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Alvar Aalto's open plan architecture as an environmental technology device

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Abstract

One of the most acclaimed architects of the twentieth century Alvar Aalto (1898 – 1976) was also educator and critic of his time. In particular, he voiced strong concerns about emerging technologies and remained a vivid supporter of humane architecture. Thus this research project investigates Aalto's approach to active and passive environmental control systems and their spatial integration. Using wind analysis and computational fluid dynamic (CFD) studies, this paper analyzes natural ventilation flow paths in two of Aalto's major works: The Alvar Aalto Viipuri Municipal Library (1935), which accidentally operated for years on stack ventilation, and Alvar Aalto's Säynätsalo Town Hall (1952), which uses a raised courtyard to shelter the inner space from strong winds enabling the operation of windows in the courtyard. Both buildings highlight a distinct flow path strategy which enhances air flow through and around the building, reaching from pure wind induced ventilation strategies to combinations of wind and stack ventilation.

The courtyard atrium or inner landscape, Aalto's major spatial devices act as an interface to create an intermediate microclimate. This microclimate mediates between the severe outside climate and a more moderate, comfortable, or even delightful interior. The courtyard has to be inside, i.e. protected in order to protect; the surrounding building thus acts as its own interface. The house acts as a climatic membrane. The main material needed to create this interface is air and its ventilation patterns, which are shaped through the spatial composition.

One of Aalto's early essays 'porraskiveltä arkihuoneeseen' for the *Aitta* 1926 sample issue hinges on the idea of inner paradise using Fra Angelico's (1400 – 1455) painting *L'Annuziazione* as a metaphor to describe and envision the inside-outside relationship of space and climate in his beginning design work (Schildt 1984: 214). Aalto's essay hinges on the way one enters a room and how the room is connected to the exterior climate and the light of the sky. I argue with Göran Schildt that the roof lights Aalto first explored at Paimio and Turun Sanomat, and elaborated at Viipuri Municipal Library, are the open sky over a modern version of a classical amphitheatre (Passe 2008). Thus, Säynätsalo Town Hall with its green raised courtyard of low height to area ratio captures the sun while still protecting the inner space from the winds and allowing the low angle of the Northern sun to penetrate and warm the whole inner space. At Viipuri, Aalto, nevertheless experimented with novel environmental control technologies, and challenged basic physics by introducing both heat and ventilation air from above, in spite of his intrinsic critique of inhumane technologies in the USA. This paper thus critically compares some of Aalto's key texts on technology with the actual design and environmental performance strategies of the two buildings.

Climate for the INNER Landscape: ALVAR AALTO's search for the right amount of technology

While many of his contemporaries embraced emerging new technologies wholeheartedly, Alvar Aalto often expressed doubt about the progress, which came along with Modern technologies. He raised concerns about the impact those new technologies would have on the lives of people and on architectural form. In his essay *Culture and Technology* written in 1947, Aalto revealed his dislike of artificial comfort by critically elaborating on technological advances in the United States. (Schildt 1978) Aalto refers to the *New Yorker* as the world's foremost humor magazine' and concludes, that:

> *'The best pieces are Chaplinesque and show man in the stranglehold of mass production. ....In a land where there are streamline beds and beds without covers – the covers being replaced by an industrially produced layer of warmth – they have truly come far'.*

While he obviously contested artificially controlled personal environments, he had already attempted to create a mechanically ventilated space 15 years earlier in the Municipal Library of Viipuri (1935) as he described in the following project analysis (Docomomo 2004: 127-128):

> *'The same ceiling also acts as a heating source with the so-called panel-heating-system. As the ceiling is divided into lighting parts and solid parts, in the area remaining between these has been placed a dense network of radiant heating pipes, thus the ceiling of the library hall has been completely used for these functions, which in the open air are served by the sun. … The building has a mechanical ventilation centre, from which fresh air is distributed via special ducts into the building's different parts. The distributing branches of these ducts are glazed fire clay or cast iron. The ventilation system can, by adding some extra parts, be changed into a complete acclimatizing apparatus.'*

Spatial driving forces of natural ventilation

In naturally ventilated buildings, free flow open spaces are supportive of the flow path where wind and buoyancy mostly act in combination. As a result, air can move up, air can move down, air can move across and air can pivot, depending on the intensity of the driving forces. Designing the flow path for natural ventilation is a matter of space connectivity either dominated by vertical direction, horizontal direction, or a combination of both. The path should connect the areas around the building which promise the creation of the largest possible pressure difference. Therefore, designing for natural ventilation starts with site planning and the investigations of external forces to understand micro- as well as macro climates. Natural ventilation is driven by two major external forces based on pressure differences: wind (Hydrostatic Pressure Differences) and stack effect (density pressure difference). The overall results are determined by the interaction of these forces with obstacles within the flow path, the building and its openings, as well as the relationship of the building and its context. The level of resistance to FLOW path is determined by the building shape, form, height, orientation and internal spatial composition. Ventilation through the building is driven by these differences in pressure. The ventilation rate is determined by the pressure difference acting across a ventilation path and the resistance of that path (CIBSE 2007)**.**

The spatial analyses of volumetric compositions of selected buildings through drawings indicate the types of overlapping free flow open spaces which illustrate the main potentials. Flow paths are truly three-dimensional in all directions of space. How exactly the shapes of these interlocking connections affect the flow of air in three dimensions is the premise for our broader research question. Two major spatial strategies are herewith identified as basic typological climate devices: the courtyard and the atrium, which develop in Alvar Aalto's architecture into the inner landscape.

Free-flow open space, as distinct from free-plan architecture (Colomina, Risselada 1988), is here defined as spatial composition that addresses flow and continuity along all 3 axes of space. Wall apertures, open passageways, niches, stairways, split level, interior windows, galleries or double height spaces connect such spaces. Enabling interlocking connections in plan and section, free-flow open space blurs the boundaries between individual rooms and between inside and outside surrounding space. Through the concept of partial enclosure, intermediate spaces are created that belong to more than one system of spatial relations and offer multiple possible movement patterns for air, light, people and vision (Passe 2008).

The Northern Courtyard as a climate device

Very early in his career Alvar Aalto established the architectural motive to create an "opening to the sky" suitable for the Finnish climate. Similar to the more contemporary Charles Correa (Correa 1996) Aalto refers to the Pompeiian patio house as a fundamental typological source, where the house is shaped around an opening to the sky or semi-open courtyard as a climate-modifying device. This in-between intermediate or interstitial space is usually entered off-axis and bases its spatial configuration strongly on the atrium as the central room with the hearth and its important socio-cultural function to gather and meet (Passe 2007).

In most climates the courtyard or atrium acts as an interface to create an intermediate microclimate. This microclimate mediates between the severe outside climate and a more moderate, comfortable, or even delightful interior. To achieve this interface, the courtyard needs to be a protected in-between space that mediates the building mass, and which in reverse is needed to create the specific microclimate. The courtyard in the Northern colder climate has to be inside, i.e. be protected in order to protect. The surrounding building thus acts as its own interface: a climatic membrane. The main material creating this interface is air. Ventilation patterns are shaped through the spatial composition (Passe 2007).

"I now wish to make your hall into an "open-air space". (Alvar Aalto)

One of Aalto's earliest essays 'porraskiveltä arkihuoneeseen' for the *Aitta* 1926 sample issue hinges on the idea of the courtyard or atrium as an inner paradise and climate device. Aalto utilizes Fra Angelico's (1400 – 1455) painting *L' Annuziazione* as a metaphor to describe and envision the inside-outside relationship of space and climate in his beginning design work (Schildt 1984: 63 – 69).

Aalto's concern in this essay is the way one enters a room and how the room one enters into is connected to the exterior climate and the light and warmth of the sky. The roof lights he first explored at Paimio sanatorium, then at Turun Sanomat building, and which he elaborated at Viipuri Municipal Library, are the open sky over a modern version of a classical amphitheatre. Aalto's biographer Göran Schildt argues, that Aalto's aim was to let this entrance space appear like the space created between exterior solids rather than the sculptural surface of an inside space (Schildt 1984: 223). His later work shows that this open space, conceived as if it were open air, developed into the inside landscape or remained a courtyard depending on program and location. Courtyards are already known in the literature (Raydan et al's Courtyards: A Bioclimatic Form, 2006) as employing 'ingenious natural cooling strategies' in hot climates. Alvar Aalto ensured that they could also act as 'ingenious warming strategies' in colder climate.

The open courtyard: Säynätsalo town hall on a hill

One of Alvar Aalto's major works of the 1950s, the Säynätsalo Town Hall, encircles a large raised green courtyard. The low height to area ratio still protects the inner space from the winds while allowing the low angle of the Northern sun to penetrate and warm the whole inner space. The double height square volume encloses a court yard on the first level (Figure 1).

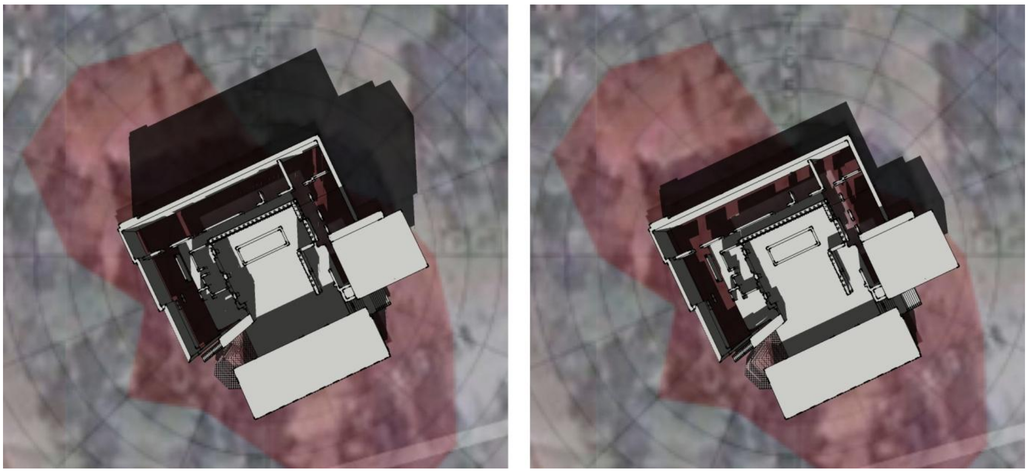

Figure 1: Solar noon shadows on equinox (left) and summer solstice (right)

Oriented at approximately 30 degrees away from North, the raised courtyard is still wide enough, so that sun can penetrate even with the low angles of spring and fall, and increase the number of warm days in the courtyard. The closed Northwest corner and the tilted orientation also act as a protection from detrimental winds and create a sheltered space. Figure 1 to 3 show diagrammatic studies of these relationships of wind velocity, pattern and direction with respect to the proportions of the courtyard itself (height and width). The courtyard creates a microclimate while still enabling natural ventilation from the warmed inner courtyard through the circulation space of the corridor into the offices.

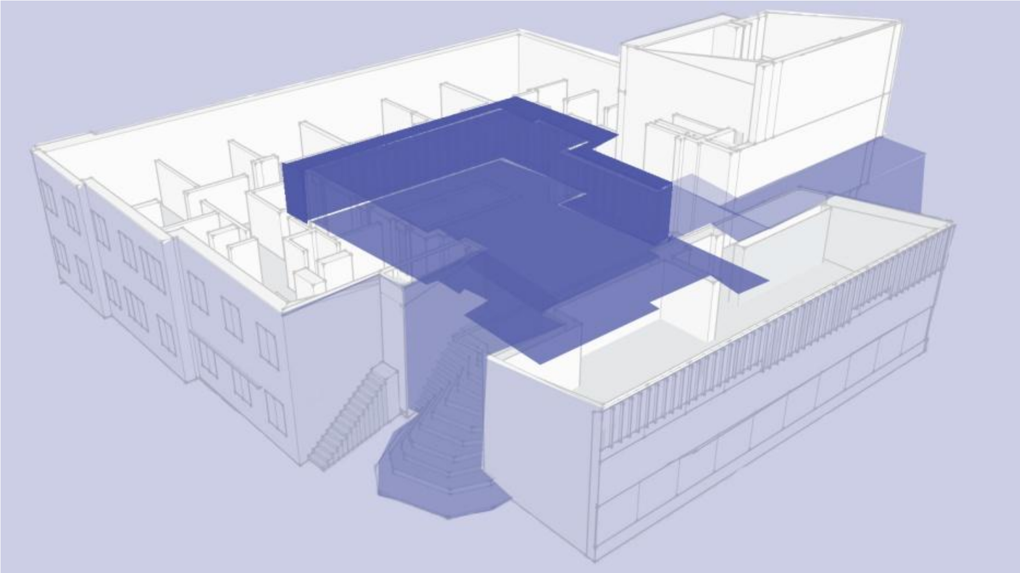

Figure 2: Courtyard proportions at Säynätsalo

Figure 3: Prevailing wind directions at Säynätsalo

The inner landscape as a climate device: Towards the free flow open section: Viipuri's spatial system and climate envelope

The Municipal Library of Viipuri/Vyborg designed by Alvar Aalto (1927-1935) was one of the first buildings in the Modern Movement to incorporate free-flow open space in plan and section to organize the migration of people and air-flow circulation throughout large rooms. The design concept also shows a pronounced effort towards integration of environmental controls for lighting, heating and ventilation. Within a rather simple boxlike exterior, the library evolves into a complex split-level with three different circulation routes through the reading spaces, leading to a recessed reading area as an ideal location for contemplation. The librarian stations are vertically connected by an internal circular staircase, enabling a fast and direct connection between all library spaces, while the 'cubistic shift' provides more expansive spatial connections for view, air and people at the surrounding levels.

Figure 4: Prevailing wind directions at Viipuri library

Viipuri's systems: mechanical ventilation and under-ceiling radiant heating

The exterior double walls were designed to move air and provide ventilation. The thick volumetric roof slabs with conical skylights were designed to direct the sunlight and enclose the heating pipes, which introduced warmth from above, as from natural solar light (Passe 2008). While windows traditionally served both means: lighting and ventilation; by contrast, the Viipuri Library separates light and air, where the windows as conical roof-lights have moved into the horizontal roof to provide perfect daylight to the reader while the ventilation has turned inwards to provide the building fresh air from a mechanical forced air system. This composition gave Aalto the freedom to elaborate his free-flow open section and to create a well-tempered space for books and people (with thermal comfort during all seasons and no glare, while still perfectly lit), while no books were exposed to direct sunlight, thus enabling conditions for reading as close to nature as possible.

It is unclear, if the mechanical ventilation systems ever functioned properly, because warm air introduced from above would have hardly reached the reader. For decades the library has been ventilated by natural ventilation flows through the open reading space with its free flow section utilizing spatial composition, open doors and infiltration (Passe et al 2009).

The only effective tool to visualize and quantify the cooling and ventilation potential of air movement in these complex interlocking spaces was a three-dimensional CFD simulation of the whole building. Stoakes et al (2011) conducted air flow simulations of the Viipuri Library to show how the spatial layout affected airflow for passive cooling and heating. Publicly available climate information for Vyborg show the average prevalent wind direction is Southwest at 7-8 knots (approx 4m/s) (Figure 4).

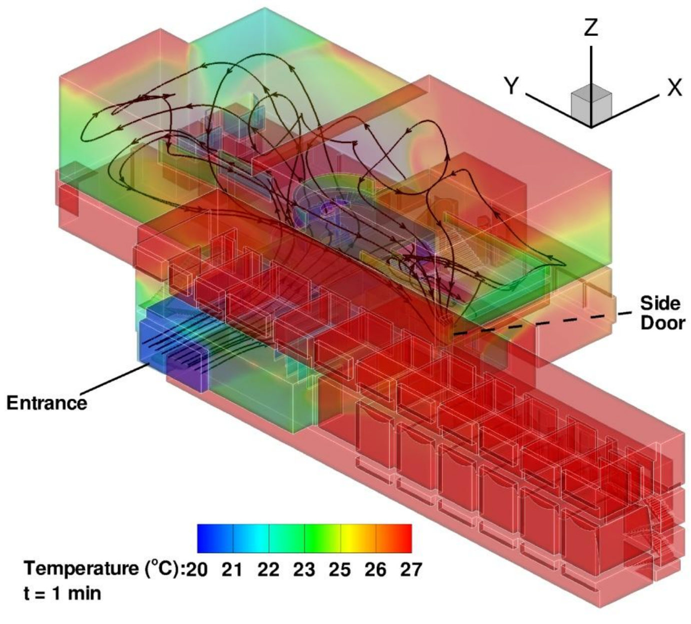

Figure 5: Internal air flow pattern at Viipuri library

Thus for the passive cooling case, it was assumed that a breeze of 2.2 m/s at 20ºC entered the building from the main entrance facing north east; the side door upstairs was simulated as being open to create a small pressure difference through the building to initiate air movement. In order to understand cooling potential, the initial temperature of the building interior was set to 27ºC to represent the effects of heat gain prior to the building being opened for business. The simulation provides important insight as to how the air flows relative to the inner landscape of the library (Figure 5).

Conclusion: Aalto's position towards technology remains ambivalent

Alvar Aalto's position to Modern technology remains ambivalent, when confronted with its powerful potential for change. Many of his lectures and publications highlight the challenges a changing world poses to the everyday life of ordinary people. But without much concern he utilizes innovative technology to improve the interior comfort conditions of his buildings as seen in the heating, ventilation and lighting system for the Viipuri library in order to overcome the challenges of the harsh Finnish climate. He was willing to risk that the novel system might not work as predicted.

On one hand Aalto is very careful to keep the relationship of the occupant to nature and local culture and thus always uses utmost care, when placing the building in the landscape and thus was able to harmonize technology, tradition and nature. Both buildings analyzed in this paper are carefully positioned at the optimum angle to the prevailing wind directions most likely based on local knowledge, which reduces the impact of wind force on the internal velocities in the case of Säynätsalo, and increases the potential intake of wind in the case of Viipuri library. On the other hand the radiant thermal heating system combined with the overhead ventilation strategy Viipuri library could be interpreted as a warm thermal blanket in the which similar in function to the electric blanket, which he so vividly rejected when talking about new technologies embraced by Modern America's lifestyle.

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