY AUTHOR

The map shows the forecast line for the year 2013. It shows where the very first movement in the ground can be

detected, long before it is visible or causes any damage. It has not yet been decided how large the Mine City Park will be, but the idea is that it will lie somewhere between the location of first indicated movements and the boundary of the mining and industrial area.

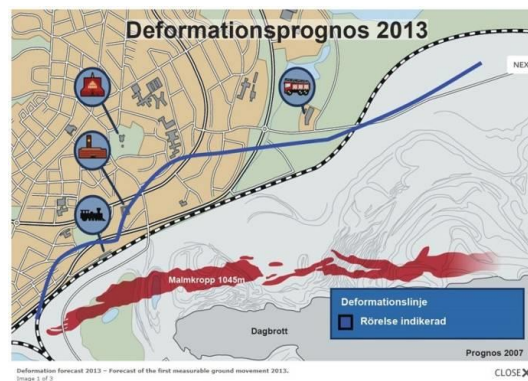
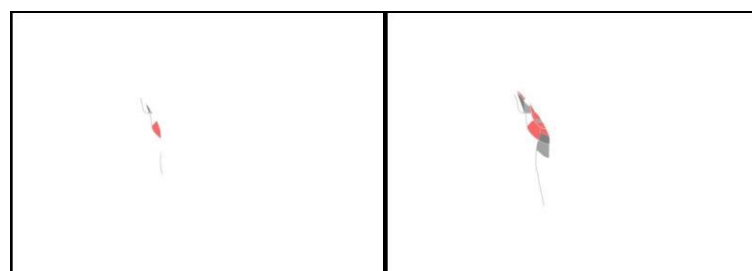
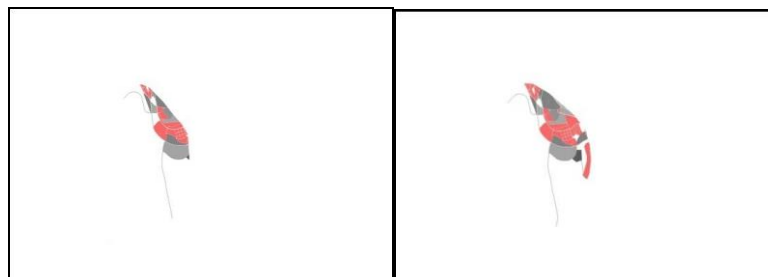


FIGURE 5 2013 AFFECTATION RANGE 2



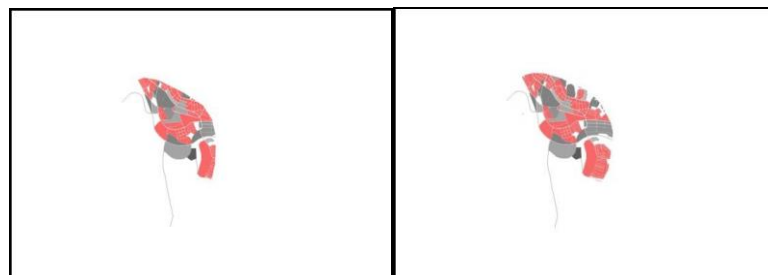
2013

2025



2035

2050



2060

2070

FIGURE 7 MINING PROCESS, BY AUTHOR

3 KIRUNA'S FUTURE

3.1 What Happens in Kiruna

In the sinking area, the LKAB used the traditional operated a new mining city park which have start this process since 2008, and also the residential district which will be affected by the deformation have already be bought by

LKAB, along with the properties on the ground.

3.2 Problems Kiruna Facing

Even though LKAB has spent 700 million SEK to this transformation process, they still argue for the future payment for the relocating works. Due to the great contribution LKAB has made to Kiruna city, LKAB thought they do not need to pay the full amount for all properties.

In addition, they also argue with the government how long they need to pay for the transformation or relocation process, since it is quite a long term process. They refused to pay all the cost at one time. The reason for this situation is that the cost for mining process became more expensive as they dig deeper, plus with the cost for above ground compensation, they need to figure out which will be more beneficial for them, abandon the iron ore or keep mining.

Although they have such an innovative plan for the new city, when they noticed the iron mine in Kiruna did not worth them to continue paying for the deformation of Kiruna, they will stop the mining process and turned to another place, even though Kiruna is in its half way of transportation.

There is the truth that, even though LKAB belongs to state, it should care for people's living. However, as talked before, they are two different systems, state government and municipality government, and though all these events, those never see any state official organization show up to make some effort during this process. In addition, it is still a company which put economical consideration as their first consideration, they will leave this area as soon as they find there is no benefit in this district. In that case, what should Kiruna do in order to make full use of the compensation given by LKAB company to relocate their houses in a rational way. Since the compensation was paid steadily which made the transportation process works step by step. It is a great challenge to think out a method how to make the relocating areas still have a strong connection in order to make this city remains to be an integrity. Instead of simply cutting the original cities into separated small pieces and relocate them in other areas.

This urban design task should follow some practical and current conditions to make its own logic for design. Based on this situation, this design should both consider the gradually relocation and also keep the relocating piece and the existing piece remain as integrity.

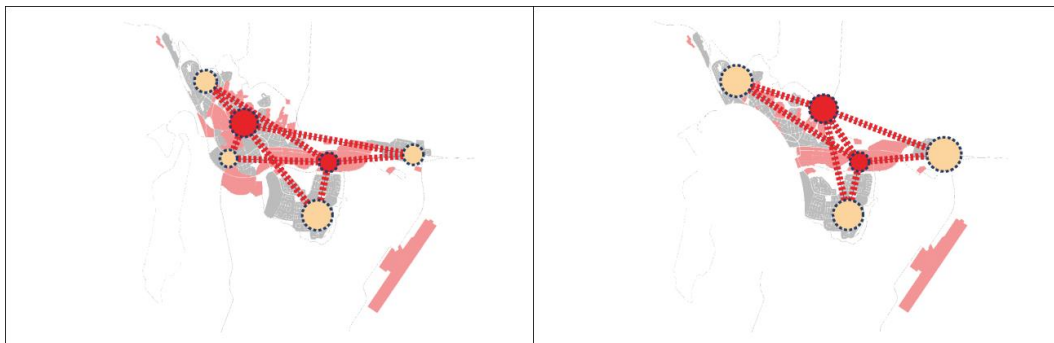


FIGURE 8 POTENTIAL METHOD, BY AUTHOR

4 DESIGN CONCEPT—FURTHER RESEARCH ON DEVELOPMENT STRATEGY

Based on the research, some conclusion could be generated from those information. Firstly, if LKAB company need to continue its mining process in Kiruna, they will, definitely, paid for all the cost for transforming and relocating which include purchasing the land and relocating houses. In the second, most of the houses will be relocated instead of being demolished. Thirdly, LKAB will stop their investment to the city relocating work when they found they cannot find any more benefit from the ore mine.

It is not a wise idea to start considering a comprehensive detailed plan for new Kiruna, since these relocating work happens step by step which make this process will face the risk when LKAB stop investment and Kiruna will be cut into two separate district.

4.1 Biomimicry Research

The concept started from doing biomimicry research on arctic creatures. In order to get a concept that could best fit the local weather conditions. This research chose polar bear as the research object and majorly studied on its fur system.



FIGURE 9 POLAR BEAR HOLLOW FUR

The fur system of polar bears shows a high efficiency in avoiding heat loss and absorbing sunshine. Since the entire fur system is composed with three layers. The outside layer is the long hollow hair and the middle layer is highly dense under hair and the last layer is a black skin. While sun shines on polar bears fur, the long hair with hollow core will direct sunshine to the black skin, and the under hair with high density will prevent heat loss. In addition, the long hair could also work as a outside cover against cold wind.

4.2 Surface Design Development

1) Multi-Layer Surface System

Inspired by the fur system of polar bear, I found the possibility of designing a building with high heat efficiency by using multi-layer surface. In my design, I intended to build a surface with two layers, the outside layer will work as a “coat” of the building, it could lead sunlight to the inside layer and also isolate the inside layer from the cold environment outside.

2) Surface Shape Strategy

The strategy for generating the shape of the surface is inspired by wind tunnel. The trails of wind in wind tunnel outline the wind shape of the objects when it flows around it. In the research, the computer generated in urban planning stage as the original objects in wind tunnel and using the predominant wind direction in winter as the wind direction to form the geometry of the surface shape. By using this logic, the computer build a wind model in processing to simulate wind and generate the contour line for surface.

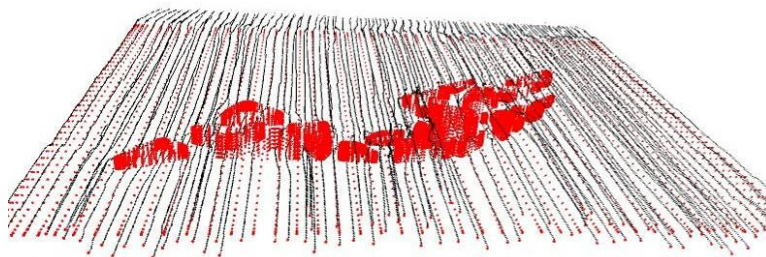


FIGURE 10 SCREEN SHOT OF PROCESSING, BY AUTHOR

3) Solar Device Strategy

Another important component in this surface is the solar device, as what the research mentioned before, Kiruna's extreme weather condition not only include the cold temperature, but also the sunshine condition, which is too much sunlight in summer and too few sunlight in winter. This condition requires the surface should be able to adjust the sunlight penetration due to the different weather conditions and users' requirement. To inspired by aperture, a special device used in camera for sunlight penetration control, and use the similar strategy to control the open space proportion.

4) Combination of Solar Device and Multi-Layer Surface

In order to make use of the solar device in multi-layer surface, the solar device was transferred into a 3-dimensional device from origin 2-dimensional device. A new feature was added into this device which allows the center circle to rise or descend in Z direction. By using this feature, this device could work as a wind fence in winter to avoid wind entering the gap between outside surfaces and inside surface and cause heat losing. While in summer, the center circle could descend and direct wind into the gap to bring in cool air to reduce indoor temperature.

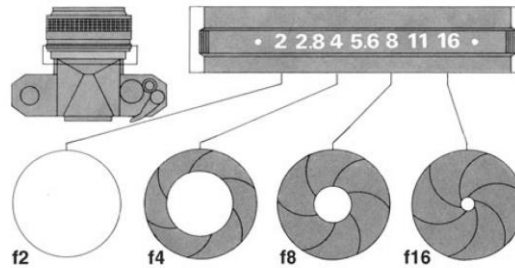


FIGURE 11 APERTURE

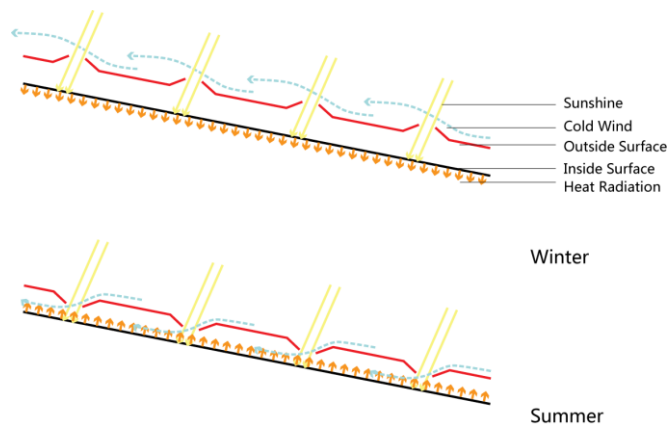


FIGURE 12 DOUBLE LAYER SURFACE SYSTEM, BY AUTHOR

5 DESIGN PROPOSAL

5.1 Wind Generating System

1) Wind Building System

The starting point to make the previous concept into actually design is to study on wind performance and find a way to simulate the wind floating. At first, wind is actually air in motion which means it could be presented by a huge group of moving air agents, this provides the possibility of simulating wind in processing tool. Secondly, wind has three features,

- 1) The speed of air in motion will be affected by other air around it, a group of air agents will maintain in a similar speed.
- 2) The direction of air will be affected by other air agents. When two group of air agents meet, they intent to merge into one group and change to the same direction.
- 3) The pressure of air is the basic feature that creates air movement, wind. While in processing, this could be presented by density of air agents. When the density of the agents is too large, the repel force will be generated between these agents to separate them. When the density of the agents is too small, the cohesion force will be generated to reduce the distance between different agents.
- 4) The wind speed varies while it takes place in different height.

With the logic listed above, the characteristics of air agents are written into code with swarm intelligence logic. Four functions were written in this processing code, which is alignment, used to maintain the agents to move with a similar speed and direction with the surrounding agents, cohesion, separation and repelling, used to simulate the wind pressure between different air agents. Based on this code, computer built the wind building system in processing.

2) Wind Building Strategy

Normally, wind has two affections to the objects on the ground, one is using the character of transportation, to transport sand or snow from bottom ground to a higher level which is the logic to form the snow drift and sand dune, another one is erosion. In my design, these two features will be used in two different aspects. The first feature will be used in surface generation and the other feature will be used in program, interior space generation.

3) Surface Generation

Based on the system that computer created before, the program buildings that generated were imported into this wind generating system as the prototype to build the surface. These buildings will repel the wind agents while that flow near the surfaces of these buildings.

The generated wind trails will be import back to model and be used as the basic reference contour lines to for the surface.

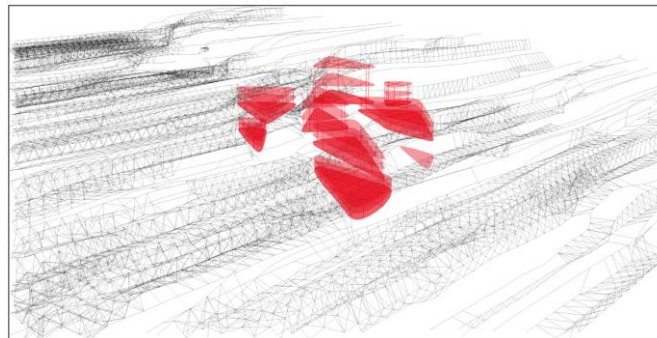


FIGURE 13 WIND FLOATING IMAGE, BY AUTHOR

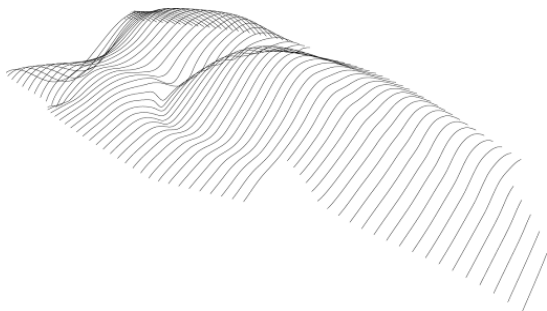


FIGURE 14 SURFACE FRAME LINE, BY AUTHOR

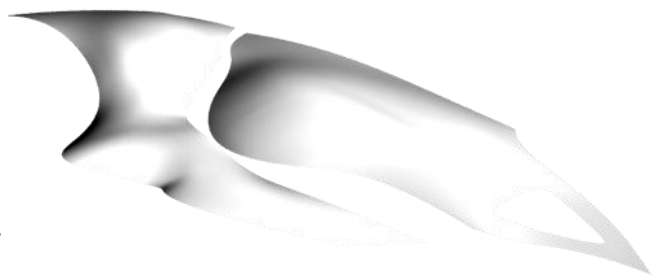


FIGURE 15 SURFACE RENDERING, BY AUTHOR

5.2 Interior Space Generation

Inspired by the wind erosion process, the interior space generation use a totally different logic compared to the surface generation logic. The surface generation is use the trails of wind agents to generate the outer skin of the program buildings. However, under the roof, the entire space was considered to be a solid part and wind was used as a drilling machine to create transportation and connection space between different programs.

In this generation system, both the roof and ground was set to be repel point, in addition to that, computer extract the center lines of the programs generated in the group stage and use these lines as additional repelling agents.

To use two wind direction in this processing in order to create a more accurate interior space, two wind trail will be generated separately and then combined as the construction line for interior space.

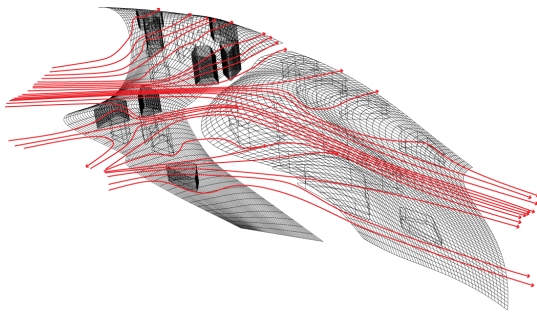


FIGURE 16 WIND FROM WEST, BY AUTHOR

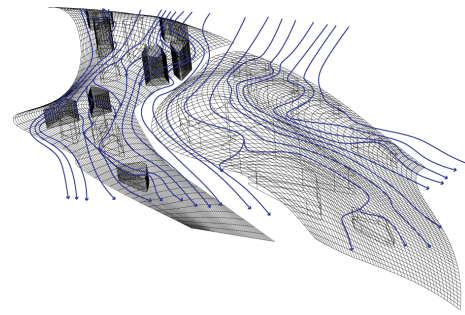


FIGURE 17 WIND FROM NORTH, BY AUTHOR

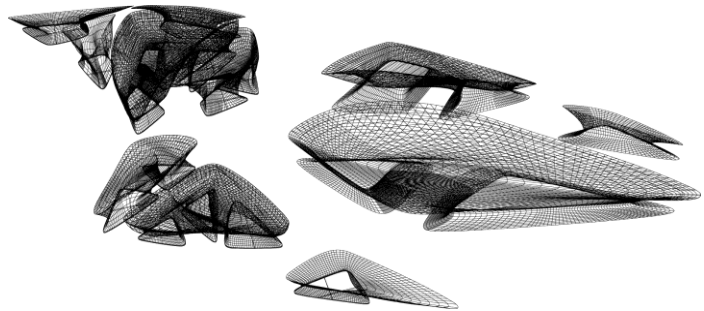
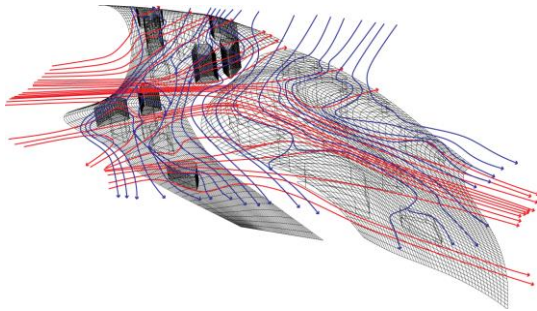


FIGURE 18 GENERATED INTERIOR PROGRAM, BY AUTHOR



FIGURE 19 GROUND PLAN, BY AUTHOR

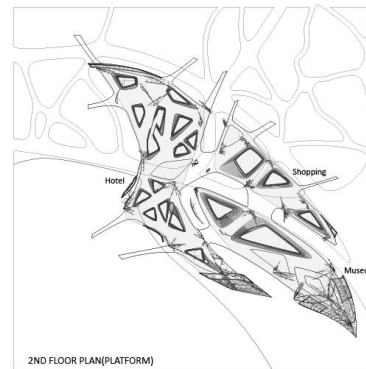


FIGURE 20 SECOND PLAN, BY AUTHOR

SECTION RENDERING



FIGURE 21 SECTION IMAGE, BY AUTHOR



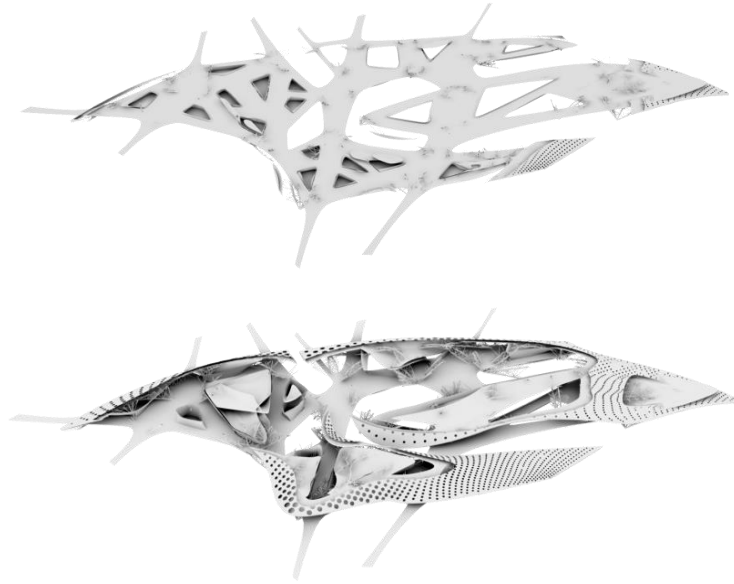


FIGURE 22 SECTION PERSPECTIVE IMAGE, BY AUTHOR

5.3 Structure System

In order to create a structure system to support long span surface, the gravity of the surface should be averagely distributed to different supporting points on the ground. This structure system was built by following the steps below.

1. Getting the support points based on surface and programs. Use Voronoi to get the center points.
2. Project the center points on the surface.
3. Use curves to connect the support points. Use curves as the major supporting structure.
4. Divide curves into a set of points and surface into point grid, use grasshopper to connect the nearest points and to form the secondary structure and connect the curve and surface.

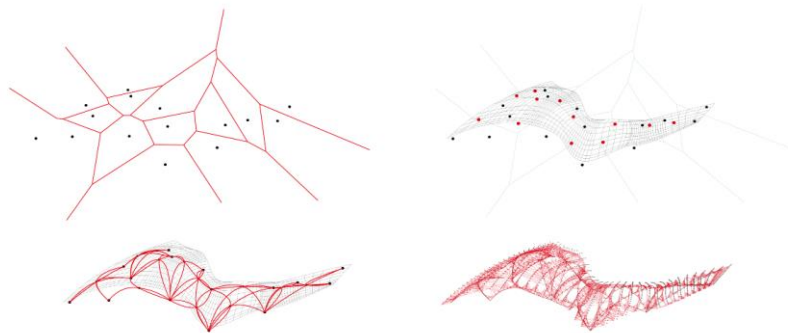


FIGURE 23 STRUCTURE SYSTEM CONSTRUCTION STRATEGY, BY AUTHOR

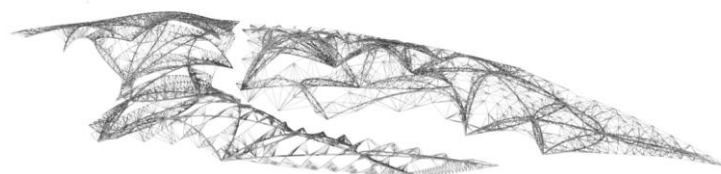


FIGURE 24 STRUCTURE RENDERING, BY AUTHOR

REFERENCES

- [1] Meffe, Gary K, 2002, Ecosystem management: adaptive, community-based conservation
- [2] Diana Laughlin, 2004, Understanding transformation in human and natural systems, journal of the community development society, Vol:34
- [3] Hultqvist, Bengt, 10/1957, The Kiruna geophysical observatory, Nature, Vol: 180
- [4] Watts, Noel, 09/1955, Kiruna-Sweden's northernmost mining town, Geographical Magazine, Vol:28
- [5] Topal, Erkan; Newman, Alexandr; Kuchta, Mark, 03/2004, Implementing a production schedule at LKAB's Kiruna mine, Web of science, Vol:34
- [6] Alexandra M Newman; Michael A Mrtinez, 05/2011, A solution approach for optimizing long and short term production scheduling at LKAB's Kiruna mine, European journal of operational research, Vol: 211
- [7] Erskine, Ralph, 03/1967, Housing at Kiruna and Svappavaara, Sweden, Architectural design, Vol:37
- [8] Niiniskorpi, Veikko Juhani, 06/2004, Development of phases and structures during pelletizing of Kiruna magnetite ore, Materials science, Mining
- [9] Wind Energy Systems by Dr. Gary L. Johnson November 20, 2001
- [10] Sun Rhythm Form, Ralph Knowles, MIT Press 1981 energy, building and the law.
- [11] Neil Leach, Architectural Design Special Issue: Digital Cities
- [12] Watts, Noel, 09/1955, Kiruna-Sweden's northernmost mining town, Geographical
- [13] Wind catchers: remarkable example of Iranian sustainable architecture, by Saidian Amin , Amirkhani Aryan , Zamani Ehsan and Khademi Masoud
- [14] Digital-botanic architecture, by Dollens, Dennis
- [15] Solar envelope concepts : moderate density building applications : final report, by Knowles, Ralph L
- [16] Wind Study http://en.wikipedia.org/wiki/Wind#Fujita_scale
- [17] Wind Erosion Study <http://courses.missouristate.edu/EMantei/creative/glg110/deserts-wind.html>
- [18] Wind Feature Study <http://old.biovip.com/content/20050519/13482.htm>
- [19] Aperture Study <http://www.geekinspired.com/photography/shooting-in-aperture-priority-mode/>
- [20] Wind Erosion Study <http://en.wikipedia.org/wiki/Erosion>
- [21] Wind Tunnel <http://qiche.info/car168/bencandy.php?fid=181&id=1122>
- [22] Polar Bear Fur <http://www.exo.net/~pauld/popularerrors/polarbearfur.html>
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- [24] Image 14, Camera Aperture http://www.facebook.com/note.php?note_id=173983312626375

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