Sustainable architecture in northern subarctic and artic climate

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Abstract. Since the antique the Vitruvian virtues three basic qualities, solid, useful and beautiful is central themes when judging architecture. Although the themes have remained, the conceptual idea of these qualities has shifted. In today’s modern society, sustainability requirements are an integrated perspective, often expressed as a balanced consideration of ecology, economy and social aspects. There are numerous approaches to measure and evaluate sustainability. Often the perspective of the evaluator’s model is predominant. An alternative approach is to ask architects or designers to describe the sustainable idea. This is an approach used to identify alternative perspectives.

In this work, we introduce a multiple case study. The scope, to investigate sustainable architecture based on the architects or designers own drawings. The aim is not to define sustainability in architecture but rather to illustrate articulated examples of integration of sustainability issues in architecture. The study is limited to a selection of 22 buildings, proposed as exceptionally sustainable in public media. The northern subarctic and artic regions here are the geographical boundary. The cold climate description is used as the background for illustrating a variety of sustainable concepts. We propose that descriptive information, interpreted from the architect or designer perspective, has important contributive factors in the understanding of sustainable housing. We argue that the architect or designers design critique influences the result of conceptual meaning. The attention given to sustainability is the founding architectural factor in these studied buildings, expressed in various forms.

Keywords: Sustainable, Architecture, Cold climate.

1 Introduction

When studying examples of sustainable architecture, it is easy to become mesmerized by the differences in the ways it is expressed simply by moving from one place to another. Similarly, the time factor has a clear impact on the depiction of sustainable construction.
An early historical insight into how the significance of the architecture is imparted can be found in the description by the ancient Roman architect Vitruvius in his multi-volume work “Ten books on architecture” [1]. He describes architecture using three basic qualities.

The first one, “Venustas”, often translated as beauty. But what is beauty? It is a subject that has caused a lot of concern. The philosopher Wittgenstein expressed it as something immeasurable, the personal experience between the viewer and the object, something that can only be experienced [1]. Some argue that even if beauty is both immeasurable and subjective, there is still something that is more universal, and that is the experience of completeness. We can feel this completeness in situations where we feel that everything is true, when things fit together, when the aesthetic shape is attractive and is independent of time, place and cultural context.

The second quality that Vitruvius emphasizes, “Commoditas”, can be translated as convenience or functionality. Good functionality is obviously essential, but if we look at how production has evolved over the last half century, the concept of function has often been regarded primarily as something that can be measured – something that is expected to fulfill important needs. An inherent challenge in the concept is also to find functional solutions that fill the needs of our times and also meet requirements with regard to flexibility so that it is possible to meet future demands for adaptation.

The third quality Vitruvius describes, “Firmitas”, can be translated as sustainability. This usually involves technical sustainability. The whole concept of sustainability is usually much broader today. It is based on the qualities of the place of construction, the energy supply systems available and the technical possibilities. Materials are important. What lies beneath, behind the facade and the paint? Is it plaster, porcelain, wood, board or concrete? By allowing the materials to retain their intrinsic and aesthetic values and instead of looking at the material’s ageing as a problem, we can look at it as an aesthetic asset.

Vitruvius chose three qualities in order to summarize what he believed architecture should incorporate. The important thing was that all of the parts would be given their importance. Similarly, we may argue today that the concept of sustainability is of importance when it is given a holistic perspective. This may be when the three qualities, good function, sustainability and beauty have a well thought out intention, and especially when great care is paid to design.

Sustainable architecture can vary in design within a geographical area, but there are key elements that unite their resulting sustainability. The scope of this work is to show how building sustainability can be expressed when the architect is allowed to make the description. The study is limited to Northern Sweden (cold climate).
2 Method

2.1 A Subsection Sample

There are numerous approaches to measure and evaluate sustainability. Often the perspective of the evaluator’s model is predominating. An alternative approach is to ask architects or designers to describe the sustainable idea with the aimed result of identifying alternative perspectives. In this work, we introduce a multiple case study from a descriptive documentation of a totally 22 sustainable buildings in Northern Sweden. Information of the particular concepts can also be found in [2].

The scope has been to investigate sustainable architecture based on the architects or designers own drawings. The aim is not to find a definition of sustainability in architecture but rather to illustrate articulated examples of integration of sustainability issues in architecture. The analysis of the text is grounded on the three virtues of Vitruvius - function, sustainability and beauty. This is illustrated in Fig. 1 where economy is introduced as a fourth feature.

Fig. 1. The Vitruvian triangle with economy as a fourth feature.

In this perspective, six different sustainability categories are identified and analysed: Climate, Site, Function, Life cycle, Low energy and Passive house.

From these texts, summarized in [2], a suggestion of integration of the six perspectives in the triangle is suggested based on a simple narrative analysis.

3 Concept

Twenty-two building concepts [2] documents were used in the conducted study. Those building concepts were categorized into the above introduced 6 perspectives. This section is condensed to comprise one selected building concept for each perspective.
3.1 Climate

3.1.1 Ice Hotel

The Ice Hotel in Jukkasjärvi, is the first ice hotel and art exhibition of snow and ice. It is today one of Northern Europe’s largest tourist attraction. The Ice Hotel is built yearly near the Torne Riverbank, approximately 20 kilometers from the city of Kiruna. Stretching over an area of 5 500 m² the hotel is built of snow and ice collected from the river. Its architecture changes with every year as the foundation must be rebuilt after the warmer seasons. During the month of March, ice is harvested and stored in the production hall with a capacity of over 4000 tons of ice - in preparation for the following season. Production of a strong structural building uses approximately 1000 tons of ice. Snow machines are used for the production of wall elements. Snow is sprayed on to metal structural forms that are left to freeze over a few days. These forms are then removed to reveal a labyrinth of freestanding chambers. Walls are built in to form corridors, rooms and hotel suites. The stored ice blocks are then transferred in to the hotel where artists from all corners of the world participate to produce art and design with ice. The ice hotel is built with natural ice taken directly from Torneälven and is shown in fig 2. The ice hotel only exists between December and April and when spring comes, everything is melting away and returning as water to the Torne River. The material is 100% reusable.

Fig. 2. Ice Hotel

3.2 Site

3.2.1 Fiskevistet

Skagsudde with the fishing villages Skeppsmalen and Skagshamn has long been a popular place for excursions, situated in the outermost archipelago Southeast of Örnsköldsvik. The area has a dramatic landscape and an interesting cultural heritage. Skagsudde is important for the local maritime shipping. The Gävle Fishermen Haxar
who arrived by boats founded the beautiful fishing village of Skeppsmalen at the beginning of the 17th century. They fished along the coast of Norrland leasing cabins and land from the farmers in the area.

The area has an abundance of archaeological, as well as contemporary cultural findings. Skagsudde constitutes the northern gate to Höga Kusten, well known for its shingle beaches and unique world heritage remnants. Fishermen huts, fishermen chapels, unique boats and tools are preserved here. Emphasising each other and creating tension between the traditional and the contemporary aspects is the theme of the building that has been erected by Skagsudde. The site and the characteristics of the items of the exhibition, along with the expectations of the building meant that tradition and modernism were forced to consolidate and find balance. Careful attention to craftsmanship and material contributes to the aesthetics of the aged materials without appearing deteriorated, see fig 3.

Fig. 3. Fiskevistet

3.3 Function

3.3.1 Architectural School

Both buildings and operational functions within the Artistic campus at Umeå University have long-term sustainability goals and themes. The new buildings are quite different from one another, yet are bound by their common principles, designed for long-term sustainability. An example of this is found in the logistical placement of all meeting points gathered together on the ground level. The new buildings are connected by a common architectural design theme, with facades clad in untreated larch wood panelling, sharing common system solutions and use of local production. The buildings are designed and constructed to last for one century. Further commonality are the smaller outdoor areas, found between various forms create natural space for pause and reflection with spectacular views. There rooms are designed with the same hardwearing
and easily cleaned coloured concrete floors found within these new buildings. A large share of the Arkitektskolans components are locally manufactured. The facades Siberian larch wood is imported from Russia while the wood elements are manufactured in Burträsk by the Västerbotten carpenters WBTrä. Window glass is delivered by the local glass business Umeå Glas AB. The design is illustrated in Fig. 4. A curtain wall of glass could not minimise the energy use, here the preferred solution to use renewable resource of wood dominated the project. The building is characterized by its flexible architectural design. The materials have been chosen to be resistant for at least one century. The technical systems are designed to provide low energy use and flexibility. The ventilation systems are integrated into the steel piles and steel beams that form the building's structural design.

Fig.4. Architecture School

3.4 Life cycle

3.4.1 Laggarbergs School

Laggarbergs School in Timrå is world recognised since its rebuild in 1994. During the past twenty-five years it is estimated that more than 500 delegations from near and far have visited and studied all of the advanced innovative ideas found within the school. Examples such as ecocycling, ventilation systems for heating and innovative discussions pertaining to separating toilets. All school children participate in a bathroom course to ensure that the correct discards wind up in the correct holder. The school building gives an impression of healthiness, one that is difficult to wear out. The design choice of building materials and technology is clearly communicated. Wood and excelsior boards are predominant and an example of the sustainable material that withstands time, see Fig. 5.

Here, the most prominent idea is the ventilation system, natural ventilation – a soundless and effective system that aims to replicate qualities of actual anthills. This system creates a perfect indoor climate where the user does not find the need to open windows at any
This project is an example of the success that may be achieved by rebuilding and transforming an old school to a modern school with a build in eco cycle - rather than demolishing it. Laggarsbergs School is built on an educational, ecological and technical vision developed in consultation with a dedicated municipal project group. The school offers, with its sustainable solutions, a physical environment that may be used as case study examples for its own courses.

![Fig. 5. Laggarbergs School](image)

3.5 **Low energy**

3.5.1 **Geografigränd**

After a short and intensive sketching phase during the spring of 2010, a final design solution with the disposition of apartments, plan drawings and exterior design was produced. The house is placed according to the existing block structure for the area with yards opening up to the south. Parallel to the sketching period, a large focus on obtaining economical support from the delegations for sustainable cities, a focus that succeeded in a positive result. In the open area of the property a sauna could be placed accompanied by a winter garden. All 137 apartments have their own balcony or outdoor patio. Each level of the three houses also have glass enclosed balconies. A ground rule for the buildings placement was the need for single sided apartments to be positioned towards a quieter area – the garden. This resulted in the design of narrower houses with corridors in the façade coupled by a characteristic window placement pattern towards the Studentvägen and Geografigränd. It is in the connection to the corridors that the common glassed in balconies are found. Each corridor bears its own colour; yellow, green, blue, lilac and red. Colours that can also be found in the balconies front in perforated sheet metal, see Fig. 6. The choice of the appropriate façade material to adapt these buildings to the ‘Ålidhemskaraktären’ (the character of Ålidhem) was brick. Brick used for the bicycle storage house was reused brick from the original burnt down building. The result is Norrlands largest low energy project. The strategy of sustainable
building with energy consensus in cold climate, places the focus on both energy and lowered total energy use. The base idea is to use the reusable district heating systems that exists in Ålidhem and minimise as well as substitute the use of electricity and fossil energy.

![Fig. 6. Geografiränd](image)

### 3.6 Passive house

#### 3.6.1 Tavleliden

From in the beginning of the design phase of the sustainable houses, this project had a project goal of ‘Triple zero’, which in principle is a zero tolerance for the three categories; non-renewable energy, emissions and waste. No energy should come from non-renewable primary energy sources as well as a general zero tolerance for toxic emissions from such as materials, construction or energy conversion. No dangerous waste means using renewable and plant-based materials that can be easily reused or recycled. All constructions parts and materials should be easily demountable. Composite materials are avoided. The buildings are carefully planned. The execution will be as accurate possible since the project is to be carried out by the students attending Dragonskolans Construction Program. This arrangement also allows students to be trained to build the next Nearly Zero-Energy Buildings, which will be EU requirements starting in 2019. The entire project consists of six single-family villas and is adapted to the students’ academic year and curriculum, in two stages. One of the buildings are illustrated in Fig. 7.

Process quality has been important in the project. In order for the villas to get the function they intended, a "Sustainability and quality program" was based on the project. The program has been developed with the client and project management, which guides the process, from the idea stage to the completed building and the future use phase. The six villas on Tavleliden is one the world’s northernmost certified passive houses 30
miles south of the arctic circle. The project is Sweden’s first with a combined certification of both passive house certificate and a more comprehensive sustainability certificate according to SGBC "Environmental Building Gold". Passive housing components have been used, chosen a construction without cold bridges and quality assured built according to PHI’s five recommendations.

Fig. 7. Tavleiden

4. Results and discussion

Based on the descriptive study of the architects who designed the investigated sustainable projects we find more focus of sustainability in the categories Passive house and Low energy, than in the categories Climate and Function. That category site is found somewhere in the middle. A summary of categorization is illustrated in Fig. 8.

Fig. 8. The Vitruvian triangle with economy and cold climate sustainable perspectives
The study takes the starting point in the perspective that depending on the time location and situation, sustainability comes to different expressions.

Developing sustainable architecture and continuing the exploration of new methods within sustainability and its integration is an increasingly valuable issue for society. Sustainability can be seen holistically as Vitruvius proposed: function, sustainability and beauty.

The built environment should be seen as a result of the chosen process form given to each individual project. We have the possibility to introduce new elements and competencies to such existing processes in order to challenge the standard solutions otherwise normally followed.

Current sustainability methods result in higher conceptual meaning when architects or designers with their feedback and theoretical tools are invited to criticize and influence result. This is confirmed in our studies, where the careful attention given to the element of sustainability is seen as a grounded architectural factor – a factor that has the capacity to be expressed in varying ways and solutions. Whether this be in the physical building elements, technical solutions, chosen materials or its program.

In summary, we propose that descriptive information, interpreted from the architects or designer perspective is an important contribution in the understanding of sustainable housing. The architects and designers role are invaluable with their holistic competencies to be integrated in the traditional process of building and designing sustainable environments.

References

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