Adaptive Building Skins

Univ. Prof. Brian Cody

Buildings are designed and constructed to exist in an external natural environment with continually changing conditions (temperature, humidity, air movement, light, sound etc.) and provide more or less constant internal environmental conditions in the spaces contained within. In most cases the desired internal conditions differ greatly from the external conditions for a significant portion of the year. Two approaches can be followed in order to provide the desired internal environment; the conventional approach of sealing off the external environment as much as possible and employing mechanical systems to provide the desired internal conditions or alternatively the buildings form, construction and skin can be designed to capture and utilize energy flows in the natural external environment and support the creation of the desired internal environment. This second approach, in which, similar to the strategies employed in some Asian martial arts, the energy of the “attacking” forces are captured and utilized to achieve the desired result is for obvious reasons the more challenging but also potentially much more efficient approach with regard to the use of resources.

The building envelope is of particular importance in the design of an energy efficient building. Alongside active energy production the building’s skin can act as an adaptable filter between the external and internal environmental conditions. The physical properties of building facades in our cities at present are however unable to adapt to changing conditions in a significant manner. This applies to both the ever changing external conditions such as climate, noise, air quality and light and the fluctuating demands and needs of building occupants on the internal side of the façade interface. Their specific properties in terms of thermal conductivity, solar heat gain transmission, light transmittance, porosity etc. are static and remain essentially constant with time although the requirements for an energy efficient building skin differ significantly under the widely varying climatic conditions at different times of the day and year. Existing responsive facades are limited to one dimensional approaches such as automated shading systems.

An adaptable and variable building skin could on the other hand react and adapt to both internal and external conditions, effectively creating “Space on Demand”. Furthermore, by tracking not only the present external conditions and internal desired conditions but also utilizing forecasts of the future external and internal conditions and incorporating these into a virtual model of the building which allows simulation and prediction of the buildings energy performance under varying conditions, it is possible to develop “smart skins”; building skins, which maximize energy performance by varying their physical properties to adapt to changing external and internal conditions. Such facades would constantly adapt to meet changing requirements by manipulating variable parameters for thermal insulation, solar energy transmittance, light transmission, thermal energy storage, air tightness and moisture diffusion.

We are currently undertaking research which will form the scientific basis for the development of a completely new approach to façade design by precisely determining the energy potential offered by the approach under various assumptions as well as useful insight into successful strategies for the development of suitable components. The proposed smart skin concept incorporates and uses forecast data relating to future weather and likely user behaviour (based on past experience and using an embedded artificial intelligence approach) as well as the present time data to decide the optimal configuration of physical properties and thus optimize performance. A novel and innovative dynamic simulation model, which is to be specially developed for this project, will provide meaningful insight into the potential and possibilities. This model will also serve as the virtual model to be incorporated into the completed building and so provide part of the intelligence necessary for the optimal performance of the smart skin. Smart materials, which can change their physical and/or chemical characteristics in order to accomplish the desired adaption to changing conditions, are a further possibility currently being studied.

Brian Cody, February 2015
äußere Klimabedingungen

Gebäudehülle

Temperatur
-15 - 35 °C
Feuchtigkeit
0 - 100 %
Licht
0 - 10000 Lux
Lärm
0 - 80 dB(A)

Innen

Temperatur
20 - 26 °C
Feuchtigkeit
30 - 65 %
Licht
0 - 2,0 mCd
Lärm
30 - 5000 Lux

Virtuelles Gebäudemodell

Steuerung

Entscheidungsregel

CPU

Gebäudeinfluss

Zukunft

Innenklima

innere Erfordernisse

Aussenklima

Zukunft

Gegenwart

adaptive Parameter

Steuerung
Further reading:


Cody, Brian: „The air that we breathe“ in Uncube, Magazine No. 16, www.uncubemagazine.com

Cody, Brian: „Form follows Energy – die Zukunft der Energieperformance“ in „energy2121, Bilder zur Energiezukunft“, herausgegeben vom Klima- und Energiefonds, omninum, ISBN 978-3-99031-014-4

Cody, Brian: "Form follows Energy", in: xia Intelligente Architektur Ausgabe 80, 07-09/2012, Leinfelden-Echterdingen, ISSN 0949-2356

Cody, Brian: "Zu kritischem Denken befähigen" in: Deutsche Bauzeitung DBZ, Heft 6, Gütersloh/D, 2012, ISSN 0011-4782

Cody, Brian: "Form follows Energy. Beziehungen zwischen Form und Energie in Architektur und Urban Design", in: Deutsche Bauzeitung DBZ, Heft 6, Gütersloh/D, 2012, ISSN 0011-4782


Autor:

Professor Brian Cody is university professor at Graz University of Technology and head of the Institute for Buildings and Energy. His focus in research, teaching and practice is on maximizing the energy performance of buildings and cities. Before his appointment at Graz University of Technology he was associate director of the international engineering consultancy Arup. He is founder and CEO of the consulting firm Energy Design Cody, which is responsible for the development of innovative energy and climate control concepts on construction projects all over the world. Professor Cody serves as member on many advisory boards and juries and is Visiting Professor and Head of the Energy Design Unit at the University for Applied Arts in Vienna.