Unfolding Utzon – Learning from Utzon’s architectural acoustic master pieces

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ABSTRACT

The paper reflects on Utzon’s experience from the Sydney Opera house with acoustics which is developed from basic knowledge about acoustics such as how volume, shapes and surface materials affect the acoustic result and how it fits with the architecture. Especially Utzon demonstrated a delicate tectonic design by integrating space, shape and materials – three factors which are closely related to the architectural expression, and which are all of crucial importance to the acoustics. Therefore unfolding Utzon’s experience with acoustics may serve as great learning which is addressed in more details in the present paper.

Keywords: Architectural acoustics, Room Acoustics, Acoustics Quality.

I-INCE Classification of Subjects Number(s): 06.0

1. INTRODUCTION

For many the architecture by Jørn Utzon is synonymous with the design of the Sydney Opera House (1973) that was made a UNESCO World Heritage Site in 2007, being one of the 20th century’s most distinctive buildings and one of the most famous concert halls in the world.

However Utzon’s architecture is more profound than the Sydney Opera House. Among others examples his architecture includes the Melli Bank in Tehran, Iran’s National Bank (1963) and the National Assembly of Kuwait (1985) as the most finest examples of Utzon’s architecture where features of the the traditional bazaar in the Middle East influenced his way of thinking and creating his modern form of architecture.

"It stands by itself as one of the indisputable masterpieces of human creativity, not only in the 20th century but in the history of humankind."

[The UNESCO World Heritage Committee, 2007]

Figure 1 - The essence of Danish architect Jørn Utzon's architecture is a fusion of form and structure inspired by nature and the visual universe of other cultures. (Photo: Ole Haupt)

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"We had the idea of constructing the building around a central hall, a bazaar street, in such a way that all departments met in side roads off the bazaar road, just as we know from the bazaars in the Middle East and North Africa..."

[Jørn Utzon]

Prior to these projects Utzon designed his own house (1952) in Hellebæk, where he introduced ‘the open plan’ in Denmark inspired by his studies of Frank Lloyd Wright’s houses. Careful consideration was given to the surroundings, especially the environmental factors such as sun, view and shelter from the wind. This one-storey private home project was followed by Utzon’s courtyard housing project, the Kingo Houses (1958) in Helsingør, a project with 63 L-shaped houses which can be seen as a prototype for the Fredensborg Houses (1963) consisting of 30 terraced houses with gardens and 47 L-shaped atrium houses form a three-winged estate. The materials chosen for the houses were tiles and wood, traditional Danish materials. Utzon originally called this concept for ‘private life’ due to the balance between the private space and the public areas organized for community life where – a nordic tradition – which Utzon explained in following quote.

“A desire for well-being must be fundamental to all architecture if we are to achieve harmony between the spaces we create and the activities to be undertaken in them. This is quite simple and reasonable. It requires an ability to create harmony from all the demands made by the undertaking, an ability to persuade them to grow together to form a new whole – as in nature; nature know of no compromise, it accepts all difficulties, not as difficulties but merely as new factors which with no sign of conflict evolve into a whole.”

[Jørn Utzon]

Both these two housing projects are based on Utzon's additive approach, starting modestly with one house followed by more houses, taking into account the landscape and its character. Utzon has talked about the layout of the houses as "flowers on the branch of a cherry tree, each turning towards the sun.". The application of the additive approach can be seen in many of Utzon's projects besides the housing projects. Examples are found in the proposals for the un-built projects like the Silkeborg Art Museum (1963), the Farum Town Centre (1966) and the proposal for a major sports center in Jeddah (1969). However, the building system, the flexible “Espansiva approach” for low-cost housing only build as a prototype is perhaps the best and most well-known example. In addition to these projects using the additive approach the Bagsværd church (1977) and Paustian's furniture store (1987) should also be mentioned and of course Utzon’s own houses Can Lis (1973) and Can Feliz (1994) at Mallorca and the furniture project Utsep (1968).
2. Inspiration and philosophy

“I have benefited greatly from the many hours I have spent with my father. He was a pillar of support for me and my brothers in the many instances when we had to make important decisions in life. For me as an architect it has been ideal to have been attached to a large shipyard, where all trades were represented, and large-scale work was carried out. When I was about to draw the Opera House in Sydney, I was not really worried that I had to convert sketches into curved surfaces towering 60 meters, define them geometrically and have them constructed. As a child I had seen huge ship-hulls. My father helped me construct the large-scale models required. Without any specific agreement he made the wooden models. After a couple of days the delicate forms were in the drawing room”

[Jørn Utzon]

The theme of nature as a source of inspiration was very much to the fore, when Utzon together with Tobias Faber presented their thinking on architecture at a lecture in Copenhagen. This became the basis for an illustrated article in Arkitekten in 1947, entitled “Tendenser i Nutidens Arkitektur” - Trends in the
Architecture of Today, Faber and Utzon (2), a manifesto, presenting the themes and interests that would become increasingly apparent in later work, Carter et al. ([1]). According to Utzon's own personal architectural credo “The Innermost Being of Architecture” written in 1948, Utzon states that, “The true innermost being of architecture can be compared with that of nature's seed, and something of the inevitability of nature's principle of growth ought to be a fundamental concept in architecture” Weston (5).

“My laboratory is the beach, the forest, the sea and seashore…”

[Jørn Utzon]

Figure 5 - The Bagsværd Community Church by Utzon Architects in Bagsværd, Denmark. (Photo: arcspace.com)

“Walking in a Danish beech forest is like going through a hall of pillars. This hall of pillars dissolves into branches and into a leafy crown represented by the roof”.

[Jørn Utzon]

The archetypal image of the beech forest was used by Utzon, in several projects and especially it was to serve as the catalyst for his design of the Paustian furniture showroom on the waterfront in the Nordhavn docks of Copenhagen, which opened in 1987. The metaphorical evocation of the birch trees, not only provides the spatial organisation, but also clarity of tectonic structural expression, with triangular gussets between the columns and beams providing lateral stability, Carter et al. (1).

Figure 6 - The Paustian furniture showroom, Copenhagen. (Photo: arcspac.com)
3. The Sydney Opera – Acoustics Design

In 1957 the relatively unknown architect Jørn Utzon won the international competition for a new Opera House in Sydney opened in 1973. Utzon’s competition proposal was characterised by a very conscious reading of the site. Bennelong Point is situated in a central point in the Sydney harbour and would therefore be viewed from all angles — including from above. Utzon had therefore envisioned the Opera House as a sculpture that was to relate to the sails of the boats in the harbour rather than the buildings of the city. As well as many hosting well-known touring theater, ballet, and musical productions, the Sydney Opera House is the home of Opera Australia, the Sydney Theater Company and the Sydney Symphony. Utzon had sought inspiration from different places (Radio House CPH), Royal Festival Hall. The competition entry for Sydney Opera House from Utzon was in the words of the competition assessors“…simple to the point of being diagrammatic” This also applied to the auditoria even though the auditoria were probably the most developed of the design proposal. The competition brief asked for a Major Hall which should primarily cater for concert recitals for an audience of 3000 to 35 00. A secondary use for the hall was to be large-scale opera, ballet, dance, choral works, pageants and mass meetings. The Minor hall was primarily to be used for drama, intimate opera, chamber music, concerts, recitals and lectures and seat around 1100. In effect it was therefore two multipurpose halls hat functioned acoustically for music as well as speech that the Opera House Committee had asked for. The plans submitted for the competition by Utzon shows the two halls sitting side by side in the podium, each carved into the podium like Greek theatres into a mountain side. The layout of the plan also resembles Greek theatres with circular steps sharing a common centre and focus point at the centre of the stage. No acousticians were involved with the design of the auditoria even though Utzon got advice with regard to the accompanying text, but Utzon would have searched for inspiration to the shape of the auditoria among contemporary auditoria. The plan of the Opera House thus resembles the radial plan that Aalto often used as outdoor gathering places as well as in his acoustic spaces - for instance the Culture House in Helsinki that was initiated in 1952, Schmidt and Kirkegaard (6).

3.1 The Acoustical Shape

It is fair to conclude that Utzon was inexperienced in acoustics in the beginning of the Sydney Opera House project — but this changed through the project After having won the competition in 1957, Utzon immediately began work by gathering a team of advisers and collecting their reports in a document known as the Red Book. In the field of acoustics the Danish acoustician Vilhelm Lassen Jordan was hired. The advice from Jordan was highly needed but the collaboration between Jordan and Utzon was troublesome. For the next years Utzon and the construction engineer from Ove Arup, were fully occupied with the construction of the podium and the sails, and it was not until after the Red Book (from March 1958), that Utzon became more involved in the design of the halls. The halls showed in the Red Book were therefore primarily done by Jordan himself. After the Red Book was handed in (March 1958), Utzon got more involved with the auditoria design, in an attempt to understand the fundamentals of acoustics and thereby design an alternative to Jordan’s rectilinear shaped auditorium. In a meeting in mid-1958 Jordan was asked to explain some of the fundamentals of acoustics to the architects. He explained how the volume is determined by the shape and functionality of the room and commented on the shape of the surfaces). With this newly gained understanding of acoustics, Utzon and his employees in August 1959 developed a scheme for the Minor Hall that they called the stepped cloud scheme. As the name suggest, it was inspired from the shape of clouds – a re-occurring inspiration for Utzon – and was intended to float like a cloud over the podium by being suspended from the sails of the opera. Another inspiration for the hall was the movement of water as Utzon’s former employees Yuzo Mikami, who drew the proposal, recalls, Jorn asked me to work on the new design of the Minor Hall auditorium. He took me to a nearby seashore by the Sound in Hellebaek, where the gentle movement of water formed the ridges of waves one after another. The continuous ridge went up higher and higher as it came nearer to the shore, and finally the crest of the wave began to break, overriding the ridge and coming down with a drumming sound onto the wet sand on the beach. We watched the movement of the waves for quite a long time. It was very dynamic and breathtakingly beautiful. Every one of the waves showed a different character in its movement. Jorn said,”Yuzo, can’t we design the ceiling of the Minor Hall something like that?” whilst looking at the breaking crest of the waves.”

The new scheme of the Minor Hall was conceived as closely related to the organic geometry of the Opera House. Where the plan and the section of the auditoria in the competition proposal were somewhat incongruous, the stepped cloud scheme attempted to create a harmony between the two. In a later tv-interview Utzon described how he wanted the auditoria to fit under the sails like walnuts. Both the nut and the shell of a walnut have undulating shapes — they are closely related but still different and this close relationship between outside and inside was what Utzon used the walnut analogy to explain, “When you see
From an acoustical point of view, however, the stepped cloud scheme was not advantageous. The large concave curve of the ceiling in the back of the room would result in focusing of sound thus creating high concentration of sound in some areas and a lack of sound in others. With this lack of acoustical quality Jordan cannot have participated much in the conception of the scheme and it was clear that Utzon’s main interest in the stepped cloud scheme was the harmony with the rest of the Opera House. His investigations into the hall were primarily concerned with the form of the auditoria as a sculpture in its own right and not as a tectonic Building Principle. During the course of he had plaster models of it cast in order to be able to develop the composition. While it was clear from the stepped cloud scheme that Utzon lacked a technical understanding of acoustics, it also seems from the shape of the scheme that he could have studied further architectural references - for instance the undulating ceiling seems to be inspired by Aalto’s Viipuri Library as well as the segmented side walls seem to have close connections to Erikson’s concert hall in Göteborg from 1935.

The stepped cloud scheme was presented in the Yellow Book, given to the Australian Government in February 1962 and was, despite its acoustical difficulties, accepted. On Utzon’s return from Sydney, where he had presented the Yellow Book, he went to Berlin and Vienna. Utzon had read about the Berliner Philharmonie where the architect Hans Scharoun and the acousticians had introduced a completely new geometry to auditorium design. This auditorium was thus an example of a new architectural approach and a new technological approach to acoustics. He contacted Lothar Cremer and Werner Gabler who were the acousticians on the project and met with them in Berlin. The partners were very experienced in the design of concert halls and had completed a number of them throughout Europe. Lothar Cremer was one of the most important acousticians of this century and professor at the technical university of Berlin while Werner Gabler was an architect specialised in acoustical spaces. The collaboration with these two Germans was to become very influential to Utzon.

Both of the new consultants were send drawings of the stepped cloud scheme in August 1962. Cremer responded quickly, “The large radius concave curvatures of the ceiling is rejected. Should such curvatures eventuate, their radius must be small. Particularly, the curvature of the rear ceiling area will lead to sound focusing onto the last rows of the stalls. Also of great disadvantage is the dome-like raising of the mid part of the ceiling with its large step toward the stage, in which the lighting is housed…This produces very strong delayed reflections in the middle of the stalls”. Gabler drew a number of sections with arrows representing the reflections of the sound to explain the problems of the current scheme. Furthermore, he included a number of suggestions as to how to substitute the large concave curvature with a number of smaller convex curves. On Gabler’s side this was an attempt to create a design tool that was ready-to-hand and thereby immediately usable to Utzon. Gabler’s attempt was successful and immediately after his letter arrived in Sydney, the drawings being produced in Utzon’s office began to show a concern for sound paths. This was the
first time such considerations were shown in the Minor Hall drawings. Utzon used the acoustician’s reflection line analysis to develop a principle for positioning each segment of the ceiling in relation to the audience and the stage. Cremer and Gabler instructed him about the geometrical relationship that was desirable to give the audience strong early reflections. From these instructions Utzon was then able to use the simple geometrical principle as a design tool. Utzon was able to draw the outer and inner perimeter that the segments had to be positioned between. The stepped cloud scheme was being reworked completely within a few months. The new scheme called no. II encompassed all the changes suggested by Cremer and Gabler, see figure 8, and clearly the instructions from Cremer and Gabler served as a ready-to-hand design tool to Utzon. “There was a fine collaboration between my office and the acoustical experts in Berlin and it was soon evident that this solution was acoustically good” (Utzon, 1965). Many of the intentions from the stepped cloud scheme, such as the radiation from a centre point and the entrance to the hall, were retained. Inspired by the newly found “spherical solution” for the sails of the Opera House that was based on the geometry of a sphere; the large concave curvature of the ceiling was inverted to smaller convex circles with differing radii. The above outline follows a more comprehensive outline in Schmidt and Kirkegaard (6).

![Figure 8 - Model demonstrating the assembly of the ceiling segments from curved components.](image)

4. The Bagsværd Community Church – Acoustics Design

The modest church, the color of the Nordic sky, stands tall and proud between birch trees, its back turned towards the noisy street. The exterior walls are clad in white prefabricated concrete panels and white glazed tiles that reflect the light. The aluminum roof gives the church an industrial, almost austere, appearance. The ambulatories and connecting pathways are covered with glass roofs. The sculptural concrete ceiling in the church is sublime and always changing with a blend direct and reflected light that filters through floating clouds. Structurally, the vaulted ceiling is supported by the glass topped ambulatories. In contrast to the tight exterior, the softly curved ceiling and the white light in the sanctuary gives you a feeling of being elevated...of getting closer to the heavens. The sculptural concrete ceiling in the church is sublime and always changing with a blend of direct and reflected light that filters through floating clouds. In Utzon's early sketches you can see his inspiration, as in his other buildings, came from nature; the sky and moving clouds. In a country where church buildings are universal, without religious references, Utzon has designed a church that exalts and comforts with poetic purity. It has been possible to shape these shells freely by means of circular geometry so that the architect's wishes concerning height, pitch and fall could be met. The demands of acoustics also influenced the shape of the rooms.
4.1 The Acoustical Shape

A church is a complex design project, also within acoustics. Volume is needed for longer reverberation time (to be optimal for organ music, and other music). Long reverberation time and a big volume (thereby often long distances) makes it difficult to achieve good clarity of speech without using speakers. Using speakers in a small church room like in Bagsværd church “ruins” the feeling of intimacy and would not fit with the otherwise delicate and tectonic design. The problem is solved elegantly in Bagsværd church. The domelike opening above the altar gives the volume needed for long reverberation time but the undulating form of the ceiling reflects sound and ensures uniform and a good clarity of speech for the whole audience.

“The sound emphasizes the atmosphere we expect – The acoustics are readable”.

[Jørn Utzon]

Utzon had no assistance from acoustic specialists but the acoustic quality as a result of the convex forms used in the design of the ceiling is no coincidence – Utzon’s acoustic understanding had developed during the design of the Minor Hall at SOH. He found the optimal geometry. Utzon now has now got an understanding of some geometric principles - how modern acoustics rely on reflections (not only direct sound), that strong early reflections are important and how concave curves concentrate sound. Utzon’s newfound understanding of acoustics is evident not only from the final design of the Minor Hall but equally from the design of Bagsværd Church from 1973 which he conducted without the assistance of acoustical consultants. Here he took many of the principles developed in the Minor Hall to their perfection. The convex curves of the ceiling are used to radiate the sound and they thereby reflect Utzon’s understanding of the fundamental principles of room acoustics. The result is a very good quality of room acoustics Mortensen (6). The curves are also the backbone in the construction of the building because the curves add to the stiffness of the eight centimetres thin concrete vaulted ceiling and thereby enable them to span the 17 meters of the church room. This church room must be said to be one of the most unique and amazing spaces in Danish architecture and can perhaps be said to exemplify what Sydney Opera House missed when Utzon’s Minor Hall was not build.
5. CONCLUSIONS

This paper has presented how Jørn Utzon developed the Bagsværd community church based on his acoustical experience from the Sydney Opera House. From that project Utzon learnt how the acoustics is affected by volume, shapes and surface materials and how it fits with the architecture. A understanding of acoustics he used for the design of Bagsværd community church from 1973 which he conducted without the assistance of acoustical consultants. Here he took many of the principles developed in the Sydney Opera House to their perfection. The convex curves of the ceiling are used to radiate the sound and they thereby reflect Utzon’s understanding of the fundamental principles of room acoustics. However Utzon obtained also a delicate tectonic design by integrating space, shape and materials with the light atmosphere and the structural solution of the ceiling.

REFERENCES