Sustainable Living In High Density Structures

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Biography

Roger Riewe was trained at the RWTH Aachen. He then founded Riegler Riewe Architekten in Graz in 1987. Further offices were founded in Cologne in 2008 and in Katowice in 2010. The office has become an internationally renowned, with projects in Austria, Germany, Poland, Croatia, Korea, Switzerland and USA. The focus is on public buildings, infrastructure projects and urban design. The realized projects have received numerous international awards and distinctions.

Roger Riewe has been guest professor in Prague, Houston, Barcelona, Aachen, Calgary and Graz. He has lectured worldwide with a specific focus on structure, space and technology. In 2001 he was appointed professor at the Graz University of Technology, where he is since then head of the Institute of Architecture Technology. The Institute of Architecture Technology, with its laboratory AtecLab, has a strong focus on research, especially in the fields of densification and public space, as well as in building and façade technologies. The institute’s research work is generally embedded in international research networks as well as bilateral research agreements.
Abstract

Sustainable living in high density structures

If naturally lit, housing-skyscrapers in hot or tropical regions not only allow daylight to enter the apartments, but also hot and sticky air, then each dwelling unit will need air conditioning to supply cool dry air. A cooling aggregate needs double the energy of a heating installation. The energy consumption required for maintaining the housing quality of all developments of the kind is enormous.

The goal of our research project Sustainable living in high density structures is to do away entirely with the need for energy-consuming air conditioning systems while simultaneously maintaining a high housing quality, a convenient atmosphere and sufficient natural light in the flat. The design of new housing typologies and urban rules enabling dense housing providing a high quality of life is an essential aspect here.

Many new high-rise projects are supplied with high-tech equipment for cooling, heating and mechanical ventilation. The results are closed glass constructions with a high amount of energy consumption. What is the effect of that?

01. These typologies are isolated in an environmental context. The glass skins create their own microclimates inside, like a cheese cover, protecting against unsuitable weather conditions. The solution seems quite easy, with regards to traditional small scaled housing typologies and some rare realized projects: not to abstain from the ecological conditions but rather use these conditions for positive aspects inside the house.

Sustainable and simple procedures are required for the implementation of energy-efficient building projects in hot and tropical areas. Thus natural physical technologies and phenomena of natural science should be seized upon. We would like to use the original and positive characteristics of materials and climatic conditions to incorporate them into the development of new building systems.

02. Architectural relevance:

Energy concepts and building services have an essential effect on façade structures and therefore also upon the external appearance of buildings. The developing of new floor plan typologies and energy solutions have therefore a great importance to the entire design of a building.

The substantial questions are:
Which existing knowledge and which new technologies must be combined and modified to create the optimal system in respect of feasibility, cost, building energy consumption and sustainability?
What is their impact in terms of architectural design?

Keywords:

façade structures, architectural design, façade technologies, floor plan typologies, air conditioning systems, high density structures, Sustainable
Sustainable living in high density structures

Outline:

Which requirements we need to fulfill to achieve sustainability?
Why we concern ourselves with the density of cities and thus also with high risers?

Thesis 01:
Building structures that are neutral with respect to their utilization are sustainable.
The necessity for a flexible programming of functions

Thesis 02:
It is possible to entirely abolish energy-consuming air conditioning systems and simultaneously maintain a high living quality, a comfortable atmosphere and sufficient natural light in the flat.

Full Paper:

First of all, the question arises, which requirements we need to fulfill to achieve sustainability and why we concern ourselves with the density of cities and thus also with high risers?
There are numerous aspects about density that have a positive impact on sustainability.

The workshop “Density” which was held 2010 at the TU Graz, Austria, dealt with the question: What are the consequences of a high density in Graz? The procedure was to evaluate the recent density of the city of Graz with the help of a model on a scale of 1:5000. The building density was calculated and demonstrated in abstract, small volume cubes. Public and private functions were marked in orange and green. The next step was to combine the many small volumes to form one compact body (cube). The new ground area of the compact cube shrank from 127,000 square kilometers to only 8,925 square kilometers. This was one result of that analysis.

Another outcome was the v/s relation. This is the relationship between the outer skin and the volume of the buildings. The existing surface of that fragmented urban housing structure has a larger outer shell than the compact cube. The additional skin of the detached single family houses is 13,375,000 square meters. The surface of the compact volume has only 1,566,000 square meters. The cube is much more sustainable in terms of e.g. insulation or protection against humidity.

As far as road transportation infrastructure and public utility installation (water, electricity) are concerned, the distances became very short und efficient. With respect to illumination and ventilation, however, the density did not prove to be energy-efficient. On the contrary: The tight block would consume 630 mega-joule per year for fresh air supply alone. For this reason, it is essential to develop building structures of the highest possible, but also well functioning, density.

We have to come up with new ideas why density can be existing and why could that be.
We have to consider the reasons for high or low density. The research team at the Department of Architecture Technology at the TU Graz in cooperation with the Chinese University of Hongkong is working in this field and looking into these questions. With the research project “Sustainable living in high-density structures in tropical and subtropical regions”, we are developing strategies and ways for new methods of resolution.
The team at the Institutes are working on the macro, meso and micro level. Due to their specific typology, some buildings on the meso and micro level can contribute to sustainability.

Thesis 01
Building structures that are neutral with respect to their utilization are sustainable
The necessity for a flexible programming of functions

There is currently a high office vacancy rate in Germany, Europe and even Hong Kong. The three top cities in terms of office vacancy in Germany are Munich (1.7 m²), Frankfurt (1.6 m²) and Berlin (1.5 m²).
m²). Closer scrutiny reveals a trend towards further increase. It makes sense to react to the acute vacancy rate by transforming office towers into residential tower blocks. The process of modification is theoretically possible, and Stefan Forster architects have just completed one such example of transformation in Frankfurt am Main, Germany. Conversion of the office tower in “Lyonerstrasse” into an apartment house is a pilot project for this kind of restructuring. Because the footprint of the tower is not overly deep, it was possible to design spacious, partially furnished two- and three-room apartments with a high quality of life. The dynamic floor plans were adapted to dispense with long access paths to and into the apartments. Because not as many lift shafts were required at the core of the building, those no longer required were replaced by WCs for the apartments. The building was transformed without altering the existing structure. However, larger glazed surfaces and a window strip façade in the style of classical modernism lend the unattractive, but pragmatic cube a new, clear-cut form.

Enlarged window openings and new open-air spaces in the form of recessed balconies offer the occupant’s greater quality of life. Three additional storeys improve the proportions of the overall building volume.

The process of transformation, then, is possible if the conditions of the existing office building are suitable. But what are the conditions? What are the pre-conditions for conversion? Meaningful transformation can be discussed by looking at the example of the Eurotower ECB high-rise in Frankfurt am Main. The curtain office façade can be removed and replaced by a new façade that meets residential requirements, as we saw in the “Lyonerstrasse” example. Successful implementation of the proposed floor plan depends mainly on the existing office tower. The open floor plan of a reinforced concrete skeleton structure allows modification of open-plan offices into a residential structure comprising smaller units by adding walls that must not necessarily be supporting.

The depth of the floor plan poses a problem. If this existing office footprint is too deep, many of the adapted apartments will not have access to light, thus making them uninhabitable. The fundamental question facing the investor is always that of the efficiency of conversion. Not only with regard to the fact that a new building may be less expensive than a conversion involving a change of use, but also in terms of cost-intensive energy-efficient renovation measures. Depending on the economic situation of the particular country, the demand for office space or housing can react suddenly and strongly. The current trend of increasing office building vacancy could take a 180-degree turn in future. Going on this assumption, then, we need to develop an architecture that permits both functions from the outset.

But the question is also whether transforming existing residential towers into office towers is possible at all. Office floor plans are characterized by free, open-plan spaces. Adding partitions is more easily done than taking away supporting structures. Existing residential floor plans, in contrast, are often characterized by smaller units with supporting walls. Removing these walls in order to create an open-plan office space is only possible by means of elaborate additional structural measures. Also, many new residential buildings do not have the room height required for offices. Offices necessarily require raised floors or suspended ceilings for cable ducts (power, light, internet) and vent shafts (A/C, air supply). Because of the greater difference in demands to be fulfilled by residential typologies, it is more difficult to convert residential units into offices.

Current tower block designs therefore permit transformation in one direction only. However, the towers should be able to accommodate both functions in parallel so as to be able to react flexibly to demand. Of course, it is necessary to define exactly the balance of efficient use between offices and dwellings. But true efficiency is only when usage can react flexibly to demand. A mixed-use tower block can react more flexibly and subtly.

In future we need highly specific towers that can be transformed efficiently from residential to office use and vice versa. New tower blocks should be able to offer both uses from the outset. Finding a solution to “morphing” tower blocks is a major challenge for the planners of tomorrow’s towers.

Starting with the more complicated, changeable entrance situation with separate foyers and access areas. Lifts must permit flexible link-up to private dwellings and semi-public offices (therefore, it must be possible to install and remove two access systems in a flexible manner). Or spans and room heights that work for both functions.
The result would have to be a kind of blank, a base that caters equally for the highly specific requirements of residential units and offices and which can offer a place that is, at least to some extent, neutral in terms of use.

Thesis 02

It is possible to entirely abolish energy-consuming air conditioning systems and simultaneously maintain a high living quality, a comfortable atmosphere and sufficient natural light in the flat.

The power station in Linz, Austria is one of the first passive-house high risers in the world. In the passive-house is almost no need for heat energy. The ventilation of the rooms works via a central ventilation unit that cools down hot air in the summer by means of an underground heat sink. The exterior façade must be well sealed and air-proof, which is, however, risky because a small gap can destroy this system. It requires a detailed planning of the implementation of the realization of the building.

The passive-house is a highly specific technical technology. It is energy-efficient but at the same time very expensive. In terms of sustainability, we can see that the overall energy balance (which includes the production energy, amount of maintenance, life span, separability and recycling of material) does not fulfill the requirements of sustainable building. There is a sealing to the outside, the windows need to be shut. The autonomous climate inside can only be kept through high energy consumption and great expenses. Moreover, this kind of superior technology is only available to a minority of the population, and is still not really inhabitable.

The delight of the tropics rewrote the barrier between the inside and the outside. Regionally, architecture varies with respect to the inside and outside of a building. To explore this in a high-density area, we take a look at a traditional approach on high risers.

We invited Edward Ng (Professor at CUHK, expert in sustainable planning and author of “Designing High Density Cities”) and Prof. John Ng, ex chief architect of the housing authority in Hong Kong for the winter school 2011 SUSTAINABLE SMART CITIES at the TU Graz.

We asked Eduard Ng, if it is possible to do away entirely with air conditioning and he replied that it would be. You have to stop the sun from shining into the interior to prevent an increase in temperature, windows need to be opened to facilitate cross ventilation. It is important to open windows in a clever way.

Like WOHA Architects done in Singapore. During the monsoon season, the risk of torrential rain is high. WOHA architects studied traditional solutions to see if there is a potential to adapt them to high rise projects. Traditional building structures in tropical regions appear to provide an interesting way of drawing air into the interior space from below. WOHA architects developed this idea further into a “curtain wall” for the Moulmein Rise project, and named it Monsoon Windows, where a horizontal panel slides open beneath a bay window (Busenkell, 2010).

The building structure and floor plan typology also have a great influence on the solution for the planning of buildings without the need for air conditioning. For example, in the Master course seminar „Facade & Structure – tropical energy – efficient system“ 2011 at TU Graz, the CUHK exchange student Matthew Leung transformed the existing Residential Tower „HARMONY“(architect: housing authority Hong Kong) to achieve cross-ventilation without air conditioning. The existing Harmony typology of Hong Kong public housing is oblivious to the chance for natural ventilation. The ends of the corridors are obstructed by the duct and natural ventilation is not encouraged. The length of the corridors also reduce the strength of the breeze. In order to enhance the wind passing through the apartment, the units and the corridors are split and opened respectively in the design. The new plan sees an open-ended corridor which allows the air to pass through. The structural walls are also arranged along the vertical axis. Thus, the maximum cross-ventilation can be achieved.

Another example is the residential tower project of the student Romana Streitwieser, based on the concept of the design studio 2010 at the Department of Architecture and Technology at the TU Graz in
cooperation with CUHK. The developed high rise in Hong Kong is a mega structure that tried to combine high density with living quality, natural lighting and ventilation. The design of such a structure was important to show that it is possible to ventilate each single flat with natural air, without any mechanical help, and thus ensuring a sustainable building.

**Conclusion:**

If naturally lit, housing-skyscrapers in hot or tropical regions not only allow daylight to enter the apartments, but also hot and sticky air, then each dwelling unit will need air conditioning to supply cool dry air. A cooling aggregate needs double the energy of a heating installation. The energy consumption required for maintaining the housing quality of all developments of the kind is enormous.

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There are several few single building projects which contain the aims of feasibility, building climate and architectural qualities. However these projects still waste a lot of energy, especially in terms of the overall energy balance. Yet, some attempts of this have been successfully realized. But these projects are not utilisable and accessible for the majority of the urban population. We are in need of a solution which can be realized for everyone.

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The research team at the Institutes of Architecture Technology and the Chinese University of Hong Kong working on 3 fields.

A - Urban densification and public space (macro level)
B - Housing typologies (meso level)
C - Façade and construction technologies (micro level)

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