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Architectural freedom and industrialized architecture - retrofit design to passive house level
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Abstract

Based on the repetitive architecture from the “building boom” from 1960 to 1973, it is discussed how architects can handle these Danish element and montage buildings through the transformation to upgraded aesthetical, functional and energy efficient architecture.
The method used is analysis of cases, parallels to literature studies and client and producer interviews. The analysis compares best practice in Denmark and best practice in Austria.
Modern architects accepted the fact that industrialized architecture told the story of repetition and monotony as basic condition. This article aims to explain that architecture can be thought as a complex and diverse design through customization, telling exactly the revitalized story about the change to a contemporary sustainable and better performing expression in direct relation to the given context.

Through the last couple of years we have in Denmark been focusing on a more sustainable and low energy building technique which also includes production and montage on site. The clients, the architects, the producers and the building contractors have through different projects developed a working method which indicates several ways to handle the retrofitting of the existing concrete element blocks from the period. Related to the actual demands to the building physic problems a new industrialized period has started based on light-weight elements basically made of wooden structures and faced with different suitable materials meant for individual expression in the specific housing area.

It is the aim of this article to expand the different design strategies which architects can use – to give the individual project attitudes and designs with architectural quality.

Through the customized component production it is possible to choose different proportions, to organize the process on site choosing either one room wall components or several rooms wall components – either horizontally or vertically. Combined with the seamless joint the playing with these possibilities the new industrialized architecture can deliver variations in choice of solutions for retrofit design. If we add the question of the installations e.g. ventilation to this systematic thinking of building technique we get a diverse and functional architecture, thereby creating a new and clearer story telling about new and smart system based thinking behind architectural expression.

Keywords

Industrialized facades, systems thinking, system component, energy performance, tightness, seamless joint, smart production
Introduction and research focus

The research project Sustainable Renovation at the Aarhus School of Architecture has an overall goal to investigate new architectural methods for the design of the retrofit of the existing building stock from 1945 to the start of the first oil crisis in 1973. The project has its focus on two main segments: the masonry and the montage period. This article we will focus on the montage period, also named the modernistic mass housing period. The research questions addressed are: how can we qualify architecture, production and montage of the buildings from the 60es in order to create more effective, optimized and better performing housing and thereby reach a passive house level? Based on the fact that the building process has for the last 40 years developed in the direction of a more and more industrialized production – and especially related to the retrofit of the repetitive architecture of the period, we find it obvious and of great importance to think systematically as an underlying understanding of the development of a facade system.

Definitions:
Component: a window or a window breast, element
Entire wall component: a collection of components or elements which form a component that act as a room-high wall in the building
Component system: the theoretic system in which the total amount of components form a unity

Earlier the building industry produced standardized elements in standard measurements for smaller components e.g. windows. All other measures of components had to be handled separately which gave extra expenses. Today individual facade components in a mass customized production are seen as a rational unity and part of the component system. The facade component is produced under roof by industrialized workers (craftsmanship) under temperate indoor working climate – safely and under much better working environmental conditions than at site, it is transported by van to the site and mounted by crane within a short period. The control of the process is developed through computer technology. This means that different dimensions of material are handled by a cost neutral production: every component is unique. This new method of manufacturing the components gives us freedom to think and work much more flexible, which is of great importance to the renovation situation, where the actual conditions can change from building site to building site – different component dimensions are demanded.

Architectural focus

The central question to investigate is what this industrial production and process mean to architecture or which new opportunities this can give to architecture? From the beginning of the montage period, the modernistic architects were exited about the aesthetic potential of the industrial production: the repetition, the uniformity: the architectural aim of the modernists was equality. The fact that the material concrete was widely used for subsidized housing has lead to several inappropriate circumstances: the buildings were – rightly or wrongly - accused of causing social problems. Thinking in repetition, mass production and the narrative of the industrialized production was of great importance to the aesthetical expression, the joint was in many cases the history of the 60es industrialized period. This joint has been the major physics problem of these buildings, together with the bad patina of the concrete. Thereby, the concept of the montage building technique was given a bad reputation. In the 90es we find the first renovations of these buildings.

Now we are preparing and carrying out the second renovation – these renovations should meet the future demands for both upgraded architectural expression and energy performance. This means that we should see the future perspective in every renovation, which again means that in sustainable renovation we should be thinking in total economy in our decisions [Vestergaard 2011].

This idealistic approach to the change of many of the existing buildings gives us as architects together with the client a great challenge in thinking strategically and to approach a future perspective included in the solutions for the design of the renovation. When we increase the energy demand we should design for a long period of time, and through a more well performing building envelope with extreme air tightness, we bring the indoor
climate to a more sensible situation related to overheating, it is necessary to manage the indoor climate. The physics of the envelope and the correlation with the ventilation is a central issue to solve in these renovations. These two factors should interact optimally and dynamically together. The cases will in a few words describe the chosen solution for both the facade and the ventilation.

A central question of the possibilities of site specific individual architectural designs is of great importance to the freedom of the artistic design of the architects: Is it possible to express and explain the form related systematic thoughts through mass customized production as systematic thinking and as a natural basic foundation? – How do we create the perspective for facades, structure and energy? The cases allows us to see the final results of the change. It is our aim to show the facade as one building component, which is of course for transport reasons divided into smaller elements, but as expression is not thought as parts, but as a whole surface related to the aesthetic, functional and energy designs. The architect is not forced to express the facade in modules, she has the freedom to think holistically and give new aesthetic expression to the future and the renovated facade.

Methods

The research method used the research subject is based on practical examples and has been analyzed and compared to theoretical literature and several aspects have been taken in consideration:
- practical examples as case studies and owner interviews
- parallels to literature studies
- internet knowledge from production companies
- producer interviews
- research reports and
- conference papers

The analysis tries to put best practice in Denmark into perspective with best practice in Austria.

Cases

All the case renovations have been designed in the previous mentioned period, and design decisions have been taken on very different terms. – What is investigated is the interesting development of the technology of the façade components, how they are planned, which size and system, how the functionalities are, the joints, how the component is meeting the existing structures, how the process of the renovation is and how the relation is to the architectural expression? Four examples are subsidized housing, one is a public school. All the renovations are based on industrialized system delivery, lightweight components of wood, the elements are layered, there are good possibilities of heavy insulation and an airtight membrane, the expression differs from the choice of the final cladding and the play with proportions, rhythm and profiling the façade.
**Gyldenrisparken**

Built in 1964
Architects: Sydjyllandsplanen
Architects, renovation: Witraz, Vandkunsten 2005-10
Performance: respects the building code BR08

Figure 1: showing the building type before, the principle of the one room component, the final result and a details of the bay window, notice the expression of the joint after.

The origin of the building were mass-produced concrete elements. The whole project were part of a huge project of 136,000 dwellings all over Denmark. Therefore, the potentials for rational renovating strategies are obvious. Room sized components are used, the joint between components is as expression exposed through a minimal notch, the façade structure is horizontally detailed. There is an architectural reference to the way the original façade is anticipated, but in the change into a light and interesting detailed cladding, a thin layer of fibre concrete, combined with color choice accentuate quality to a higher level and an expected long lasting nice expression. The renovation does not meet an ambitious energy performance – the argument was that the subsidized economy related to this building segment does not support energy demand. [Bech-Danielsen 2011].

**Langkærparken – the climate block**

Built in 1968-73
Architect: Børge Kjær
Architects, renovation: Nova 5 Architects 2010
Performance: planned to meet the “nearly Zero Energy” level

Figure 2: the original building typology, the 2 room horizontal wall component, the final result, the facade stripped before assembling the components.

These blocks of flats have the same original building typology as before. The renovation is a pilot project with the aim to investigate and learn from the planning with regards to the architectural, technical, production and financial possibilities of renovation projects. Four different low energy standards were demanded. The building owner ambitiously chose the most energy efficient “nearly 0 level”. This level was the most expensive [Vestergaard 2011]. Learning through the process the room size of the components was changed to the
horizontal dimension of about 6x2.8m. Windows are mounted in the components from the production site, which gives good air tightness. The components are horizontal and “standing” on the load bearing structure which gives difficulties for a continuous airtight membrane: each component is fastened and tightened to the existing structure. The size of the components brings the total length of interface down in relation to room sized components which also gives better air tightness. The architectural expression is based on a mass-like expression, but without the expression of the joint, the horizontal bands of windows are “cut” into the mass and keep a reference to the original design. The ventilation system is ambitiously changed and central. All tenants moved from their flats during the building period and were temporarily re-housed in the area. The financing of this pilot project demanded a huge investment by the owner, which is not affordable in future renovations.

Heimdalsvej, Frederikssund
Built in 1972
Architect at the renovation: Mangor og Nagel 2011-12
Performance: before renovation 112kWh/m2a, after renovation simulation/planned 35.3 kWh/m2a, achieved year one 28.2 kWh/m2.

Figure 3: showing the south facade before, the renovated facade after, detail of insulation and plaster, and a perspective from the layout showing the interaction between buildings.

The ambition of the level of renovation was “is it possible go to reach passive house standard?” within an economy very close to the level of the rent? The strategy was that: what could be saved on an expensive central heating bill could be changed into a high performing building envelope. The renovation resulted in an extra rent of minimal character i.e. 2,4% rise. – No extra financial sources are used.

The housing block is covered with a new building envelope which is horizontally assembled as façade. All walls of now app. 500 mm deep components are built up as boxes and mounted outside the existing structure on a new foundation around the existing building. High performing windows are used and the roof is highly insulated. This strategy gives an excellent possibility to create a successful airtight membrane. The inside connection to the load bearing structure is made while the tenants are living in their flats, resulting is no expenses for re-housing in this case. A inside distance of 1 meter close to the façade was the working area for building up and fixing the connection and finishing an extra layer of insulation. The ventilation is solved as decentralized systems for each unit/flat. The outer façade is profiled by a finishing layer of insulation, plastered and giving character to the aesthetics of the façade.

School in Swanenstadt, Austria
Built app. 1960es
Architect renovation: Dipl. Ing. Heinz Plöderl, PAUAT - 2008
Performance:
before renovation 135 kWh/m2a
after renovation 14,1 kWh/m2a
Swenanstadt represents a project which is both a new addition and a renovation of the existing. The components are horizontal and very long, some up to 24 meters – this is caused in the fact that the production place is very close to the assembling plot. The façade is mounted in an outside layer close to the existing [Plöderl 2008], which in this case gives the architecturally design opportunity to emphasize the existing columns by artistically carrying out an exciting reference between the original and the new component system. This narrative design tells through the composition of the new façade the storey about dialog between the old structure and the new. The ventilation system related to the retrofit part is de-central, which means that all class rooms have their own installation, which aesthetically is enrolled in the façade composition. In total this case show how architecture and spatial expression has been a driver for an upgraded architectural design.

**Riihimäki, Innova project, Finland**

Built 1975  
Architect renovation: K. Lylykangas 2011 - 12  
Performance: planned to meet max 25 kWh/m²a – Passivhaus retrofit standard

The Finnish example operate with vertical components of app. 12 meters length [Lylykangas 2011] mounted vertical and aesthetically emphasizing the buildings mass with a design where windows are cut into the mass. The facades are profiled through insulation in order to stop the monotony – the surface is plastered and painted in slightly different colours still to break repetition. The roof has got an addition of a new installation space from which incoming air is directed through the new components to the individual flats, exhausted air is taken out from the existing vertical shafts located in the centre of the flats. Smart thinking has given the possibility to optimize the existing possibilities of both the facades potentials and the existing shafts. As a result of this minimized intervention the tenants have been living in the flats under the working period of the renovation.
Discussion - summery

The cases show different approaches to many aspects of designing a façade. It is obvious that we have many possibilities for solving both technical, functional, aesthetical challenges which is given in the individual projects – but from the cases we want to emphasize that if the multi disciplinary responsible group of actors of the building process work together in an integrated way it is possible to find and explore the renovation field from a very expensive situation to a cheaper and more effective process which also gives benefits to the tenants.

The Gyldenrisparken case show us how important it is to make an architectural design, which in its artistic attitude raises the aesthetical expression of the building still referring to the industrialized building system, which gave birth to one of the most important periods in our welfare society.

The Langkærparken learned us a lot about technical solutions and details, about installations and about the level of energy effectiveness – it is also obvious that the building costs have to be lowered, this gave us possibility to rethink the coming renovations.

The Heimdalsvej learned us that an effective design and production idea can save both tenants and the building process many problems – the build renovations should be economically kept within a reasonable rent for the tenants. Effective thinking and improved systems can bring the renovation to a very low financial situation.

The Swansenstadt shows us a very interesting architectural approach in which we can find inspiration to widen up the architectural attitude – how can the former industrialized architecture be artistically transformed into a new and narrative design telling the story about the dialog between the old and the new industrialized way of handling the physical frame of our lives?

The Innova case told us that even verticular elements gives us new and smart possibilities for the designing of the renovation.

Conclusions and recommendations

Through the design and smart thinking it is shown that the building envelope plays a huge role as transmittance between the indoor and the outdoor environment. This transition which besides of giving a good daylight distribution should also solve the aesthetical outlook of the façade, should ventilate the house, bring energy performance and air tightness together with smart systems to product and assemble the façade.

The future facade renovations will as a minimum be designed to meet the demands of the building code at the current time, but we see now that the market tendencies are towards long lasting ambitious solutions, taking the total economy into consideration, which means more and more energy efficient performance – most of the cases fulfill the passive house criteria’s.

To change this and use the effective paradigm – such as the passive house strategy – all responsible in the decision chain should learn from the eye opening cases. But it is of an overall importance through this transformation to upgrade our architectural expression in a qualitative way.

It is important to think in a long perspective when planning the renovation project – the existing building code is simply not taking care of the total economy and the future coming energy demands.

Remember also to plan and built for disassembly.

The advantage of industrially produced components is: rationality and effectiveness, low price, fast montage, one producer and one contractor. This gives fewer interfaces between craftsmen – in total we can conclude from the cases shown that this gives lesser inconvenience for the tenants.
To create through components does not mean to express a huge repetition, but it has been done often. It is up to the architect to challenge the production with variation and individuality, computer technology can control the process and secure the needed variation and expression, especially now where joints can be seamless and can be optimized. We have a possibility for good detailing and that the architecture can be explored as a homogeneous unity.

But it is important to open up and learn in all links in the learning chain – this means everybody involved: clients, the architects, the engineers, the authorities and the hole producing part of the building sector.

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References:
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