



CESB19

**Central Europe towards
Sustainable Building**

July 2–4 2019 | Prague

Book of Abstracts



CESB19 conference is organized under the auspices of the four international organizations: iiSBE, CIB, UNEP-SBCI, FIDIC.

Organizing Committee

Antonín Lupíšek
Jakub Diviš
Petr Hájek
Petr Hejtmánek
Jana Hořická
Terézia Němcová
Magdaléna Novotná
Tereza Pavlů
Tomáš Prajs
Kateřina Sojková
Jan Tywoniak
Jakub Veselka
Martin Volf
Julie Železná

Book of Abstracts

Central Europe towards Sustainable Building 2019 (CESB19)

2nd–4th July 2019, Prague, Czech Republic

Editors: Kateřina Sojková, Petr Hájek, Jan Tywoniak, Jana Hořická, Antonín Lupíšek

Cover: Petr Hejtmánek

Published by: Czech Technical University in Prague, Faculty of Civil Engineering,
Department of Building Structures, Thákurova 7, 166 29 Prague 6

Printed by: powerprint s. r. o., Suchbátská 1018, 252 62 Horoměřice

1st edition, Prague, June 2019, 226 pages

Copyright © Czech Technical University in Prague, 2019

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any mean, without prior written permission from the Publisher and the Author.

This book was prepared from the materials supplied by the authors.

There are no legal consequences arising out of application of information published in this book both for publisher and for authors.

Scientific Committee

Petr Hájek
Jan Tywoniak
Daniel Adamovský
Manuela Almeida
Maria Balouktsi
Nina Bartošová
Vlastimil Bílek
Luc Boehme
Rolf André Bohne
Dalibor Borák
Ruben Paul Borg
Anatolijs Borodinecs
Luis Bragança
Steve Burroughs
Albert De La Fuente
Jan Desmyter
Jakub Diviš
Pavol Ďurica
Lukas Ferkl
Ctislav Fiala
Axel Föhl
Kristina Fořtová
Benjamin Fragner
Buntara Sthenly Gan
Antonio García Martínez
Jacopo Gaspari
Vanessa Gomes da Silva
John Grunewald
Guillaume Habert
Aylie Han
Dalibor Hlaváček
Jana Hořická
Giuliana Iannaccone

Stephan Jörchel
Karel Kabele
Targo Kalamees
Ferenc Kalmár
Miloš Kalousek
Bohumil Kasal
Jiří Kolísko
Pavel Kopecký
Petr Kuklík
Jerzy Kwiatkowski
Nils Larsson
Sébastien Lasvaux
Richard Lorch
Antonín Lupíšek
Thomas Lützkendorf
Karel Maier
Ricardo Mateus
Tomáš Matuška
Peter Maydl
Yu Morishita
Andrea Moro
Jan Mukařovský
Jiří Nováček
Jiří Novák
Magdaléna Novotná
Miles Kenneth
Oglethorpe
Doris Österreicher
Milan Ostrý
Alexander Passer
Tereza Pavlů
Tomas Peltan
Bruno Peuportier

Tomas Plauska
Ronald Rovers
Jan Růžička
Senot Sangadji
Matthew Schwarzkopf
Seongwon Seo
Harijanto Setiawan
Kateřina Sidiropulu
Janků
Ondřej Šikula
Jiri Skopek
Roman Smutny
Michal Šourek
Jerzy Sowa
Kamil Staněk
Zbyněk Svoboda
Martina Sýkorová
Zsuzsa Szalay
Joel Ann Todd
Alexandra Troi
John Van Oorschot
Jure Vetršek
Martin Volf
Jakub Vorel
Petr Vorlík
Frantisek Wald
Peter Walker
Lisa Wastiels
Wei Yang
Noriyoshi Yokoo
Radek Zigler
Ivana Žabičková
Julie Železná

Foreword

In October 2015 UN adopted Resolution: Transforming our world: the 2030 Agenda for Sustainable Development. This Agenda is a plan of action for people, planet and prosperity and should stimulate action up to 2030 in areas of critical importance for humanity and the planet. The principal goal is to end poverty, protect the planet and ensure prosperity for all.

There are specified 17 Sustainable Development Goals with 169 associated targets which are integrated and indivisible and balance three dimensions of sustainable development: economic, social and environmental. These new goals and targets came into effect on 1 January 2016 and guide the actions up to 2030. It is expected, that all stakeholders, all of us, will work to implement the SDGs Agenda within own countries and at the regional and global levels, considering national specifics and priorities.

These goals, targets and proposed solutions should be widely discussed in the international group of experts, considering global measure of the problem and consequently regionally specific situation. The conference Central Europe towards Sustainable Building 2019 (CESB19) can contribute to the exchange of ideas and support the intensive search for plausible solutions.

The conference CESB19 is a part of SBE conference series organized under auspices of iiSBE, CIB, UNEP SBCI and FIDIC in various regions of the world. CESB19 continues the tradition of sustainable building conferences in Central Europe. The CESB team has already organized four international conferences – in 2007, 2010, 2013, and 2016.

The main conference topics were:

- Buildings and climate change
- Innovative use of materials and products in sustainable buildings
- Systems for energy efficient and energy positive buildings
- Decision-support tools and assessment methods for a sustainable built environment
- Sustainable retrofitting of existing buildings
- Sustainable urban development
- Industrial heritage regeneration
- Policy and public awareness

Members of the Scientific and Organizing committees are very proud to present in this Book of abstracts altogether 169 abstracts of papers prepared by authors from 34 countries. Full paper proceedings has been published in collaboration with

IOP Publishing as open access electronic proceedings within IOP Conference Series Earth and Environmental Science. Proceedings is available at the publisher website <https://iopscience.iop.org/issue/1755-1315/290/1>. Further, for each paper, an active QR-code is provided in this book of abstracts to facilitate access to full papers for a reader.

A day prior to the CESB19 conference was organized YRSB19 – iiSBE Forum of Young Researchers in Sustainable Building 2019 – a conference for young researchers, especially doctoral students.

We would like to express our thanks to all authors for presentation of their achievements and sharing their ideas within our community. All abstracts and papers were carefully blind reviewed thanks to active participation of 97 members of the Scientific Committee.

We also thank to the Czech Technical University in Prague, Faculty of Civil Engineering and University Centre for Energy Efficient Buildings and international conveners iiSBE, UNEP, CIB and FIDIC for their kind support. We thank also to all supporting organizations that provided their auspices, to our media partners who helped us to spread the word and last but not least to our commercial partners and exhibitors.

A special thanks are addressed all members of the organizing committee, especially Kateřina Sojková, Jakub Diviš, Petr Hejtmánek, Jana Hořická, Terézia Němcová, Magdaléna Novotná, Tereza Pavlů, Tomáš Prajs, Jakub Veselka, Martin Volf, Julie Železná, for their continued efforts in organizing this event. All help and support were needed for successful organization of the conference and all satellite events. Without help and kind support of all these people and organizations the CESB19 conference would not be possible.

We hope that CESB19 conference has contributed to the enhancement of knowledge in the field of sustainable buildings and built environment considering changing natural, as well as socio-economic situation in the world.

In Prague in May 2019

Petr Hájek
Jan Tywoniak
Antonín Lupíšek

Contents

Foreword	5
-----------------------	---

Keynote Lectures

Buildings and Climate Change: Accelerating Transformation	25
R Lorch	
A New Generation of Sustainable Structural Concretes – Design Approach and Material Properties	26
H S Müller, J S Moffatt, M Haist and M Vogel	
Large Scale Urban Developments in Austria – Challenges and Opportunities Based on Two Case Study Examples	27
D Österreicher and M Treberspurg	
Sustainability in Building Construction – A Multilevel Approach	28
T Lützkendorf	

Materials

Hygrothermal Risk Analysis of Recently Constructed Timber Buildings Exposed to Outdoor Climate Changes by the End of the Century in Germany	33
S Ameri and N Rüther	
The Biophilic Power and Environmental Urgency of Earthen Construction	34
L Ben-Alon, V Loftness, K A Harries and E C Hameen	
Alternative Sands as Substitute for Natural Sand for the Construction Sector	35
L Boehme and A Depoortere	
Decisive Use of Building Materials Based on Hygrothermal Analysis	36
M Brauner, A Ghaffarianhoseini, N Naismith and J Tookey	
The Use of Natural Materials for Construction Projects – Social Aspects of Sustainable Building: Case Studies from Australia and Europe	37
S Burroughs and J Růžicka	

Demolition-and-Reconstruction or Renovation? Towards a Protocol for the Assessment of the Residual Life of Existing RC Buildings.....	38
E Casprini, C Passoni, A Belleri, A Marini, G Bartoli and P Riva	
Stability of Wall Panels with One-Sided Board Sheathing for Timber Structures.....	39
J Celler, J Dolejš, J Pošta and R Jára	
3-D Printing in Building Construction: A Literature Review of Opportunities and Challenges of Reducing Life Cycle Energy and Carbon of Buildings	40
M K Dixit	
The Utilization of the Finest Fraction of Recycled Aggregate from CDW for Concrete	41
K Fortova and T Pavlu	
Secondary Materials in the Building Sector – Energy and Material Flows	42
K Gruhler, T Bimesmeier and C Deilmann	
Laboratory Concrete Specimens Waste, a Case Study on Life Cycle Assessment.....	43
A L Han, H Setiawan and P Hajek	
Choice of Sustainable and Durable Concrete Structure Using LCA	44
A Horáková, I Broukalová and A Kohoutková	
The Use of Products Recycled from Municipal Waste in Sustainable Architecture	45
A Iringová, D Vandlíčková and M Diviš	
Modern Earth Building – the Current State of Earth Building from a German Perspective	46
S Jörchel	
Fire and Mechanical Properties of Hemp and Clay Boards for Timber Structures.....	47
H Kallakas, J Liblik, P F Alao, T Poltimäe, A Just and J Kers	
Using TRC as an Environmentally Effective Alternative for Subtle Elements of Railway Furniture	48
L Laiblova, T Vlach, P Hajek, K Hajek, A Vanek and J Repka	
Fostering the Integration of Circular Economy Aspects into the Construction and Real Estate Industry	49
C Lemaitre, A Braune, C Ruiz Durán and D Geiselmann	

Integration of Seismic Risk into Energy Retrofit Optimization Procedures: A Possible Approach Based on Life Cycle Evaluation	50
C Menna, U Vitiello, G M Mauro, D Asprone, N Bianco and A Prota	
Environmental Impact of Concrete and Concrete-Based Construction Waste Leachates	51
K A Mocová, L N A Sackey and P Renkerová	
Eco-Friendly Building Materials	52
A Nowotna, B Pietruszka and P Lisowski	
Catalogue of Construction Products with Recycled Content from Construction and Demolition Waste	53
T Pavlů, J Pešta, M Volf and A Lupíšek	
Life Cycle Assessment of Recycling Processes for Demolition Waste	54
J Pešta, T Pavlů and V Kočí	
Characterization of Hemp-Lime Bio-Composite.....	55
B Pietruszka, M Gołębiewski and P Lisowski	
Fire Protection of Steel Structures by Low Pressure Water Mist in Large-Scale Fire Test	56
M Pokorný, M Eliáš and F Kregl	
The Influence of Building Materials on Relative Humidity of Internal Microclimate.....	57
J Růžicka and J Diviš	
Biodegradation of Mineral and Silicone Plasters and Its Comparison	58
P Ryparová, M Kostecká and J Tywoniak	
Material Flows In Buildings' Life Cycle And Regions – Material Inventories To Support Planning Towards Circular Economy	59
G Schiller, T Lützkendorf, K Gruhler, I Lehmann, K Mörmann, F Knappe and N Muchow	
Non-Destructive Testing of Recycled Aggregate Concrete	60
Z Sierens, B Vandevyvere, L Kyndt, G Tytens and J Li	
External Wooden Constructions – Protection by Titanium Dioxide	61
P Svara, P Kuklík, M Šrámová Slušná, S Svorová Pawelkowicz and P Ecorchard	
Utilization of Fermentation Residues in the Production of a Brick Block	62
J Šál and P Nováková	

Circular Housing Retrofit Strategies and Solutions: Towards Modular, Mass-Customised and ‘Cyclable’ Retrofit Products	63
A van Stijn and V H Gruis	
Effect of Glass Fibres on the Mechanical Behaviour of Concrete with Recycled Concrete Aggregates (RCAs)	64
B Vandevyvere, Z Sierens, E Verstryngge, L Vandewalle and J Li	
Innovative Thermal Insulation Products for a Circular Economy	65
V Vasile, C Petcu, V Meit� and M C Zaharia	
Optimization of RC Structures with Regard to Amount of Embodied CO₂ Emissions	66
M �en�sek and P H�jek	

Assessment and Optimization Tools

Development of LCAByg: A National Life Cycle Assessment Tool for Buildings in Denmark	69
H Birgisdottir and F N Rasmussen	
Implementation of the DGNB Framework for Carbon Neutral Buildings and Sites	70
A Braune, D Geiselmann, S Oehler and C Ruiz Dur�n	
The Influence of Technology Performance Durability in the Cost-Optimal Analysis of a ZEB	71
L Danza, A Bellazzi, A Devitofrancesco and G Guazzi	
Module D in the Building Life Cycle: Significance Based on a Case Study Analysis	72
L Delem and L Wastiels	
A BIM-Based Framework to Visually Evaluate Circularity and Life Cycle Cost of buildings	73
C Di Biccari, J Abualdenien, A Borrmann and A Corallo	
Building Information Modelling for Whole-Building LCA: BIM4LCA ..	74
V Gomes, N N Barros and R C Ruschel	
Whole-Buildings Life Cycle Assessment Sensitivity to Scenario Choices	75
G D Guimar�es, L Zucarato, M Saade, M Silva and V G Silva	
Life Cycle Analysis of Vertical Building Extensions – Environmental Impacts of Different Material Selection	76
A Hafner and M Storck	

Hands-On: Sustainable Approach in Architectural Education	77
D Hlaváček and M Čeněk	
Decrease of Cement Production Environmental Burden – LCA	78
A Horáková, H Schreiberová, I Broukalová and J Fládr	
Concrete, Sustainability and Limit States	79
K Hrabová, B Teplý and P Hájek	
Smart BIM-AM Journey to Green Buildings	80
C K Lee, H Y S Chan, C Y C Poon, K M G Yip and P H F Yuen	
Financing Renewables while Implementing Energy Efficiency Measures through Consumer Stock Ownership Plans (CSOPs) – The H2020 Project SCORE	81
J Lowitzsch	
Application of “Element”-Method in Sustainability Assessment	82
T Lützkendorf	
The Theory-Practice Gap in Value Management – A Case Study in Sri Lankan Construction Industry	83
M M M P Mahinkanda and Y G Sandanayake	
Multi-Criteria Decision Making in the Social Sustainability Assessment of High-Rise Residential Buildings	84
B Maleki, M d M Casanovas Rubio, S M A Hosseiniand A de la Fuente Antequera	
Significant Sustainable Facilities Management (SFM) Practices in the Health Care (HC) Sector	85
F S Nazeer, S Gunatilake and T Ramachandra	
Multiscalarity in International Sustainable Assessment Systems: A Qualitative Comparison of LEED, CASBEE, BREEAM, DGNB and ESTIDAMA on Building, Neighbourhood and City Scale	86
M Orova and A Reith	
A Life-Cycle Approach to Building Energy Retrofitting: Bio-Based Technologies for Sustainable Urban Regeneration	87
F Pittau, G Habert and G Iannaccone	
Possibilities of Using Modern Technologies and Creation of the Current Project Documentation Leading to the Optimal Management of the Building for Sustainable Development	88
K Prušková, M Dědič and J Kaiser	

Experiences from the Implementation of the Assessment System for Sustainable Building (BNB) in Germany89

A Rietz, N Kerz and M Welsch

Life Cycle Costing of Public Construction Projects90

R Schneiderova Heralova

Linking Together Independent Sustainable Building Development Plans.....91

M Šúra

The Influence of Energy Performance Certification the Market Value of Residential Buildings92

L C Tagliabue, F Re Cecconi, N Moretti and M C Dejacó

Strategies for Simultaneous Embodied Energy and Operational Energy Reductions in Buildings during the Design Stage93

G A Tennakoon, A S Waidyasekara, B J Ekanayake and S F Nazeer

Quality Label in Buildings and Construction – a Green Label Supporting the Sustainability of Buildings in Slovenia.....94

M Tomšič, N Ječič and M Š Zavrl

Cost Estimation in BIM for Transportation Constructions in Czech Republic95

S Vitasek and J Zak

Changes of the Operating Costs during the Life Cycle in Existing Housing Stock96

D Vytlačil

Life Cycle Assessment Of Cooling and Heating System Based on Peltier Module97

A Želazna and J Gołębiowska

High-Performance Building Systems and Components**Building Envelope Thermal Upgrade for School Buildings in Jordan**...101

H H Ali and R Al-Hashlamun

Flat Roofs Defects – Norwegian Building Sector Perspectives.....102

E Andenæs, A Engebø, T Kvande, R A Bohne and J Lohne

Two-Stage System for Utilization of Renewable Solar Energy in Modern Building Facade Technology103

B Bielek, M Krajčík, P Buday and M Macák

The Environmental Performance of a Remote-Region Health Clinic Building, Australia, Based on Instrumental Monitoring.....	104
S Burroughs	
PCM Integrated in BiPV Ventilated Façade Concepts: Experimental Test Cell Platform and Initial Full-Scale Measurements	105
J Curpek, M Cekon and J Hraska	
HAM Analysis of Selected Wooden-Framed Walls	106
P Durica, V Kabatova, P Juras and J Rybarik	
Window Design Strategies for Environmentally Friendly and Energy Efficient Patient Rooms: A Case Study in the Belgian Context	107
N Eisazadeh, K Allacker and F De Troyer	
Towards the Façades of the Future: A New Sustainability Assessment Approach.....	108
G Gilani, O Pons and A de la Fuente	
Thermal Performance of Window with Vacuum Glazing. Case Study ..	109
I Chmúrný and D Szabó	
Implications of Model Complexity for the Simulated Thermal Behavior of a Casement Window	110
S N Khosravi, O Šikula, U Pont and A Mahdavi	
Air Handling Unit with Heat Pump	111
M Kny, V Mazanec, D Adamovský and J Včelák	
Optimization of Distance Rings in Panel Radiators.....	112
T Legner and J Bašta	
Experimental Assessment of the Façade-Integrated Thermoelectric Air-Conditioning Unit towards Development of the Autonomous Curtain Walling Module	113
T Matuska, V Zmrhal, V Zavřel and P Slanina	
Performance of Unglazed Photovoltaic-Thermal Collectors for Cooling Purpose	114
T Matuska, N Pokorný and V Shemelin	
Influence of User Electricity Load Profile and Calculation Time Step on the Photovoltaic System Balance	115
J Novotny and T Matuska	

Environmental Benefits of Timber-Concrete Prefabricated Construction System for Apartment Buildings – a Simplified Comparative LCA Study	116
P Ryklová, Š Mančík and A Lupíšek	

Attractiveness of Using Photovoltaic Panels in a Building Connected to a Mainly Renewable Electricity Grid	117
M R M Saade, M G da Silva and V Gomes	

Potential Benefits of PV-Shading System in Office Buildings and Semi-Continental Climate Conditions	118
N Skandalos, J Tywoniak and K Stanek	

Effects of Early Structural Changes of Engineered Soils on Green Roof and Bioretention Performance	119
M Snehota, J Hanzlikova, P Heckova, J Sacha, V Jelinkova and A Kaestner	

Environmental Assessment of Latent Heat Storage Technology	120
K Struhala, M Ostrý and S Bantová	

Reducing Energy Consumption for Air-Conditioning by Commissioning and Optimized System Operation	121
J Šimek, M Lain and J L M Hensen	

Simple Free Use Simulation Software for Buildings with Photovoltaic System and Battery	122
P Wolf and S Kichou	

Determination of Moisture Buffering Capabilities of Common Furniture Materials	123
J Zemitis and A Borodinecs	

Energy

Waste Water Recovery System with Heat Pump for Hot Water Preparation	127
R Červín and T Matuška	

I-ZEB: Design and Development of a ZEB Test-Laboratory for an Integrated Evaluation of Building Technologies	128
L Danza, L Belussi, B Barozzi, A Bellazzi, A Devitofrancesco, M Depalma, G Guazzi, I Meroni, C Maffè, M Ghellere, F Salamone, F Scamoni and C Scrosati	

DataRen, a Territorial Energy Demand Modelling Tool	129
F de Oliveira, S Schneider and P Holmuller	

A Revolutionary Study Commons and University Library Extension, The Chinese University of Hong Kong	130
S M Fung and T Yuen	
Use of Heat from Wastewater	131
K Hrabová, T Hrdlička and M Tlašek	
Parametric Study: Impact of Selected Factors on the Energy Demand of a Family House	132
P Juras, P Durica and J Jandacka	
The Assessment of Construction Details in Terms of 3D Thermal Fields and the Impact on Building Design	133
M Kalousek and M Novák	
Renewable Energy Supply for Remote Station Located in Antarctica – Simulations Based on Real Measured Data	134
S Kichou, P Wolf and P Kapler	
Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings	135
K W Kong, K W Lam, C Chan and P Sat	
Solar Aperture of a Building Enclosure: The Case Study of a Well-Insulated Family House in Semi-Continental Climate	136
P Kopecký and K Sojková	
Carbon Dioxide Emissions from Operation of Czech Building Stock and Potential for Their Reduction	137
A Lupíšek	
Identification of Characteristic Heat Load Profiles of Different Usage Units in Non-Residential Buildings	138
C Matschi, G Vogt and I Nemeth	
Mapping of Cities Wastewater Heating/Cooling Capacity	139
N Meeten	
Experimental Verification of Indirect Adiabatic Cooling by Ventilation Air	140
O Nehasil and D Adamovský	
The Impacts of the Exterior Glazed Structures and Orientation on the Energy Consumption of the Building	141
T Odineca, A Borodinecs, A Korjakins and D Zajecs	

Effect of Traditional Persian Materials and Parametric Design on the Thermal Performance of a Generic Building in Mediterranean Climate.....	142
N R M Sakiyama, S B M Hejazi, C C de Oliveira, J Frick and H Garrecht	
A Heat Demand Load Curve Model of the Swiss National Territory	143
S Schneider, P Hollmuller, J Chambers and M Patel	
A Zero Energy House for and by Frank Gehry	144
M Schuler, K Dvořáková and Z Malík	
The Influence of Heat Gains on the Heating System Design	145
J Spurny and M Kabrhel	
A Feasibility Study on the Waste-to-Biogas SOFC-Based Multi-Generation with Energy Storage System for Building Applications in China	146
S Zhang, Q Wang, L Hu, W Shi and M Qu	

Sustainable Urban Development

Material Efficiency of Housing in Times of Demographic Change – Evidence from Case Study Research into two German Municipalities ..	149
A Blum and R Gutting	
From Assessment to Implementation: Design Considerations for Scalable Decision-Support Solutions in Sustainable Urban Development	150
V Bukovszki, D Apró, A Khoja, N Essig and A Reith	
A Systemic Approach for the Optimization of Urban Surfaces Usage ...	151
S Croce, D Vettorato and R Paparella	
Building-Integrated Photovoltaics and Urban Environment from the Perspective of Sustainable Architecture	152
M Čeněk and D Hlaváček	
Exploring Concept of Sustainability through Understanding Traditional Resource Management Practices: Case of Thar Desert, India	153
D Ghosh Saxena	
Ecosystem Services Assessment Methods for Integrated Processes of Urban Planning. The Experience of LIFE SAM4CP Towards Sustainable and Smart Communities	154
C Giaimo and S Salata	

Study on Spatial Evolution of Chinese Green Building	155
T Hao and J Wang	
Challenges and Opportunities of Urban Fabrics for Sustainable Planning In Cuenca (Ecuador)	156
M A Hermida, D Cobo and C Neira	
Periurban Urbanization and Travel Choice Behaviour: Problem or Solution?	157
M A Hermida, D Astudillo and F León	
Communities Shaping Sustainable Cities	158
J Hořická	
Measuring Livability at the Neighborhood Scale – Development of Indicators and Methods for the Comparison between Neighborhoods and Best Practice within the Chosen City	159
H-H Chen and U Dietrich	
GIS-3D Platform to Help Decision Making for Energy Rehabilitation in Urban Environments	160
J L Izkara, A Egusquiza and A Villanueva	
Can Buildings Save and Improve Municipal Infrastructure?	161
W Kujawski	
Sustainable Campus Development in the Context of a Private Higher Education Institution in Hong Kong, a Case Study at the Hang Seng University of Hong Kong	162
H H Y Lee	
The Integration of Sustainable Cities in the Marshes (Iraq)	163
A A Rashid Kbah	
Planning and Implementing Low Carbon-Communities in Canada.....	164
J Skopek, S Pope and S Bucking	
Urban Decay in Central Hill, Port Elizabeth	165
F Swanepoel and J Smallwood	
System Model for Prediction of Energy Consumption in Cities.....	166
D Vytlačil	

Retrofitting of Existing Buildings

OptEEmAL: Decision-Support Tool for the Design of Energy Retrofitting Projects at District Level	169
M A García-Fuentes, G Hernández, V Serna, S Martín, S Álvarez, G N Lilis, G Giannakis, K Katsigarakis, L Mabe, X Oregi, D Manjarres, H El Ridouane and L De Tommasi	
Retrofitting Hospitals: A Parametric Design Approach to Optimize Energy Efficiency	170
J Gaspari, K Fabbri and L Gabrielli	
Typology of Unclassified Buildings and Specifics of Input Parameters for Energy Audits in Latvia	171
A Geikins, A Borodinecs, G Daksa, R Bogdanovics and D Zajecs	
Development of a Modular Retrofitting System for Residential Buildings and Experience from Pilot Installation.....	172
P Hejtmánek, K Sojková, M Volf and A Lupíšek	
New European Document on Assessment of Existing Structures and Building Stock	173
M Holický	
Thermal Retrofitting of Dormitory Under Historic Protection – Case Study	174
J Kwiatkowski, J Sowa and A Wiszniewski	
A Multi-Step Design Framework Based on Life Cycle Thinking for the Holistic Renovation of the Existing Buildings Stock.....	175
C Passoni, A Marini, A Belleri and C Menna	
Internal Ventilated Plinth as One of the Possible Solution for Moist Buildings.....	176
J Pazderka, P Hájek, H Žáková and M Nývlt	
A Bibliometric Analysis on Costs Estimation of Building Retrofit	177
F Re Cecconi, N Moretti and M C Dejacó	
Energy Renovation of Social Housing: Finding a Balance Between Increasing Insulation and Improving Heating System Efficiency	178
E Van De Moortel, K Allacker, F De Troyer, L Stijnen and E Schoofs	
The District Energy-Efficient Retrofitting of Torrelago (Laguna de Duero – Spain)	179
A Vasallo, E Vallejo, G Massa, A Macía, L Pablos, C Criado, E Arrizabalaga, J Iturralde, A Gordaliza, I De Castro and F Larrinaga	

Energy Sustainable Living – Deep Renovation of Residential Building – PAVE	180
J Včelák and E Novák	

Incremental Integrated Holistic Rehabilitation: A New Concept to Boost a Deep Renovation of the Existing Building Stock	181
J Zanni, S Labò, C Passoni, E Casprini, A Marini, A Belleri and C Menna	

Indoor Environmental Quality

Influence of Airflow on Thermal Comfort in an Energy-Saving House..	185
D Adamovský and M Kny	

Performance Analysis and Energy Saving Potential of Room Integrated PCM Wallboards for Passive Cooling Application.....	186
B Chhugani, M Yasin, F Klinker, H Weinlaeder, S Weismann and M Reim	

Acoustic Evaluation of the Air-Conditioning Unit in the Room	187
J Králíček and M Kučera	

Assessment of the Indoor Environment for Education	188
M Kraus and P Nováková	

Daylighting Design Process for Visual Comfort and Energy Efficiency for a Signature Building	189
N Kutlar and M P Mengüç	

Effect of the Personalized Ventilation to a Human Thermal Comfort ..	190
V Mazanec and K Kabele	

Virtual Air Temperature Function for Room Thermostats	191
O Nehasil, J Horváthová, A Kohoutková and M Kny	

A Commercial Building Lighting Demand-Side Management through Passive Solar Design.....	192
O K Overen, E L Meyer and G Makaka	

Measuring Airtightness in a Tall Multi-Family Passive House when Exposed to Wind and Thermal Lift (Stack Effect)	193
S Rolfmeier and P Simons	

Potted Plants as Active and Passive Biofilters Improving Indoor Air Quality	194
J Sowa, J Hendiger, M Maziejuk, T Sikora, Ł Osuchowski and H Kamińska	

Sound Insulation of a Wall in a Panel House with Demountable Joints..	195
J Vychytil and M Vychytil	

Heritage Regeneration and Sustainability

Technical Cultural Heritage on the Elbe-Vltava Waterway	199
P Fošumpaur, T Kašpar and M Zukal	
Sirius: Retrofitting Brutalism in Sydney	200
V Gandhand ML North	
Potential and Impact of Incorporating Roof Photovoltaic to Enhance Environmental Sustainability of Historic English Churches in the United Kingdom	201
S Khatri, K Ip, M Picco and A Hashemi	
Cost Optimization for Renovation and Maintenance of Cultural Heritage Objects.....	202
D Macek, R Schneiderová Heralová, E Hromada, I Střelcová, I Brožová, S Vitásek, J Pojar and R Bouška	
Historical Water Management Constructions, their Value, Function and Significance.....	203
K Nedvedova, M Dzurakova, A Vyskocil, Z Svitak, R Kleparnikova and D Honek	
Building Integrated Photovoltaics (BIPV) in Line with Historic Buildings and Their Heritage Protection	204
E Novak and J Vcelak	

Awareness-Raising Campaigns and Tools

Adoption of Sustainable Construction for Small Contractors: Major Barriers and Best Solutions	207
B G Hwang, W Q Liu, M Shan and J M Lye	
Rethinking Public Buildings' Functions: The Case for Participatory Design Methodology.....	208
V Kandusová and T Vácha	
Green Construction Capability Model (GCCM) for Contracting Companies	209
H Setiawan, W I Ervianto and A L Han	
Young Leaders of the City of the Future	210
D Śmiechowski	
Using Public Opinion to Estimate Improvements in Economic and Social Dimensions of Sustainability	211
M Sůra	

Policy Making Processes

Assessment of Different Methodologies for Mapping Urban Heat Vulnerability for Milan, Italy	215
S Bhattacharjee, E Gerasimova, C Imbert, J Tencar and F Rotondo	
Greening Actions and the Related Potential Impacts on Outdoor Comfort in a Dense Built Environment	216
J Gaspari and K Fabbri	
Energy Saving and Climate Adaptation of Buildings: A Paradox?	217
S Golz, J Nikolowski and T Naumann	
ENERGIS: Decision-Support Tool for the Implementation of Energy Policies at Urban and Regional Level	218
G Hernández Moral, V I Serna González, G Massa and C Valmaseda Tranque	
Statistics and Governance. Current Issues of Affordable Housing: The Case of Prague.....	219
T Hudecek, P Hlavacek, J Hainc and M Cervinka	
Author Index	221

Keynote Addresses

Buildings and Climate Change: Accelerating Transformation

R Lorch

Editor-in-Chief, *Buildings and Cities* journal: www.buildingsandcities.org
Visiting Professor, University College London, UK
richard@rlorch.net

The UNFCCC Paris Agreement and its Nationally Determined Contributions, together with the Sustainable Development Goals, can be a driver for a comprehensive, positive societal transformation in the way we live and work. Three main building blocks comprise the new urban paradigm: energy, transportation and the built environment. The transition to a low-carbon society means buildings and cities must be at the nexus of climate strategies. The international research community has played a vital role in contributing to understanding the underpinning technical and economic problems as well as developing plausible solutions. However, different approaches are now urgently required to help implement solutions that are rapid, radical, deep and scalable. In order to achieve significant decarbonisation, the research agenda needs to be broadened in scope to embrace public policy, provide wider social narratives and rethink the roles/responsibilities of professionals and public officials. A shift in the research agenda from a purely technical focus to a wider approach embracing policy and strategy will accelerate the desired changes. The academic community has an essential role in adapting the existing curricula for professional education to redefine the meanings and practices underpinning professionalism. For example, this needs to embrace the wider professional responsibilities owed to society particularly for performance, impacts and outcomes.

See full paper



A New Generation of Sustainable Structural Concretes – Design Approach and Material Properties

H S Müller¹, J S Moffatt², M Haist² and M Vogel¹

¹ Institute for Concrete Structures and Building Materials (IMB), Karlsruhe Institute of Technology (KIT), Gotthard-Franz-Str. 3, 76131 Karlsruhe

² Institute of Building Materials Science, Leibniz University Hannover, Appelstr. 9A, 30167 Hannover

harald.mueller@kit.edu, j.moffatt@baustoff.uni-hannover.de,
haist@baustoff.uni-hannover.de, michael.vogel@kit.edu

Sustainable concretes, also termed eco-concretes or green concretes, produced with a significantly reduced cement content provide a promising alternative for improving concrete sustainability without using supplementary cementitious materials, such as fly ash or slag. However, the production of such eco-concretes is a challenge in view of concrete technology and concrete properties. In particular, new design concepts as well as new admixtures have to be developed and applied to produce concretes with a cement clinker content of approx. 100 kg/m³ while keeping the concrete performance on a level similar to ordinary structural concrete of today.

To evaluate the sustainability of these new types of concretes not only the very low ecological impact due to the composition may be regarded, but in addition also their technical performance, i.e. their mechanical, physical and chemical properties have to be taken into consideration.

This contribution firstly gives an overview on sustainable approaches for concrete structures, further introduces the Building Material Sustainability Potential as an index, which is applied in combination with the service life prediction for cement-reduced concretes using full probabilistic methods. The composition of these particular structural concretes is discussed and related test results for their performance are presented. The contribution closes with an introduction to graded concrete structures as an innovative approach for the improvement of concrete sustainability on a structural level and presents testing results for mechanical and durability properties of graded bending beams.

The paper at hand extends the information given in [1] by looking more closely at the performance of graded concrete structures and here in particular by considering concretes produced from intermixing two concrete types (i.e. eco-concrete and UHPC) in the fresh state.

See full paper



Large Scale Urban Developments in Austria – Challenges and Opportunities Based on Two Case Study Examples

D Österreicher^{1,*} and M Treberspurg²

¹ Department of Landscape, Spatial and Infrastructure Sciences, Institute of Spatial Planning, Environmental Planning and Land Rearrangement, University of Natural Resources and Life Sciences, 1190 Vienna, Austria

² Treberspurg & Partner Architekten, 1140 Vienna, Austria,
martin.treberspurg@treberspurg.at

doris.oesterreicher@boku.ac.at

As urban densification is on the rise and the population of cities are increasing, strategies for eco-friendly urban development plans are needed in order to ensure the long-term sustainable growth of our cities. Quality of life and socio-economic considerations are in this context equally important as environmental factors such as energy efficiency, resilience and a future proof mobility concept. Especially large scale urban developments require long-term planning as the actual implementation phase can take decades for completion and advances in technology can significantly change over time. However these developments offer the unique opportunity for research and innovation, as accompanying studies can support the projects throughout the whole life cycle ranging from planning to implementation and monitoring during operation. To discuss the challenges and opportunities of large scale urban development projects, two Austrian case studies, that differ in time, scale and overall context have been selected: The solarCity Linz in the county of Upper Austria and the Aspern Seestadt in the City of Vienna.

See full paper



Sustainability in Building Construction – A Multilevel Approach

T Lützkendorf

Karlsruhe Institute of Technology (KIT), Department of Economics, Centre for Real Estate, Chair for Sustainable Management of Housing and Real Estate, Kaiserstr. 12, 76131 Karlsruhe, Germany

thomas.luetzkendorf@kit.edu

The implementation of sustainable development principles requires integrating general goals for maintaining a balance between the environment, society and the economy into the specific area of work and responsibility of the actors involved, as well as their work and decision-making processes. It also requires adapting them to the specific object of assessment. For the construction and real estate industry, this means, among other things, extending the already complex interrelationships of designing, constructing and operating real estate properties by considering sustainability aspects. This not only has consequences for the decision-making processes of individual actors, but also for the exchange of information along the value chain and across the individual levels of action. Typical levels of action are the manufacturing of construction products, the provision of services (transport, construction site processes), the building, the neighbourhood, the city, the region, the national building stock. Selected actors also deal with the management of municipal, commercial and institutional building stocks.

At all levels of action, developments are currently underway to support sustainable development. At the product level, the extension of the present scope of Environmental Product Declarations in the direction of additional requirements for environmental information is currently underway. This development will allow the reporting of additional indicators for the quantification of environmental impacts on the global environment, support a more sophisticated assessment of the GWP, and provide guidance on risks to health and the local environment as additional information. At the construction level, the results of a sustainability assessment in determining the value of the asset as well as determining the conditions for financing and insurance will be taken into account more than ever before.

Again, the consideration of additional indicators in the environmental performance assessment is discussed. BIM provides a tool to handle complex design and assessment tasks that affect data delivery requirements – EPDs must be designed to be BIMable among others. The aim is to combine life cycle costing (LCC) and life cycle assessment (LCA). The life cycle carbon footprint is becoming an important indicator. Almost all countries are currently working on the introduction of compulsory calculation and assessment rules as well as carbon footprint benchmarks. This is also integrated as a requirement in the green public procurement. It remains to be seen what impact the introduction of taxes or fees on CO₂ can have.

Urban neighborhoods are becoming an important level of action for sustainable development. In addition to sustainability rating systems, preferably for new neighborhoods, process-related strategies and recommendations for the further development of existing ones are establishing themselves. Of particular interest is the ability of residents to actively participate in the process of sustainable development. In general, sustainable urban development is currently in the public interest – see also SDG11 – a goal for sustainable development dealing with the topic of sustainable development of cities and communities. The city is thereby the object of assessment, the level of action and, through its administrative institutions, also an actor. Many cities have already formulated their own goals in the direction of climate neutrality or sustainability and developed corresponding strategies. Here, too, it is important to involve individual stakeholder groups in a more effective and systematic way.

For national climate protection and sustainability strategies, it is advantageous to formulate sub goals for individual industries and sectors. In the construction and real estate industry, this approach encounters problems because it is a cross-cutting issue. Frequently, goals for the national building stock are therefore formulated, which have the character of a budget for greenhouse gas emissions.

Increasingly, there is also a link with sustainability reporting for company-owned building portfolios.

It becomes clear that the topics of climate protection and resource conservation are dealt with at all levels of action. This requires a multi-level provision and processing of appropriate indicators. It is recommended to pursue this approach also in the standardization activities of CEN TC 350 and ISO TC 59 17. Indicators such as GWP and primary energy consumption, non-renewable, are and can be used at all levels of action. The carbon footprint evolves as a key indicator. However, the handling of the issues of resource use and resource efficiency is still a problem. In addition to the use of the indicator ADP, new opportunities are arising. A differentiated description of the use of resources according to four different types of materials – i.e. fossil energy materials, non-metallic minerals, metals and biomass – enables a better support of the management of resources. This requires taking into account parts of the life cycle inventory in the EPD.

With new, additional indicators on the one hand, and involvement of other actors such as valuation professionals and banks on the other hand, new tasks are emerging. The requirements for transparency and traceability of data are growing. There is a need for approaches that can capture the quality of data and signal it to third parties. Furthermore, it has to be clarified who takes the responsibility for the accuracy and reliability of the data. As the number of indicators increases, the question arises as to how this information can be communicated to third parties. Third-party actors can be clients active in the construction market who want to select a construction product or valuation professionals who want to consider the results of the environmental performance assessment. From the author's point of

view, partially aggregated results on the basis of “endpoints” can be useful to this end. A presentation of assessment results organised according to carbon footprint, other impacts on the global environment, use of material resources, impacts and risks to the local environment, as well as impacts and risks to health, can facilitate the interpretability of assessment results. In this respect, it is important to develop suitable communication formats with respect to the various levels of action, the exchange of information along the value chains and the various actors with specific interests and options for action. It is recommended to maintain information that preserves basic data and background information while allowing the transformation and aggregation of information to meet the specific information needs of respective actors. A modern information management process is thus a prerequisite for the provision and use of information to support decisions for sustainable development.

See full paper



Materials

Hygrothermal Risk Analysis of Recently Constructed Timber Buildings Exposed to Outdoor Climate Changes by the End of the Century in Germany

S Ameri* and N R  ther

Fraunhofer WKI, Center for Light and Environmentally-Friendly Structures, Bienroder Weg 54 E, 38108, Braunschweig, Germany

shaghayegh.ameri@wki.fraunhofer.de

Scientific evidence predicts significant climate changes in the future and the world faces warmer days with extreme precipitation. The purpose of this study is to investigate the effect of predicted climate changes until 2100 on the hygrothermal behavior of well-insulated residential timber buildings are being constructed recently in Germany according to the new low and zero energy standards. Considering the facts that wood and timber constructions are sensitive to moisture and moisture changes and these buildings should have a service life of 50 to 100 years, the hygrothermal performance of several exterior wall assemblies has been analyzed by means of coupled heat and moisture transfer numerical model in this period. Predicted climate data -by the end of the century- for several cities in different Germany's hygrothermal regions, extracted from climate service centers' databases and applied as an outdoor condition. The article discusses the response of a number of buildings envelopes exposed to these exterior environments. Accordingly, critical aspects of moisture performance regarding the risk of mold growth and fungal decay were in each assembly analyzed. In this regard, relevant solutions were suggested aiming construction of more resilient timber structures to climate changes.

See full paper



The Biophilic Power and Environmental Urgency of Earthen Construction

L Ben-Alon¹, V Loftness², K A Harries³ and E C Hameen⁴

¹ Carnegie Mellon University, School of Architecture, Pittsburgh PA 15213

² Carnegie Mellon University, School of Architecture, Pittsburgh PA 15213

³ University of Pittsburgh, Civil and Environmental Engineering Department, Pittsburgh PA 15260

⁴ Carnegie Mellon University, School of Architecture, Pittsburgh PA 15213

rbenalon@andrew.cmu.edu

The built environment must meet the highest demands of human habitation, resource management and community enrichment. To achieve these goals, modern built environments should adopt restorative environmental and biophilic design principles which seek to reconnect the human built environment with nature. In this paper, the biophilic aspects and environmental benefits of earthen construction are assessed and compared to conventional construction in order to demonstrate the tangible and intangible benefits of earthen materials. Specifically, the synergies between biophilic design attributes and earthen construction are elaborated, characterizing the ecological, health, and community collaboration advantages that earthen structures provide. Subsequently, the results of an environmental Life Cycle Assessment (LCA) of earthen building materials from cradle to gate enumerate the environmental preferability of earthen materials over conventional materials.

See full paper



Alternative Sands as Substitute for Natural Sand for the Construction Sector

L Boehme and A Depoortere

KU Leuven, Faculty of Engineering Technology, Research Group RecyCon,
Sporwegstraat 12, 8000 Bruges, Belgium

luc.boehme@kuleuven.be

While the need for sand in the construction sector is increasing, natural sand becomes scarce. On the other hand, several sand-like fractions out of industrial residues become available. This paper focusses on the potential use of these “alternative sands” as substitute for natural sand in the construction sector. The investigation included the study of the properties of alternative sands and a market research. In order to determine the properties, standard tests were performed such as the determination of the particle size distribution, the fineness modulus, the methylene blue test, determination of the density and the water-absorption. The particle size distribution of several fine recycled aggregates and of other fine fractions, derived from different producers, were compared to each other and to natural sand. This was to how alternative sands relate to natural sand and more specifically if they can be compared to natural sand and if they match the requirements of use of sand in constructional applications set by the standards and the standard specifications for road construction SB250. As a result, an overview table is made with the potential applications for each type of sand.

See full paper



Decisive Use of Building Materials Based on Hygrothermal Analysis

M Brauner, A Ghaffarianhoseini, N Naismith and J Tookey

AUT Auckland University of Technology, New Zealand

marcela.brauner@aut.ac.nz

Sustainable buildings, planning and construction process in the 21st century require an interdisciplinary approach by which the use of materials and products has to be a result of a complex decision procedure. Every building in its life span has an immense impact on the environment. This study shows that even small changes in material specification can engender a significant influence on indoor air quality and the whole ecosystem. This paper represents the second part of a research study described and presented by the CESB16 conference. An experimental and numerical study on real houses delivers new data which demonstrate the importance of material determination during the design process. Four different scenarios have been tested in two houses while introducing water vapour into a room to simulate occupancy. Indoor relative humidity, temperature and absolute humidity in the same room (size, position in the house, orientation) have been monitored while introducing various materials with a divergent moisture buffering capacity. This research has been based on real measurements assessed the data and compared with the hygrothermal performance of the original construction. The study further used a hygrothermal simulation to demonstrate the possibility of early materials assessment and allowance for the targeted specification of building materials. The information on how to efficiently use the hygrothermal qualities of materials in a build environment is a contribution to the goal of designing and constructing sustainable buildings.

See full paper



The Use of Natural Materials for Construction Projects – Social Aspects of Sustainable Building: Case Studies from Australia and Europe

S Burroughs¹ and J Růžicka²

¹ Remote Sustainability Consultant, Australia

² FCE CTU in Prague, Czech Republic

drsteve@drsteveburroughs.com.au, jan.ruzicka@fsv.cvut.cz

The three pillars of sustainability are the economic, environmental and social pillars. To achieve sustainable construction projects, these three priorities must be balanced. Considering social aspects is of equal importance when considering the design, materials and technologies used in buildings. The increased use of naturally based materials from renewable sources using traditional techniques is common in sustainable buildings and can help balance some of the social aspects. Building with traditional technologies such as compressed earth blocks (CEBs), rammed earth, adobe, or strawbale technologies is a viable option to conventional construction methods when the structure meets modern scientific and engineering standards. High-quality, sustainable buildings are achievable using local resources and local labour. This paper presents case studies from remote Australia and Europe and shows the social and environmental impacts according to the technology used. Prior consideration of the social aspects can result in the improvement of the sustainability of the building.

See full paper



Demolition-and-Reconstruction or Renovation? Towards a Protocol for the Assessment of the Residual Life of Existing RC Buildings

E Casprini¹, C Passoni¹, A Belleri¹, A Marini¹, G Bartoli² and P Riva¹

¹ Department of Engineering and Applied Science, University of Bergamo, via Marconi 5, 24044, Dalmine (BG), Italy

² Department of Civil and Environmental Engineering, University of Florence, via di S. Marta 3, 50139 Florence, Italy

elena.casprini@unibg.it

When is demolition mandatory? To date there is a lack of specific tools and protocols enabling a rigorous scientific assessment of the deterioration level of existing structures, guiding the choice between the real possibility of renovation or the unavoidable need of demolition. In the present paper, an attempt is made to develop a protocol suitable to assess the actual capacity of existing structures and predict their future behaviour based on inspection and diagnosis of the building. The potential benefit of such a tool is to help detecting the best intervention strategy making the renovation process more sustainable and efficient. Toward this perspective, a critical analysis and comparison of literature models on the residual capacity of structural elements has already been carried out by the authors. The assessment of the preservation state is herein further extended to the overall structural level, by proposing a new approach relating the performance of deteriorated elements over time to the behaviour of the whole structural system.

See full paper



Stability of Wall Panels with One-Sided Board Sheathing for Timber Structures

J Celler¹, J Dolejš¹, J Pošta² and R Jára²

¹ CTU, Faculty of Civil Engineering, Department of Steel and Timber Structures, Thakurova 7, 166 29 Praha 6 – Dejvice, Czech Republic

² CTU, University Centre for Energy Efficient Buildings, Trinecka 1024, 273 43 Bustehrad, Czech Republic

jiri.celler@fsv.cvut.cz

The subject of this paper is a new knowledge in experimental and numerical analysis of the stability of the wall panels with one-side board sheathing. The reinforcement of the panel is provided by means of glued timber composite I-shaped element consisting of a web made of a wood-based desk – OSB board embedded into flanges of solid timber. At present, the design of wall panels with I-shaped cross-section stiffeners and double-sided sheathing is based on test results and simplified analytical calculation. For the design of wall panels with I-shaped cross-section stiffener rib and one-sided board sheathing, a reliable procedure for determining the buckling load bearing capacity has not been described so far. It is assumed that the base of this work can be used for more effective material use of subtle light timber frames. By optimization of the supporting structure, increased heat-technical properties will be effectively achieved. New outputs of experimental analysis on wall panels in real dimensions, as well as material tests of individual components such as solid wood, OSB board and staples will be presented in this paper. Moreover, this paper presents the results of detailed numerical analysis, which are validated on the basis of the experiments performed.

See full paper



**3-D Printing in Building Construction: A Literature Review
of Opportunities and Challenges of Reducing Life Cycle Energy
and Carbon of Buildings**

M K Dixit

Dept. of Construction Science, Texas A&M University, College Station TX 77840
mdixit@tamu.edu

Buildings consume approximately 48% of global energy each year as embodied and operating energy. Embodied energy is consumed in all products and processes used in building construction, maintenance, replacement, renovation and demolition. Operating energy is consumed in heating, cooling, lighting, and operating building equipment. To effectively reduce life cycle energy usage, both embodied and operating energy must be optimized. However, in spite of advancements in building envelope technologies, building systems/controls, building energy modelling, and material production, the energy and carbon footprint of buildings is still enormous. Perhaps, a new paradigm is needed to transform the way our buildings are designed and constructed. One emerging technology that could possibly help bring this paradigm shift is 3-D printing or additive manufacturing. Although, its application to mainstream construction is yet to be tested, it surely demonstrates energy and carbon benefits through innovative materials and construction processes. In this paper, we conduct a systematic review of literature to study the state of the art of 3-D printing or additive manufacturing in building construction. The goal will be to identify challenges and opportunities of saving operating and embodied energy and show future research directions to use 3-D printing technologies for energy optimization.

See full paper



The Utilization of the Finest Fraction of Recycled Aggregate from CDW for Concrete

K Fortova and T Pavlu

University Centre for Energy Efficient Buildings of Czech Technical University in Prague,
Trinecká 1024, 273 43 Buštěhrad, Czech Republic

kristina.fortova@cvut.cz

The main aim of this study is to verify the use of fine recycled aggregate originating from construction and demolition waste. Fine fraction of aggregate up to 4 mm (sand) is commonly used for ordinary concrete. This research tests the properties of concrete whose sand content has been partially replaced by fine recycled aggregate. The use of these fine particles could reduce the consumption of natural sand. There were also tested samples with a mineral admixture up to 1 mm in size, which appear as dust during the crushing of waste concrete. The use of these fine particles fills pores between larger particles to make the aggregate skeleton of the concrete mixture denser. Furthermore, the fine particles can contain a small amount of unhydrated cement. The results of physical and mechanical and deformation properties of concrete mixtures are presented.

See full paper



Secondary Materials in the Building Sector – Energy and Material Flows

K Gruhler, T Bimesmeier and C Deilmann

Leibniz-Institute of ecological urban and regional development (IOER), Dresden,
Germany

k.gruhler@ioer.de

The recycling of construction and demolition waste is an important step-stone towards the achievement of resource conservation and the reduction of environmental impacts through construction. To this end, the recycling of construction waste usually is considered from a mass perspective. But it is necessary to add an energy perspective to the production of secondary raw materials in order to develop environmental sound solutions and to reveal likely conflicts between environmental objectives. It is not yet clear how to implement such a combined analysis. Therefore, the aim is to develop an orientation framework that integrates the mass and energy perspective of recycling in the construction industry. The paper presents differences and specific particularities of building product groups and answers the following question: What is the energy expenditure associated with the sorting and processing of construction and demolition waste and what is a suitable basis for comparing the various options for the use of recycling materials?

See full paper



Laboratory Concrete Specimens Waste, a Case Study on Life Cycle Assessment

A L Han¹, H Setiawan² and P Hajek³

¹ Faculty of Engineering, Diponegoro University, Semarang, Indonesia

² Faculty of Engineering, Universitas Atma Jaya Yogyakarta, Yogyakarta, Indonesia

³ Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic

hanaylie@live.undip.ac.id

Material laboratories generally receive extensive amounts of concrete specimens for testing purposes. The tested specimen rises an environmental issue from the point of view of material waste accumulation. A study at the material laboratory was conducted, resulting in a database of daily concrete waste deposited at the landside, and the predicted increase trends based on a one-decade period of data collection. Based on these data, the emission of CO₂ resulting from these test samples was evaluated, and a life cycle assessment plan was designed through impact assessment and interpretation of results. Practical solutions for a cradle-to-cradle and cradle-to-gate approach were explored, implemented and evaluated.

See full paper



Choice of Sustainable and Durable Concrete Structure Using LCA

A Horáková, I Broukalová and A Kohoutková

Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech
Technical University in Prague

anna.horakova@fsv.cvut.cz

The paper presents a new perspective on the issues of life cycle assessment (LCA) and durability analysis of structures. In the case study, a comparative analysis of three variants of the chosen structure was performed. Subsequently the durability of all variants was assessed. The structural solutions were modified to achieve a targeted life cycle for all variants. Modified structures were evaluated in LCA. The study points to the fact that orthodox compliance with code prescriptions can lead to an uneconomical and unsustainable solution and suggests an approach where the design of the structure is adjusted for the required service life.

See full paper



The Use of Products Recycled from Municipal Waste in Sustainable Architecture

A Iringová, D Vandlíčková and M Diviš

Faculty of Civil Engineering, University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia
agnes.iringova@fstav.uniza.sk

Analysis of the use of products recycled from municipal and construction waste as a substitute of products from non-renewable sources. Current legislation on waste management in Slovakia. The process of manufacturing materials from recycled municipal waste and its environmental benefit to society. The products from recycled municipal and construction waste used in building constructions. Model verification of their application in building envelope construction. Their use as thermal, acoustic, and fire protection of wood-based buildings. Physical characteristics of model lightweight building envelopes assessed using mathematical and simulation solutions. Environmental comparison of a common solution for envelope construction with a solution using recycled waste products.

See full paper



Modern Earth Building – the Current State of Earth Building from a German Perspective

S Jörchel

Dachverband Lehm e.V., Friedrich-Naumann-Str. 16, 99423 Weimar, Germany
dvl@dachverband-lehm.de

Modern earth building today is in quite dynamic development process. While it was a quite “exotic” building material in the end of the last century it is today well known as a sustainable and appropriate building material. This paper will focus on Standards and Regulations, Environmental Product Declarations (EPD), Earth building in teaching and vocational training as well as on innovative earth building products introduced in the market. The new and revised DIN on earth building products will be published within a year as well as the Environmental Product Declarations (EPD). Strategies to embed earth building in teaching and vocational training of building professionals are ongoing and will be presented like introduction of earth building skills in the formal educational framework of building trades. Innovative earth building products are introduced in the market with prefabricated rammed earth elements, a number of clay boards and combined construction techniques of wood and earth panels not to forget the use of straw bale building in combination with earth products to mention just a few aspects.

See full paper



Fire and Mechanical Properties of Hemp and Clay Boards for Timber Structures

H Kallakas¹, J Liblik², P F Alao¹, T Poltimäe¹, A Just² and J Kers¹

¹ Department of Material and Environmental Technology: Laboratory of Wood Technology, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

² Department of Civil Engineering and Architecture, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

heikko.kallakas@taltech.ee

The use of timber with other bio-based building materials is often restricted due to the fire hazard. The primary protection for timber against fire is provided by cladding. Currently, there is limited fire protection design data on clay and hemp boards since they are relatively new products. Furthermore, the mechanical performance of boards is of utmost importance in timber frame assemblies. This paper presents a test program that determines the tensile and bending strength of boards accompanied by a comparison to widely used gypsum plasterboards. The fire protection effect for timber is assessed by using a cone heater. Main results indicate that clay and hemp boards are adequate alternatives for the gypsum plasterboards as they can demonstrate similar performance. Hemp boards made by dry method perform significantly better compared to the ones made by wet method. Clay boards with special additive demonstrate increased fire performance compared to more ecological boards. This study contributes to further research that is needed in order to provide design parameters for sustainable building solutions in the future.

See full paper



Using TRC as an Environmentally Effective Alternative for Subtle Elements of Railway Furniture

L Laiblova^{1,2}, T Vlach^{1,2}, P Hajek^{1,2}, K Hajek¹, A Vanek¹ and J Repka^{1,2}

¹ Faculty of Civil Engineering, CTU in Prague, Thakurova 7, 166 29 Prague 6, Czech Republic

² University Centre for Energy Efficient Buildings, CTU in Prague, Trinecka 1024, 273 43 Bustehrad, Czech Republic

lenka.laiblova@cvut.cz

This paper presents the possibilities of an innovative and aesthetic solution of furniture from concrete for railway stations. At present, the railways in the Czech Republic undergo significant changes. Due to automation and centralization there is a lot of stations without permanent staff. Thus the need for railway station furniture, that exhibits considerable resistance to damage during the intense operation and deliberate vandalism, is raising. Currently, the most used material is metal. Such equipment is expensive and requires constant maintenance. Current concrete furniture is too massive, heavy and usually has a lack of aesthetic or architectonic appearance. The paper presents some results of research and development of the new, modern solution based on the use of concrete to form aesthetic furniture elements, while saving consumption of concrete and maintaining the required parameters and dealing with deliberate destruction. Reduction of concrete as a second most used material is one of the key factor of this solution focusing sustainability goals. This paper thus also presents the environmental analysis and comparison with standard solution.

See full paper



Fostering the Integration of Circular Economy Aspects into the Construction and Real Estate Industry

C Lemaitre¹, A Braune¹, C Ruiz Durán¹ and D Geiselmann²

¹ Deutsche Gesellschaft für Nachhaltiges Bauen – DGNB e.V., Tübinger Straße 43,
70178 Stuttgart, Germany

² DGNB GmbH, Tübinger Straße 43, 70178 Stuttgart, Germany

c.lemaitre@dgnb.de; a.braune@dgnb.de; c.ruiz@dgnb.de; d.geiselmann@dgnb.de

The conscious use of natural resources has always been a key concern of the German Sustainable Building Council (DGNB) since its foundation in 2007. In order to further drive forward this topic and to foster a more circular resource use within the construction and real estate industry, the DGNB has integrated circular economy bonuses into the current version 2018 of the DGNB System, providing a positive impact on the overall certification outcome. The DGNB System is thus the first of its kind to make circular economy principles an assessable and measurable aspect of buildings. The circular economy bonuses range from the reduction of the material input and the avoidance of waste through the reuse and recycling of building components up to the implementation of sharing models leading to an increased usage intensity of the buildings. In close cooperation with its members, the DGNB has developed a guideline on the integration of circular economy aspects into the construction and real estate industry. The guideline published in January 2019 provides examples of putting these aspects into practice and encourages planners to integrate innovative and circular building solutions into the planning of sustainable buildings.

See full paper



Integration of Seismic Risk into Energy Retrofit Optimization Procedures: A Possible Approach Based on Life Cycle Evaluation

C Menna¹, U Vitiello¹, G M Mauro², D Asprone¹, N Bianco³ and A Prota¹

¹ Department of Structures for Engineering and Architecture, University of Naples Federico II, via Claudio 21, 80125, Napoli (NA), Italy

² Department of Engineering, Università degli Studi del Sannio, Piazza Roma 21, 82100 Benevento (Italy)

³ Department of Industrial Engineering, University of Naples, Piazzale Tecchio 80, 80125 Napoli (Italy)

costantino.menna@unina.it

Most of the retrofit processes applied to existing buildings are frequently targeted at reducing energy consumption over the building lifetime, neglecting possible interactions with other sources of uncertainty. On the contrary, recent Italian earthquakes highlighted the need to couple energy aspects with structural retrofit design to avoid tragic consequences and optimize, at the same time, the rational use of environmental and economic resources. The interaction between the two aspects has been rarely managed following design codes due to the absence of methodological frameworks. Motivated by these considerations, the study aims to integrate energy and structural aspects related to seismic risk in a life cycle-based decision-making framework for the retrofit design of existing buildings. As a case study, the methodology is applied to a three-storey RC building assumed to be located in different Italian sites. These are characterized by different climatic conditions and seismicity levels.

See full paper



Environmental Impact of Concrete and Concrete-Based Construction Waste Leachates

K A Mocová, L N A Sackey and P Renkerová

University of Chemistry and Technology Prague, Technická 5, 166 28 Prague 6, Czech Republic

klara.mocova@vscht.cz

Studies concerning environmental impact of construction materials are very rarely based on experiments performed with real mixed samples and test organisms (ecotoxicological bioassays). In our study, ecotoxicity of two concrete samples from different producers and one concrete-based construction waste in leachate form were assessed. Leachates were treated by various designs, i.e. i) without any treatment, ii) original pH + nutrients addition, iii) pH adjustment to 7.0, and iv) pH adjustment to 7.0 + addition of inorganic nutrients. Ecotoxicological bioassays with freshwater algae *Desmodesmus subspicatus*, freshwater plant *Lemna minor* and freshwater invertebrate *Daphnia magna* were performed. The metal content was determined both in solid samples and leachates. Results showed differences in toxicity level among the concrete sources when original leachates without any treatment were tested. On the contrary, the test design recommended by Czech legislation, i.e. lowering of the pH and addition of nutrients usually significantly decreased the sample toxicity and the potential differences among concrete samples. We suggest that the toxicity of concrete leachates may result not only from the highly alkaline pH but also from the potential persistence of high pH values both within dilution process and time. The higher toxicity was in accordance with higher level of leachate conductivity. Therefore, for the purposes of aquatic ecotoxicity assessment, we recommend either making no pH adjustment or performing the bioassays both with treated and untreated leachates.

See full paper



Eco-Friendly Building Materials

A Nowotna, B Pietruszka and P Lisowski

Building Research Institute, Department of Thermal Physics, Acoustics and Environment,
21 Ksawerow street, 02-656 Warszawa, Poland

a.nowotna@itb.pl, b.pietruszka@itb.pl

In recent years, the construction industry has developed an ecological direction, which aims to use natural materials. These materials can be both vegetable and animal origin. Building structures made of such semi-finished products are usually light, non-destructive for environment, and in many cases made of recycled materials. Such an eco-building model often does not require energy inputs for production. It contributes to the development of energy-saving investments which meet the current technical requirements. These materials can perform an insulating function, like sheep's wool or cellulose, as well as construction or finishing function made of products like plywood, fibrous materials with an external gypsum or wooden panel or clay plaster with straw. Such products are perceived as healthy and cheap, and in many cases available locally. These solutions can have a significant impact in modern construction due to the increase in the prices of traditional construction products and energy savings during construction and investment use. The article aims to provide basic information about selected materials of natural origin and compare them in terms of hygrothermal research.

See full paper



Catalogue of Construction Products with Recycled Content from Construction and Demolition Waste

T Pavlů, J Pešta, M Volf and A Lupíšek

University Centre for Energy Efficient Buildings of Technical University in Prague,
Trinecká 1024, Buštěhrad, Czech Republic

tereza.pavlu@cvut.cz

The main objective of the present project for the Czech government was to create a catalogue of construction products and materials which contain recycled content from construction and demolition waste. The motivation for the work was to support a higher utilization of construction products with the content of secondary raw materials in the Czech Republic. It was designed for architects, designers, civil engineers, construction contractors and public and private investors. The catalogue provides an overview of products with recycled content, a list of valid requirements on the utilization of recycled materials listed in standards and legislation. Examples of good practice are presented to break the existing psychologic barriers to the use of secondary raw materials in the Czech construction industry. This contribution summarizes the findings in the field of the recycling of construction and demolition waste and its further use as produced secondary raw materials in the construction industry.

See full paper



Life Cycle Assessment of Recycling Processes for Demolition Waste

J Pešta^{1,2}, T Pavlů¹ and V Kočí²

¹ University Centre for Energy Efficient Buildings of Technical University in Prague, Trinecká 1024, Buštěhrad, Czech Republic

² Faculty of Environmental Technology, University of Chemical Technology in Prague, Technická 5, Prague 6 – Dejvice, Czech Republic

jan.pesta@cvut.cz

This contribution is aimed to evaluate the environmental impacts of recycling construction and demolition waste with the use of Life Cycle Assessment. In the first step, the LCA was used as an analytical tool for the comparison of recycled aggregates production. Recycled aggregates were produced from brick and concrete waste. Chosen functional unit for the comparison was 1 ton of recycled aggregate (RA). The results show that concrete aggregate production has a higher impact on Climate Change category (1,51 kg CO₂ eq.) than brick aggregate production (1,18 kg CO₂ eq.). Then, in the second step, new concrete mixtures made of recycled aggregates were compared. Functional unit was 1 m³ of concrete. Environmental impacts of concrete mixtures were compared with reference concrete mixture. These compared concretes are classified as C20/25 according to CSN EN 206 + A1. Mixtures with concrete RA have a higher environmental impact than mixtures which were made of brick RA. GaBi Software ts for data processing was used. Environmental impacts assessment according to the ReCiPe method characterization, version 1.08 was used.

See full paper



Characterization of Hemp-Lime Bio-Composite

B Pietruszka¹, M Gołębiewski² and P Lisowski¹

¹ Building Research Institute, Department of Thermal Physics, Acoustics and Environment, 21 Ksawerów Street, 02-656 Warszawa, Poland

² Warsaw University of Technology, Faculty of Architecture, Department of Structural Design, Building Technology and Technical Infrastructure, Koszykowa Street, 00-659 Warszawa, Poland

b.pietruszka@itb.pl

Hemp-lime bio-composite (hemcrete) is a new building material consisting of two main constituents: hemp shiv and lime-based binder. Hemp shiv is a woody core of *Cannabis Sativa* plant obtained in decortication process and chopped into particles. Lime-based binder is a mix of binders with highest content of hydrated lime (other ingredients often present in a mix are: natural hydraulic lime, pozzolans, cement and others). Its natural origin, ability to create healthy indoor environment, good thermal properties and especially high ecological values (including low carbon emission in the entire life-cycle) makes it a sustainable alternative to commonly used materials in construction industry. Due to its mechanical properties hemcrete is not a load-bearing material. It is used as a filling material for single-layer walls with a structural frame and as an insulation material for existing walls, floors and roofs. Construction techniques include forming monolithic walls by compacting the mix in a formwork, spraying, bricklaying from precast blocks and prefabrication of entire wall elements. In this paper the results of mechanical and hygrothermal properties of the developed hemp-lime composites will be presented. The results will be used to obtain the hygrothermal characteristics of the building partitions applying numerical simulation methods.

See full paper



Fire Protection of Steel Structures by Low Pressure Water Mist in Large-Scale Fire Test

M Pokorný¹, M Eliáš¹ and F Kregl²

¹ UCEEB CTU in Prague, Buštěhrad, Czech Republic

² FKservis s.r.o., Libušín, Czech Republic

marek.pokorny@cvut.cz, f.kregl@fkservis.cz

Water mist extinguishing systems are becoming more popular due to their much higher fire-fighting efficiency at lower water consumption compared to conventional sprinklers. The article focuses on the possibility of further utilization in a form of cooling structures and presents the results of a research in the area of low-pressure water mist and the development of a new low-pressure water mist cooling system. It also introduces a new possible direction for application of cooling steel structures or their surroundings in order to increase fire resistance of steel structures. To verify the cooling effects of low-pressure water mist, a large-scale fire test with a model of steel roof construction was carried out in a room with dimensions of $4.0 \times 4.0 \times 2.0$ m. The fire test was conducted in two scenarios. The first scenario is a reference test without application of water mist, where temperatures of the burning room and steel structures are monitored. Compared to the first scenario, the second scenario includes the use of low-pressure water mist protection of the steel structure model at the time of full fire development.

See full paper



The Influence of Building Materials on Relative Humidity of Internal Microclimate

J Růžicka¹ and J Diviš²

¹ FCE CVUT in Prague, Czech Republic

² UCEEB CVUT in Prague, Czech Republic

jan.ruzicka@fsv.cvut.cz, jakub.divis@cvut.cz

Sustainable building covers wide range of criteria including environmental, social and economy issues. Relative humidity of the internal environment belongs to the group of social criteria dealing with the quality of indoor microclimate and is one of the important indicators. Low humidity level can cause dry skin, throats and nasal passages and can cause annoying static electric sparks. High humidity level can lead to growth of moulds and bacteria and can cause condensation problems on the cold surfaces. Appropriate level of relative humidity can be operate by building service systems which increases operating energy in buildings and is sensitive to correct set up, control and monitoring. Relative humidity can be also influenced by the choice of building structures and structural materials without any operating energy. The paper summarizes latest research on the influence of relative humidity on health hazards and influence of building structures and structural materials on the relative humidity.

See full paper



Biodegradation of Mineral and Silicone Plasters and Its Comparison**P Ryparová¹, M Kostecká² and J Tywoniak¹**¹ Faculty of civil engineering, Czech Technical University, Thákurova 7, Prague 6² Klokner Institute, Czech Technical University, Šolínova 7, Prague 6

pavla.ryparova@fsv.cvut.cz

The article focuses on the determination of a fungal growth range on plaster depending on external conditions. The experiments compare three types of plaster which are the most widely used in Europe. The selected plaster is two mineral and one silicone. These types of plaster are standard mixtures developed and donated by manufacturing company from Czech Republic.

The article contains comparison of germination and growth of mould on the surface of samples with the type of used degradation process before inoculation of mould. The types of used degradation were carbonation, freeze-thaw cycle, degradation by soil microorganism and high moisture. The microbial resistance was made based on modified Norm ČSN EN ISO 846. The samples were placed on mineral agar and in the 100 % humidity. The resistance of samples was evaluated by microscopy analyses.

See full paper



Material Flows In Buildings' Life Cycle And Regions – Material Inventories To Support Planning Towards Circular Economy

G Schiller¹, T Lützkendorf², K Gruhler¹, I Lehmann¹, K Mörmann²,
F Knappe³ and N Muchow³

¹ Leibniz Institute of Ecological Urban and Regional Development (IOER), Weberplatz 1, 01217 Dresden, Germany

² Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany

³ Institut für Energie- und Umweltforschung (ifeu), Wilckensstraße 3, 69120 Heidelberg, Germany

g.schiller@ioer.de

The built environment is the cause of most of the material flows in the anthroposphere and the biggest material storage: Over 90 % of the anthropogenic stock stored in durable goods can be found in the built environment, with non-metallic minerals being the main contributor. In Germany, most of the materials that leave the stock due to demolition or renovation are recovered. In Saxony, a German state, the recovery rate is nearly 99 %, but only 55% of mineral construction and demolition waste is recycled. There is still substantial potential for closing recycling loops. This requires the combined effort of all those actors that influence these material flows – from the investor and constructor of the single building to those responsible for waste management at municipal level and the waste disposal and construction materials industry. However, the information currently available is insufficient to support an effective urban mining. This will be encountered by an ongoing research project that aims to enhance existing informational instruments regarding construction related material flows in the built environment. The project follows a dualistic research approach considering informational instruments at (1) individual building level and (2) at regional level. The objective of the paper is to present an approach on how material inventories can be better aligned with practical information needs. After introducing the overall concept and methodology as well as describing the process of analysing the current state of information flows, first results considering the structure of material in- and outputs and the needs for information of different actors are presented.

See full paper



Non-Destructive Testing of Recycled Aggregate Concrete

Z Sierens, B Vandevyvere, L Kyndt, G Tytens and J Li

KU Leuven, Technology Campus Bruges, Faculty of Engineering Technology, Department of Civil Engineering, Technology Cluster Construction, Spoorwegstraat 12, 8200 Bruges, Belgium.

zeger.sierens@kuleuven.be, brecht.vandevyvere@kuleuven.be,
lorenz.kyndt@student.kuleuven.be, glenn.tytens@student.kuleuven.be,
jiabin.li@kuleuven.be

Currently, recycled aggregate concrete is a widely used building material. Due to negative influences on concrete's mechanical properties, it is mostly used in low-valued applications. Nevertheless, high quality recycled concrete aggregates derived from a good quality original concrete can be used in high-valued applications, such as precast concrete. These high quality aggregates can be obtained by optimizing the crushing process. To ensure recycled aggregate concrete quality, the influence of different parameters on its mechanical and durability properties must be established. The quality of recycled concrete in high-valued applications can easily be measured via non-destructive tests. In this research project, the properties of recycled aggregate concrete are tested in a non-destructive way in order to establish a correlation between the different properties. Results of several laboratory tests show a good relation between the static elastic modulus and the dynamic elastic modulus, calculated by measuring the ultrasonic pulse waves and resonance frequency. Nevertheless, a study to transfer this knowledge into practice will demonstrate the applicability of the results.

See full paper



External Wooden Constructions – Protection by Titanium Dioxide

P Svora¹, P Kuklík¹, M Šrámová Slušná², S Svorová Pawelkowicz² and P Ecorchard²

¹ University Centre for Energy Efficient Buildings of Technical University in Prague, Trinecká 1024, 273 43 Buštěhrad, Czech Republic¹)

² Institute of Inorganic Chemistry of the Czech Academy of Sciences, 250 68 Husinec-Řež, Czech Republic

svorapet@fsv.cvut.cz

External wooden constructions have their own place in building industry from ages. The external wooden construction easily degrade due to UV radiation, atmospheric conditions and biological aggressors. We are trying to eliminate the negative impact of degradation factors by wood protection. Types of wood protection include all measures which would protect wood from influences of fungi, insects, weather (temperature, humidity, wind, etc.), natural calamities (fire, flood) and they can be divided into chemical protection and radiation protection. In our paper we will discuss a new solution based on titanium dioxide (TiO_2). Titanium dioxide was proved to be an efficient UV absorber and moreover, in its crystalline form, it is able to destroy biological aggressors too. Nowadays, there is no information about the interactions between wooden surface and non-photoactive or photoactive form of TiO_2 . TiO_2 exists in many morphological forms. The planar particles were chosen for purpose of the experiment. They can be prepared as non-photoactive and photoactive. This material was applied on wooden surface in the form of dispersion and created a transparent layer.

See full paper



Utilization of Fermentation Residues in the Production of a Brick Block

J Šál and P Nováková

The Institute of Technology and Businesses in Ceske Budejovice, Czech Republic
sal@mail.vstecb.cz

Use of fermentation residues burden a number biogas plants. Its incorporation into arable land remains the most common practice, although application costs represent approximately the same benefits for fertilization, despite the risk of soil formation and the associated degradation of the soil's ability to retain water. An alternative to the use of spent dust is to re-enter the raw material of the biogas plant or a second alternative to the use of particulate coal as wall surfaces in the interior because of its sorption capacity that captures a wide portfolio of air pollutants.

This article focuses on further possible liquidation and a beneficial alternative to the use of bio-waste and is the use in building ceramics. Samples were made of brick fragments of varying amounts of biochar in which to perform different measurements, such as determining the length change and the weight loss, apparent porosity, determining the compressive strength and further. Measurements have shown that burning bricks containing this substance will cause burns and thus formation of pores. Besides porosity, influenced by the presence of biochar and other properties of the brick body. These properties article also describes. Not only do we get rid of this waste, but we also use bio-waste to improve the material commonly used in the construction industry.

See full paper



Circular Housing Retrofit Strategies and Solutions: Towards Modular, Mass-Customised and 'Cyclable' Retrofit Products

A van Stijn^{1,2} and V H Gruis¹

¹ Department of Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, The Netherlands

² Amsterdam Institute for Advanced Metropolitan Solutions (AMS), Amsterdam, The Netherlands

a.vanstijn@tudelft.nl

The building sector consumes 40 % of resources globally, produces 40 % of global waste and 33 % of CO₂ emissions. Creating a circular built environment is therefore of paramount importance to a sustainable society. The housing stock can be made more circular through circular retrofitting. However, strategies and solutions integrating circularity within housing retrofit are lacking.

This paper focusses on developing a circular housing retrofit strategy and solution for Dutch housing constructed between 1970 and 1990. Through literature study, potential circular retrofit approaches are identified and translated into a general strategy. By developing a concrete retrofit solution, we illustrate how this general strategy can be applied in practice.

It is found that in the Dutch context 'all-in-one' sustainable retrofits are difficult to realise. By applying modular (allowing component-by-component retrofit), 'mass-customisable', and 'cyclable' retrofit products, natural maintenance moments can be employed to gradually create a circular housing stock. As an example of such a product we describe the Circular Kitchen (CIK), which was developed together with industry. The CIK applies a plug-and-play design, separating components based on lifespan. The CIK supply-chain arranges 'relooping' of the CIK in a 'return-street' and 'return-factory'. The CIK business model applies financial arrangements such as lease and 'sale-with-deposit', motivating the return and 're-looping' of the CIK after use.

In conclusion, the strategy presented in this paper has the potential to support circular housing retrofit in the Dutch context and for housing with similar characteristics. However, development of more circular retrofit products is necessary to create a fully circular housing stock over time.

See full paper



Effect of Glass Fibres on the Mechanical Behaviour of Concrete with Recycled Concrete Aggregates (RCAs)

B Vandevyvere¹, Z Sierens¹, E Verstrynge², L Vandewalle² and J Li¹

¹ KU Leuven, Technology Campus Bruges, Faculty of Engineering Technology,
Department of Civil Engineering, Technology Cluster Construction, Spoorwegstraat 12,
8200 Bruges, Belgium.

²KU Leuven, Department of Civil Engineering, Kasteelpark Arenberg 40, Box 2448,
3001 Leuven, Belgium.

brecht.vandevyvere@kuleuven.be, zeger.sierens@kuleuven.be,
els.verstrynge@kuleuven.be, lucie.vandewalle@kuleuven.be, jiabin.li@kuleuven.be

This paper presents an experimental study on the influence of glass fibres on the mechanical behaviour of concrete with recycled concrete aggregates (RCAs). In the test programme, four concrete mixtures with coarse RCAs and glass fibres are manufactured. The used fibres are the CEM-FIL MinibarsTM with a fibre content of 5 kg/m³, 10 kg/m³ and 15 kg/m³, respectively. The investigated properties are the compressive strength, the splitting tensile strength, the modulus of elasticity as well as the flexural behaviour. The latter is determined by the three-point bending test on concrete beams according to the standard EN 14651: 2005+A1:2007 – *Test method for metallic fibre concrete: Measuring the flexural tensile strength (limit of proportionality (LOP), residual)*. Based on the test observations, it seems that the used glass fibres are able to improve the mechanical behaviour of recycled aggregate concrete (RAC).

See full paper



Innovative Thermal Insulation Products for a Circular Economy

V Vasile, C Petcu, V Meiță and M C Zaharia

National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development "URBAN-INCERC", 266 Pantelimon Road, 021652, Bucharest, Romania

vasile@incd.ro

The depletion of non-renewable resources is followed by severe ecological and social impacts, and the heavily usage of raw, virgin resources leaves significant, long lasting footprints. In order to move into a more sustainable economic system, a recently more frequently discussed approach for overcoming the current linearity of product lifecycles is the concept of circular economy (CE). The transition to a more circular economy, where the value of products, materials and resources is maintained and circulated (by recycling activities) in the economy for as long as possible, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. In this context, ecological solutions consisting of materials which helps carbon sequestration and necessitates small amounts of energy for production are becoming increasingly popular from buildings construction point of view, namely: the raw material is cheap and in large quantities; have low thermal conductivity; are from a renewable source. The paper presents an analysis of some innovative thermal insulating products made from renewable or recycled resources (recycled plastics, low quality wool, straw, cellulose), their thermal conductivities over a temperature interval and acoustics coefficients (α_s , α_w), the purpose being to inform the market in order to increase the present level of technical knowledge and to facilitate the implementation of high energy efficiency buildings with products from *recycled materials or using industrial by-products*.

See full paper



Optimization of RC Structures with Regard to Amount of Embodied CO₂ Emissions

M Ženíšek and P Hájek

Czech Technical University in Prague, Faculty of Civil Engineering, Prague, Czech Republic
michal.zenisek@fsv.cvut.cz

The volume of CO₂ emissions (and other greenhouse gases) has been rising almost continuously for several decades. Concrete is the most used man-made material in the world, thus the construction of reinforced concrete (RC) structures is associated with high environmental impact, mainly due to the consumption of cement as binder for concrete and steel as reinforcement. This article analyses the available options for the design of RC structure to reduce embodied CO₂ emissions. The main part of the article is a case study demonstrating optimization of the load-bearing structure of multi-storey building. Emphasis was placed on achieving the optimal variant in terms of CO₂ emissions, while maintaining a comparable cost of the construction. The results of this study show that in this particular case the use of concrete with a lower strength brings lower environmental impact than of concrete with higher strength. The reason is that the production of lower strength concrete allows the use of cements with a lower clinker content which is decisive for CO₂ emissions. However, the use of concrete with higher strength allows more subtle structural members with lower content of concrete and potentially with higher durability.

See full paper



Assessment and Optimization Tools

Development of LCAbyg: A National Life Cycle Assessment Tool for Buildings in Denmark

H Birgisdottir and F N Rasmussen

Danish Building Research Institute, Aalborg University, Copenhagen, Denmark
hbi@sbi.aau.dk

In the autumn of 2014, the Danish government presented a national strategy for the building sector. Sustainability was mentioned as one of five focus areas for the future political work within the sector. Subsequently, the development of a national Life Cycle Assessment tool for buildings was initiated, and the first version of LCAbyg was launched in 2015. The primary goal behind the development of LCAbyg has been, with judicious, intuitive and transparent visualization of LCA results, to increase building designer's awareness of the life cycle impacts of buildings, and to understand where, in the building life cycle, reductions of environmental impacts can be achieved. This paper describes the principles of the LCA tool in terms of the required input data for the building assessment, the calculation methods within the model and how the LCA results are presented to the user. The paper furthermore demonstrates how the tool enables the user to perform comparisons of different construction solutions and material uses, and elaborates on how the predefined visualization of results qualifies the designer to identify hotspots and to understand and mitigate the major impacts throughout the building's life cycle.

See full paper



Implementation of the DGNB Framework for Carbon Neutral Buildings and Sites

A Braune¹, D Geiselmann², S Oehler³ and C Ruiz Durán¹

¹ Deutsche Gesellschaft für Nachhaltiges Bauen – DGNB e.V., Tübinger Straße 43, 70178 Stuttgart, Germany

² DGNB GmbH, Tübinger Straße 43, 70178 Stuttgart, Germany

³ Architect for Sustainable Building, Im Laukenstein 24, 55270 Jugenheim, Germany

a.braune@dgnb.de; d.geiselmann@dgnb.de; oehler@archkom.de; c.ruiz@dgnb.de

With more than 30% of the total global greenhouse gas emissions generated from the constructions sector, fostering sustainable buildings is one of the key levers in order to address the highly urgent topic of climate change. The German Sustainable Building Council (DGNB) is striving to make a significant contribution to the achievement of the national targets defined in the Paris Agreement in order to limit global warming to well below 2°C. The key to achieving these targets for the building sector lies in fostering climate neutral operation of new construction and, even more challenging, in realizing a carbon neutral building stock by 2050. With the discussion paper for a new format of the German Energy Code “GEG 2050” claiming the introduction of a „Building Emissions Law 2050“, DGNB has started a much-needed debate on shifting the focus of performance metrics from “primary energy demand” to “CO₂-emissions”. In order to translate the requirements into building practice and to make their implementation assessable and measurable, the DGNB has developed a “Framework for Carbon Neutral Buildings and Sites”, which includes three main parts: 1. Carbon Accounting Rules defining consistent calculation rules for buildings and sites, 2. Carbon Disclosure Rules with specific rules regarding the type and the content of the communication towards the customer and 3. Carbon Management Rules establishing a roadmap to carbon neutral building operation (“Klimaschutzfahrplan”) that demonstrates a net zero carbon balance by latest 2050, using a linear trajectory to zero from today onwards. The Framework has been published as a preview version in May 2018 and now is currently being revised within a pilot phase.

See full paper



The Influence of Technology Performance Durability in the Cost-Optimal Analysis of a ZEB

L Danza, A Bellazzi, A Devitofrancesco and G Guazzi

Construction Technologies Institute, National Research Council of Italy (ITC-CNR),
Via Lombardia, 49, 20098 San Giuliano Milanese (MI)

ludovico.danza@itc.cnr.it

The high number of existing buildings needing refurbishment actions justifies the need of a methodology that considers its service life after the refurbishment process. Cost-effectiveness assessment of refurbishment scenarios in building design is a crucial phase in the decision-making process towards a ZEB realization. Energy renovations involve an important investment, whose amount increases considerably when a ZEB target is fixed. When cost-optimal methodology is applied to different refurbishment scenarios, the costs evaluated take into consideration not only the initial investment cost, but also the running costs over the years and the payback time of the adopted solutions. Nevertheless, technologies hypothesized in the scenarios undergo a process of performance decay taking place since the first year of buildings' operations. The thin balance between needs and energy supply of a ZEB may be broken by deteriorating the energy performance of the whole building. Consequently, the running costs can increase significantly over the years and also the payback time, calculated over the annual costs of the building. The goal of this paper is to apply a cost-optimal assessment on a reference building, comparing the results of simulations with durability approach and those that do not consider the performance decay.

See full paper



Module D in the Building Life Cycle: Significance Based on a Case Study Analysis

L Delem and L Wastiels

Belgian Building Research Institute, Brussels, Belgium

laetitia.delem@bbri.be

According to the European standard for the assessment of the environmental performance of buildings (EN 15978), potential benefits and loads beyond the building's life cycle as a consequence of recycling, reuse or energy recovery of building materials can be declared in module D. However, in practice module D is rarely included in LCA studies as it requires an optional calculation step and information at the product level (from EPD's according to EN 15804) is often missing. By means of a case study analysis, considering five building cases with varying types of load-bearing structures, the present study evaluates the relative importance of module D on building level and provides a better insight in the main materials contributing to module D. The results show that based on the current Belgian end-of-life scenario's the contribution of module D can be significant at the building level (representing up to 50 % of the total life cycle impact). This contribution varies more according to the LCIA indicator considered than to the building variant. In terms of the materials, the metals represent the main contributors to module D.

See full paper



A BIM-Based Framework to Visually Evaluate Circularity and Life Cycle Cost of buildings

C Di Biccari¹, J Abualdenien², A Borrmann² and A Corallo¹

¹ Department of Innovation Engineering, University of Salento, Edificio Aldo Romano, Campus Ecotekne, 73100, Lecce, Italy

² Chair of Computational Modeling and Simulation, Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Arcistrasse 21, 80333, Munich, Germany

carla.dibiccari@unisalento.it

The Circular Economy paradigm seeks to shift products and systems from linear to “closed loop” life cycles applying specific business models and strategies to their designs and lifelines. The implementation of the circular economy in buildings depends on the efforts made by all the stakeholder involved in the life cycle of a building, where it can draw most of the benefits if the application of a circular business model is planned during the design phases. Building Information Modeling is an approach that helps designers in creating and managing semantically rich 3D-models describing the status of the building over its life cycle. In this paper, a BIM-based framework for evaluating the application of circular business models of buildings from the circularity and the life cycle cost points of views is proposed.

See full paper



Building Information Modelling for Whole-Building LCA: BIM4LCA**V Gomes, N N Barros and R C Ruschel**

University of Campinas, School of Civil Engineering, Architecture and Urbanism, Rua Saturnino de Brito s/n, Cidade Universitária Zeferino Vaz, Campinas, SP, Brazil, 13083-889

vangomes@unicamp.br

Combining sustainable design strategies and building information modelling (BIM) can change traditional practices and efficiently lead to high-performance designs but is still impaired by deficient software interoperability. Automatic extraction is one of the most cited ways that BIM models can support environmental analyses. However, the reviewed literature does not confirm validation of such procedure by lifecycle assessment (LCA) experts and register incipient procedures to systematically increase implementation of BIM for LCA. This paper explores contributions offered by BIM to facilitate and improve whole building LCA to verify the hypotheses that (1) automatically extracting bills of materials from BIM models with level of development (LOD) 300 positively contributes to LCA processes (BIM+LCA); and (2) embedding environmental parameters and calculations directly into the model to extract calculated impacts instead of pure material quantities (BIM4LCA) can significantly enhance such contribution. We selected one case study to support analysing the variations between baseline (manual quantity survey from design documents) and BIM-supported automatic extraction of bill of materials, and the suitability of the model's LOD to LCA purposes. Revit Architecture 2016 was used for modelling architectural, structural, plumbing and HVAC elements. We demonstrated that LOD 300-modelling is aligned to the accuracy level currently practiced in whole building LCA and that BIM models can indeed be prepared to facilitate LCA (BIM4LCA) through a low complexity, high effectiveness operational measure. This procedure provides reasonably quick feedback to support decision-making and enhance environmental performance of new building designs, until "Extraction, Transformation and Loading" (ETL) technologies or full interoperability become mainstream practice in the AECO industry.

See full paper



Whole-Buildings Life Cycle Assessment Sensitivity to Scenario Choices

G D Guimarães, L Zucarato, M Saade, M Silva and V G Silva

224 Saturnino de Brito Street – Campinas, Brazil / University of Campinas
g192227@dac.unicamp.br; vangomes@unicamp.br

Life cycle assessment (LCA) is an important technique to measure environmental impacts of products and processes and its application to diagnose and optimize whole-buildings' environmental performance has increased in the past years. However, LCA results carry uncertainties which may limit their utility as environmental decision-making support. Since normative choices are unavoidable within whole-building LCA (wbLCA) modelling, it becomes important to analyse their inherent uncertainty. Recent literature indicates that different material wastage values, lifetime choices and end of life scenarios are the main uncertainties drivers on wbLCA. To understand how these choices influence wbLCA results, we conducted a scenario analysis, to estimate the effects that parameters and input choices produce on final results by describing possible future situations. Cumulative Energy Demand (CED) and CML 2001 v.2.05 methods were selected for calculating embodied energy and global warming potential in SimaPro 7.3. Our results indicate that wbLCA outcomes vary greatly with different alternatives for normative choices, and a scenario uncertainty analysis is necessary to understand all implications of its results.

See full paper



Life Cycle Analysis of Vertical Building Extensions – Environmental Impacts of Different Material Selection

A Hafner and M Storck

Resource Efficient Building, Ruhr-University Bochum, Germany

annette.hafner@ruhr-uni-bochum.de; michael.storck@ruhr-uni-bochum.de

Adding storeys to existing buildings plays a large role in sustainable urban densification and helps to decrease the growing demand for urban city housings. Vertical building extensions create living space without the need for further land use, by extending existing buildings vertically by one or more storeys. Research points to the possibility of creating 1.1 million homes through storey additions in German metropolitan areas. A common method for investigating environmental impacts of a building is a life cycle assessment (LCA). Because of vertical building extensions being a relatively new concept, research is lacking, especially for LCAs. Therefore, this study describes frameworks and rules for LCAs of vertical building extensions. Moreover, environmental impacts of different material selection within storey additions are investigated. For this, a realised storey addition is analysed and main construction materials of the exterior wall and roof are replaced. The environmental impacts of material selection are then compared using the impact category global warming potential. Results show that the choice of material has a large influence on LCA results. In this case, the wood construction has the lowest greenhouse gas emissions and amounts to approximately 180 kg CO₂ eq/m². The highest greenhouse gas emissions are emitted by a steel construction with approximately 230 kg CO₂ eq/m².

See full paper



Hands-On: Sustainable Approach in Architectural Education

D Hlaváček and M Čeněk

Department of Architectural Design II, Faculty of Architecture, Czech Technical
University in Prague, Thákurova 9, 166 34 Prague 6, Czech Republic

dhlavacek@fa.cvut.cz, martin.cenek@fa.cvut.cz

Human activity, including resource depletion, pollution and waste production, has a negative influence on the natural environment. Building industry is one of the major causes of the situation. It is therefore essential to change the approach to building design in order to lessen the impact of human activity on the environment. Architects are still not properly prepared for this change. This is caused by the education they receive in the traditional studio-based teaching process. In contrast to engineering disciplines, the student of architecture is able to look at the issue of designing in a holistic way. However, he is overwhelmed by a large number of topics and subjects that must be addressed. The issue of “sustainability” thus often gets on the edge of his interest. As part of the studio teaching at the Faculty of Architecture of CTU, we are looking for methods to naturally integrate sustainable thinking into the architectural concept already in the early stages of the design. The paper focuses on the so-called design-build projects, as one of the paths that lead to an integral design and an effective way of implementing sustainable design into the architectural concept.

See full paper



Decrease of Cement Production Environmental Burden – LCA**A Horáková, H Schreiberová, I Broukalová and J Fládr**Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech
Technical University in Prague

anna.horakova@fsv.cvut.cz

A big progress has been made in decrease of environmental impacts of cement production. Dust pollution around cement plants has been considerably decreased thanks to efficient dust separators. An intention of further emission reduction has been announced. The environmental burden of cement production is also decreased by substitution of cement by alternative binders. Hydraulic properties of energy by-products have been investigated for a long time to check their potential as a partial substitution of traditional cement binder. The paper will focus in examining the influence of variation of the concrete composition on the environmental impacts, identification of the most severe procedures in the cement production and analysis of meaningfulness of implementation of the proposed measures. The environment is a complex system. Potential modifications of concrete composition or production technology may bring benefits in certain areas and on the contrary cause environmental harm from another perspective. Hence, analysis of the cement production impacts cannot be based on one aspect, and a broad portfolio of impact categories will be assessed regarding concrete production environmental burden.

See full paper



Concrete, Sustainability and Limit States

K Hrabová¹, B Teplý¹ and P Hájek²

¹ Brno University of Technology, Czech Republic

² UCEEB, Czech Technical University in Prague, Czech Republic

kristyna.hrabova@usi.vutbr.cz, teply.b@fce.vutbr.cz, petr.hajek@fsv.cvut.cz

Efficient sustainability management of concrete structures requires the use of tools which allow material, technological and construction variants to be quantified. The present contribution, apart from discussing the issue of sustainability of concrete structures, focuses on the quantification of concrete resistance to degradation. An indicator expressing quality, with regard to sustainability, is determined using information on concrete performance characteristics, service life and eco-costs, enabling the quantification and comparison of various cases. Cradle-to-gate system boundary and the full probability method are used. The aim is to propose a suitable methodology which can simplify decision-making about the design and choice of concrete mixes from a wider sustainability perspective, as an extensional and integrating approach to evaluating load-bearing capacity and durability. Two case studies of probabilistic sustainability quantification are shown using sustainability potential indicators for two different definitions of service life (due to carbonation of concrete and freeze/thaw effects), considering also the concrete performance's and impact on the environment.

See full paper



Smart BIM-AM Journey to Green Buildings

C K Lee, H Y S Chan, C Y C Poon, K M G Yip and P H F Yuen

Electrical and Mechanical Services Department, The Government of HKSAR, 3 Kai Shing Street, Kowloon Bay, Kowloon, Hong Kong, China

cklee@emsd.gov.hk

Building Information Modelling (BIM) has been widely adopted for buildings design and construction to facilitate coordination works, however, there are a few studies of its application in the long lifecycle of buildings operation and maintenance (O&M). An integrated BIM – Asset Management (BIM-AM) System which enables visual cross-reference from real-world objects to BIM model and even to their maintenance record, O&M manuals, asset relationships, live views of Closed Circuit Television (CCTV) system, real-time data from Building Management System (BMS) and wireless Internet of Things (IoT) sensors as well as location information from a Real Time Location System (RTLS) on one single integrated mobile platform with the aid of Radio Frequency Identification (RFID) scanning technology has been developed. While the BIM-AM System has been proven its novelty, originality, capability and potential towards smart O&M by the patent granted in 2017, BIM can be further developed in green building aspects with the application of Computational Fluid Dynamic (CFD). Different sets of boundary conditions, including supply air temperature, supply air flow, number of people and so on, were simulated for comfort level. A predictive model was formulated to achieve an intelligent control of air-conditioning system, including supply air temperature reset and adjustment of supply and/or fresh air flow, with the balance of human comfort.

See full paper



Financing Renewables while Implementing Energy Efficiency Measures through Consumer Stock Ownership Plans (CSOPs) – The H2020 Project SCORE

J Lowitzsch

European University Viadrina, Große Scharrnstraße 59, Frankfurt (Oder), Germany
lowitzsch@europa-uni.de

Consumer (co-)ownership in renewable energy (RE) has proved successful in engaging consumers in financing RE, thus becoming “prosumers” which in turn induced positive behavioural changes in energy consumption. Providing a collective low threshold financing mechanism for RE the Horizon 2020 project SCORE implements “Consumer Stock Ownership Plans” (CSOPs) in three pilot projects in the Czech Republic (City of Litoměřice), Poland (City of Słupsk) and Italy (Susa Valley).

Additionally SCORE seeks to respond to the European Buildings Initiative (part of COM(2016) 860 final “Clean Energy For All Europeans”) and in particular to the challenge to develop flexible energy efficiency (EE) and RE financing platforms at national or regional level targeting grants towards vulnerable consumers as laid out in its annex. In this context EE projects for blocks of flats can be a lever for consumer owned RE projects where the installation costs partly overlap with EE measures as for example insulation of rooftops and installation of rooftop PV systems. These EE projects typically qualify for subsidies to financing EE improvement of flats and municipal buildings and thus can cross subsidize also the investment in micro RE installations.

This paper demonstrates synergies between EE measures and RE investments via CSOP-financing in blocks of flats in Poland and the Czech Republic. Empirical evidence from Germany backs these effects of consumer co-ownership. Preferential conditions for Renewable Energy Communities under the 2018 recast of the Renewable Energy Directive (RED II) will support such schemes in the future.

See full paper



Application of “Element”-Method in Sustainability Assessment

T Lützkendorf

Karlsruhe Institute of Technology (KIT), Centre for Real Estate, Germany
thomas.luetzkendorf@kit.edu

The application of sustainability assessment in the design of buildings for the analysis, assessment and improvement of design variants is still a long way from becoming an everyday activity. Often, it is only carried out to respond to a special request from investors/building owners or in connection with funding programs. To date, sustainability assessment is often considered as an additional task detached from the rest of the design process and primarily serving sustainability certification. This raises the question of how the task of sustainability assessment can be integrated into the design process even better than before and combined with traditional design tasks. One approach is to use the “Element”-method. Relevant parts of the structure are described in terms of their physical composition and construction work to be performed for their production. It is an approach used in the determination of construction costs. The task of checking compliance with a given cost frame/budget already set in client’s brief or at an early design stage comes with a continuous determination and assessment of construction costs along the different design stages. A similar approach can be followed for environmental impacts. The “Element”-method initially supports a combination of LCC and LCA – an approach that is being followed already more frequently. The consideration of elements additionally supports the assessment of the ease of deconstruction and recycling friendliness as well as effects on and risks to health and the local environment. Experiences from Germany will be presented along with a discussion of current applications.

See full paper



The Theory-Practice Gap in Value Management – A Case Study in Sri Lankan Construction Industry

M M M P Mahinkanda and Y G Sandanayake

Department of Building Economics, Faculty of Architecture, University of Moratuwa,
Katubedda, Moratuwa, Sri Lanka

madhaveemahinkanda@gmail.com, ysandanayake@uom.lk

Construction industry is a leading contributor to the economic, social and environmental sustainability of the country. However, it heavily consumes resources. Hence, it is vital to utilise resources efficiently and effectively. In this context, ensuring sustainability and value for money are crucial constructs in successful construction project delivery. Value management (VM) is widely accepted as a proactive concept for managing value. Although, VM concept is extensively accepted internationally, its applications do not seem to be well embraced in the construction sector of the majority of developing countries including Sri Lanka. The concept has not been practiced effectively by the industry practitioners due to lack of understanding of VM concept. Hence, this study aims to investigate the theory-practice gap in VM in Sri Lankan construction industry. A literature review followed by seven case studies were carried out and gathered data were analysed using code-based content analysis. Findings revealed that there is a theory-practice gap in VM resulting in ad-hoc informal implementation of VM job plan. Although theory states that VM can apply at any stage of a project, the case study projects have applied VM concept mainly during post contract stage as a cost cutting strategy. The study recommended strategies to bridge the VM theory-practice gap in order to deliver best value for client's money and ultimately achieve sustainability in Sri Lankan construction industry.

See full paper



Multi-Criteria Decision Making in the Social Sustainability Assessment of High-Rise Residential Buildings

**B Maleki, M d M Casanovas Rubio, S M A Hosseini and
A de la Fuente Antequera**

Civil and Environmental Engineering Department, Universitat Politècnica de Catalunya
(UPC BarcelonaTECH), Spain

bahareh.maleki@upc.edu, mar.casanovas@upc.edu, m.amin.hosseini@gmail.com,
albert.de.la.fuente@upc.edu

Factors such as global urbanization, scarcity of land, and rising land prices will increase the need for high-rise buildings. Population growth has led to dense life in residential high-rise buildings (RHRB). On the one hand, RHRB have benefits such as the maximization of land use. On the other hand, disadvantages such as ignoring features of cultural context, difficulties in guaranteeing natural ventilation and the high maintenance expenses are considered as their weaknesses. According to previous studies, most current RHRB do not consider social cohesion and local identity. Studies have proven that dimensions of social sustainability have been scarcely considered. The main objective in sustainability assessment of RHRB consist in reducing the environmental impact and increasing the efficiency and residents' satisfaction. Recent studies have considered modern methods for assessing the sustainability; in this regard, multi-criteria decision-making (MCDM) approaches are one of the most common alternatives to assess sustainability. The aim of this research is to develop a MCDM tool oriented to specifically assessing sustainability by using the Integrated Value Model for Sustainability Assessment (MIVES). The MIVES approach allows minimizing subjectivity in decision making while objectively integrating economic, environmental and social factors. In this paper, a new sustainability assessment model, which has been specifically configured to analyse social parameters for high-rise residential buildings, is presented. The findings show that most of the RHRB aspects positively affect the characteristics of the buildings and surroundings, while also affecting the psychological needs of humans.

See full paper



Significant Sustainable Facilities Management (SFM) Practices in the Health Care (HC) Sector

F S Nazeer¹, S Gunatilake² and T Ramachandra²

¹ Research Scholar, Department of Building Economics, University of Moratuwa, Sri Lanka

² Senior Lecturer, Department of Building Economics, University of Moratuwa, Sri Lanka

sabrinanazeer@gmail.com

Health Care (HC) is identified as one of the most polluting industries. HC is recognised as the second energy intensive sector emitting 8% out of total 40% of CO₂. HC is also ranked among the top 4 sources in spreading harmful substances in affecting health and wellbeing of the society. Facilities Managers are identified to be in a unique position to manage the building's operations and hence integrating sustainability in the current practice of Facilities Management (FM) in HC sector. However, identification of sustainable FM practices is challenging as FM practice differ in terms of facility type, building engineering system, organisation's business sector and culture. In this regard, the paper investigates the significant FM services and practices in integrating sustainability in HC sector.

The study used a two round Delphi survey involving 10 experts who are specialised in FM and sustainable practices in the HC sector to identify the most significant FM services and sustainability practices. The results identified 8 FM services and 44 sustainability practices as significant. Building services (BS) was identified as the most significant FM service, whilst practices such as "identifying applications for energy saving measures" and "ensure appropriate onsite, off-site storage, transport of wastes" were identified as the most important sustainability practices. The results of the study will be further carried forward to a questionnaire survey to rank and assign scores for each significant sustainability practices in order to develop an assessment framework to evaluate the SFM practice in HC sector.

See full paper



Multiscalarity in International Sustainable Assessment Systems: A Qualitative Comparison of LEED, CASBEE, BREEAM, DGNB and ESTIDAMA on Building, Neighbourhood and City Scale

M Orova and A Reith

ABUD Mérnökiroda Kft., 38 Kisfaludy street, Budapest, Hungary

orova.melinda@abud.hu

Sustainable assessment systems have been developed for evaluating different scales of the built environment (building, neighbourhood and city). Multiple scale assessments are necessary as only their coexistence can allow recognition of the environmental, social and economic sustainability of the whole built environment. The integration of assessments of different scales can provide efficient methods and better synergies in the urban fabric. This paper analyses the different scales of the most widespread systems (LEED, BREEAM, CASBEE, DGNB, Estidama) and attempts to define how the indicator systems on different scales relate to each other by comparison on four levels (general, category, index and indicator). The results show that the different scales of an assessment scheme mainly work as individual certification systems, but there are strong connections between building and neighbourhood systems. The comparison indicates that the city scale assessments have the most different characteristics, mainly because building and neighbourhood scale contains prescriptive measures that require action, while the city scale has descriptive indicators that monitor the status of the city. Based on the conclusions, options for further studies includes comparison of building systems for operation phase and city systems; a further analysis of indicator scale connectivity for determining the quality and quantity of system integrations between the three scales.

See full paper



A Life-Cycle Approach to Building Energy Retrofitting: Bio-Based Technologies for Sustainable Urban Regeneration

F Pittau¹, G Habert¹ and G Iannaccone²

¹ ETH Zürich, Institut für Bau- und Infrastrukturmanagement, Chair of Sustainable Construction, Stefano-Franscini-Platz 5, 8093 Zürich.

² Politecnico di Milano, Department of Architecture, Built Environment and Construction engineering (ABC), Via G. Ponzio 31, 20133 Milano.

pittau@ibi.baug.ethz.ch

The construction sector and, more specifically, the building renovation sector plays a decisive role in the achievement of the EU targets for the reduction of energy consumption and CO₂ emissions. The main strategies implemented by the EU are aimed, on one side, at increasing the number of buildings to be renovated and, on the other, at promoting deep renovation on the existing stock. The main objective is to drastically reduce the CO₂ emissions associated with the energy consumption of buildings during their operation in consideration of the decarbonization targets by 2050. Several studies have shown that around 75% of the EU building stock needs energy retrofitting, and a significant amount of thermal insulation is expected to be installed on the building envelopes in order to decrease the energy losses. The carbon emission for the production of materials and construction might slow down the transition to a low carbon society and significantly reduce the carbon budget available by 2050. In this perspective, the paper shows the results of some recent research activities aimed at identifying alternative approaches based on the use of biogenic materials applied to the building envelope retrofitting. On one side, they meet the energy and CO₂ targets established by the EU while promoting, on the other one, sustainable regeneration processes that include, among the others, the storage of CO₂ in building elements and the efficient land use. A specific calculation tool, based on a dynamic LCA method, is introduced to holistically quantify the environmental benefits expected over time.

See full paper



Possibilities of Using Modern Technologies and Creation of the Current Project Documentation Leading to the Optimal Management of the Building for Sustainable Development

K Prušková, M Dědič and J Kaiser

Department of Applied Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 2077/7, 166 29 Praha 6, Czech Republic

kristyna.pruskova@fsv.cvut.cz

Nowadays, we use many of the modern technologies to make the optimal design of new buildings. Building Information Modeling Technology offers state-of-the-art solutions that allow the design of a building to create in many variants a realistically time-consuming development process and, by virtue of an almost fully automatic assessment of the variants, choose the most appropriate one according to the required criteria. Such a design of the building assumes its optimal behavior according to the criteria required by the investor, the user and other stakeholders, but also helps to keep the construction towards the sustainable development goals. There are many existing buildings that have obsolete properties. The management and durability of such buildings is very costly. Such buildings should be refurbished to meet the properties and imitations of new building behavior. 3D scanning technology goes hand in hand with the building sector digitization and outputs from 3D scanning technology serves as a useful basis for further working with data using BIM technology. This paper outlines the possibilities of creation of basics for current documentation with graphical information of these buildings and how it may serve for evaluation of possible options for repairs and reconstructions through the whole building lifecycle and further use in facility management.

See full paper



Experiences from the Implementation of the Assessment System for Sustainable Building (BNB) in Germany

A Rietz, N Kerz and M Welsch

Division Sustainable Building, Federal Institute for Research on Building, Urban Affairs and Spatial Development, Straße des 17. Juni 112; 10623 Berlin, Germany

andreas.rietz@bbr.bund.de

Sustainability is one of the most important challenges for the future. Sustainable building is therefore an important component of the national sustainability strategy in Germany. The Federal Ministry of Building has developed instruments to implement its ambitious goals with the Guideline and the Assessment System for Sustainable Building (BNB). The aim was, to implement federal building on a sustainable basis and to assume an exemplary role for other public clients. This strategy has been successful to date. The combination of mandatory introduction and exemplary effect has motivated some federal states already introducing sustainability assessment with the BNB in their area of responsibility, while others are testing this approach at least with the launch of pilot projects. In order to support implementation, instruments and tools for the application of the BNB were developed as part of the national “Future Building” research initiative. An important step is the introduction of the Electronic Assessment System for Sustainable Building (eBNB). It enables the recording and control of all parameters necessary for the effective implementation of the requirements of sustainable building. As part of an ongoing scientific monitoring, the implementation will be evaluated on the basis of the federal buildings currently completed and certified by the BNB. So far, the BNB certifications show that even high sustainability requirements can be economically implemented.

See full paper



Life Cycle Costing of Public Construction Projects

R Schneiderova Heraldova

Czech technical University in Prague, Faculty of Civil Engineering, Thakurova 7,
16629 Prague 6

heralova@fsv.cvut.cz

The purpose of this paper is to highlight the role of life cycle costing in the preparation phase of public construction projects. Life cycle costing is a method of economic analysis directed at all costs related to constructing, operating, and maintaining a construction project over a defined period of time. In the early phase of construction projects, an enormous benefit in life cycle costing can be achieved. The commonly used construction cost minimization approach should be substituted for life cycle cost optimization. In order to gain the maximum value for money, all costs incurred over the whole life span must be estimated. The optimization of the life cycle costs of a construction project is essential for a complex decision making process. All taken into consideration, the solution with the minimum value of life cycle costs can be chosen. Public investors are required to meet the objectives of sustainable building, and as a group they face limited financial resources and frequently a very strict institutional framework including procurement procedures. The quantification of life cycle costs, when deciding on a construction project, is required by the public sector in the Czech Republic. In addition, the estimated amount of life cycle costs has become a criterion in public tenders. The paper summarizes experience in building design valuation in terms of these life cycle costs.

See full paper



Linking Together Independent Sustainable Building Development Plans

M Šůra

CTU, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague, Czech Republic
sura@fsv.cvut.cz

The contribution describes two basically independent projects, both claiming to be oriented on sustainable building paradigms. The two projects had investors of two different types – one using public money to the benefit of community, the other was purely private money of a private economic operator. Both investors examined the sustainability in relation to the surrounding conditions and processes, discovered the concurrent existence of the other's investment plans, and determined overlapping areas of interest.

In the article we describe the overlapping areas, variant solutions intended to improve sustainability for lower costs, the pros and cons of the variants, and the harmonization of both investors' requirements. This was used to choose the variant best fitting both investors, and finally modify it slightly.

See full paper



The Influence of Energy Performance Certification the Market Value of Residential Buildings

L C Tagliabue¹, F Re Cecconi², N Moretti² and M C Dejaco²

¹ Department of Civil, Environmental, Architectural Engineering and Mathematics
University of Brescia, via Branze, 43 – 25123 Brescia, Italy

² Department of Architecture, Built Environment and Construction Engineering
Politecnico di Milano, Via G. Ponzio 31, 20133 Milan, Italy

nicola.moretti@polimi.it

The market value of the physical assets over the time varies as a function of different factors related, for instance, to the correct execution of buildings and systems; the conformity with procedures defined for the use phase of the systems; the implementation of maintenance plan, defined in order to maintain the building and its parts in good conditions. Nevertheless, there is not a clear evidence of how the market value is affected by the energy performance measured by the Energy Performance Certification in Italy. The aim of this research concerns the definition of an assessment methodology of the impact of the energy performance on the market value of assets. The methodology has been developed and tested in a case study on the city of Milan, Italy. At first, an investigation of homogeneous income areas has been carried out, afterwards an analysis of the market values of assets has been done. The results have been integrated in a Geographic Information System and gaps in the market values have been associated to the energy performance. Despite the methodology has still to be refined, it has been demonstrated its validity. To conclude, further parameters representing the energy performance of the buildings could be encompassed in the assessment, in order to achieve a more precise energy profile of the building under analysis.

See full paper



Strategies for Simultaneous Embodied Energy and Operational Energy Reductions in Buildings during the Design Stage

G A Tennakoon, A S Waidyasekara, B J Ekanayake and S F Nazeer

University of Moratuwa, Moratuwa, 10400, Sri Lanka

ra-biyanka@uom.lk

With the global energy consumption reaching unsustainable levels, the need for regulating energy consumptions has been emphasised. Hence a variety of methods are followed in different countries to minimise the impacts of embodied energy (EE) and operational energy (OE) in buildings. Considering either EE or OE in its individuality is not a pragmatic approach and it is important to consider means of reducing both EE and OE in parallel. The design stage was identified as the most suitable stage for integrating energy efficiency measures, since most crucial project decisions are taken at this stage. Although a multitude of research has been conducted on EE and OE individually, there seems a lack of research that focuses on both these aspects together. The extensive literature review was followed by 5 preliminary interviews with subject matter experts and then semi structured interviews with 12 experts were conducted. It was revealed that determining strategies for achieving simultaneous EE and OE reduction is difficult. The identified strategies to be implemented in the design stage were classified as material selection related, design approach related, building morphology related, procurement process related and other strategies, with a majority of strategies falling under the 'procurement process' category.

See full paper



Quality Label in Buildings and Construction – a Green Label Supporting the Sustainability of Buildings in Slovenia

M Tomšič¹, N Jejčič¹ and M Š Zavrl^{1,2}

¹ Building and Civil Engineering Institute ZRMK, Ljubljana, Slovenia

² New University, European Faculty of Law, Nova Gorica, Slovenia

miha.tomsic@gi-zrmk.si

Sustainable actions in the building sector need to be supported by appropriate quality assurance (QA) and control protocols and tools. In late 1990s the first – and to this date the only comprehensive – quality label for construction products and services was established in Slovenia: the Quality Label in Buildings and Construction (ZKG). It is a voluntary green label addressing not only the specific technical characteristics of products and services, but among other also the production process quality, internal QA schemes, regular training and education of staff, innovation and development activities, economic aspects, the impact of the activities on the environment, and the social role of the company in the local area. In this way it addresses the three core pillars of sustainability. The label has gained a prominent status and is being referred to in calls for tenders both in public and private sectors and in national subsidy schemes. The paper presents the structure and content of the assessment scheme and ranking system exposing their core elements. A more detailed approach is presented on the case of a window as a construction product and on the case of installation of windows as a service, underlining the positive role of the label with regard to raising the quality standards in the building sector on the national level.

See full paper



Cost Estimation in BIM for Transportation Constructions in Czech Republic

S Vitasek and J Zak

CTU in Prague, Faculty of Civil Engineering, Department of Construction Management and Economics, Thakurova 7, Prague, 166 29, Czech Republic

stanislav.vitasek@fsv.cvut.cz

Detailed and precise drafts of competition are key to successful BIM implementation in Czech localization, as they are used for creating BIM model and they are further worked with. This can only be ensured by specifications in contract – as far as information model and Cost management (CM) are concerned, the specifications required are data appointment and Execution plan of building information modeling which both should be included in contract. The data defined in these documents carry great potential for further use within building information modeling, realization and operation, and they have not yet been used to full extent of their potential. This paper explores what should be included in the above suggested key documents from CM point of view and also what is the current level of construction documentation in transportation engineering in the Czech Republic.

See full paper



Changes of the Operating Costs during the Life Cycle in Existing Housing Stock

D Vytlačil

Department of Engineering Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague, Czech Republic

vytlacil@fsv.cvut.cz

The paper describes the dynamic model of the changes of the operating and investment costs that are associated with the energy consumption in the building. These costs are assessed for the building structure and HVAC systems. The aim of the research is to find the time dependent energy consumption and the cash flow that depends on the investments to energy saving arrangements and operations. The solution is based on the system dynamics method. The method makes possible to interconnect technical and economic parts of the problem. The main parameter in the model is the energy consumption in the building per floor square meter and year. This parameter is influenced by a deterioration of the building structure and the components of the active elements. Another influence are the investments that are realized with the aim to decrease the energy consumption. The example of the calculation of the main system parameters during the building life cycle with two projects is presented in the paper. The main output from this research is the developed model which makes possible to investigate the influence of multiple energy saving projects during the building life cycle.

See full paper



Life Cycle Assessment Of Cooling and Heating System Based on Peltier Module

A Żelazna and J Gołębiowska

Lublin University of Technology, Faculty of Environmental Engineering Nadbystrzycka
40B, 20-618 Lublin

a.zelazna@pollub.pl

Sustainability in the construction branch refers strongly to the service life of buildings. According to many literature studies, typical energy standard buildings are characterized by significant share of the operational phase on their life cycle, considering various environmental indicators. Thus, the kind of the energy source is very often the key factor influencing the results of building's Life Cycle Assessment. The innovative solution of cooling and heating system based on Peltier device is developed at Lublin University of Technology. The results obtained during laboratory tests (COP 0,767) as well as the results of Life Cycle Assessment procedure (GWP at the range of 0,22–0,9 gCO_{2eq}/Wh) show that the developed system, after specific modifications, may be treated as environmentally friendly source of cooling and heating energy.

See full paper



High-Performance Building Systems and Components

Building Envelope Thermal Upgrade for School Buildings in Jordan

H H Ali and R Al-Hashlamun

Department of Architecture, Jordan University of Science and Technology, Irbid Jordan
hikmat.ali@gmail.com

Following the educational reform in Jordan in 2003, the government decided to cease the construction of old, prototypical, and uninsulated schools in favor of thermally insulated site-specific buildings. However, more than 2917 uninsulated school buildings built before the reform have continued to function. Therefore, this research focuses on evaluating and comparing the thermal efficiency of the envelope of old, uninsulated prototypical schools with that of thermally insulated, site-specific school's buildings in Jordan. Furthermore, it will develop envelope retrofit strategies for the remaining 2917 uninsulated schools. The proposed envelope retrofit alternatives will be analyzed in terms of potential energy saving and initial cost, based on which a holistic approach is developed by combining energy-efficient and economically feasible retrofitting alternatives. The research here uses mixed design methods to fulfill its purposes, including data collection from the literature and national archives, self-reported data, field monitoring of environmental parameters inside classrooms, and energy simulation using (Design Builder) software, in addition to economic analysis using the simple payback period analyses method. Based on analyses, a holistic approach to envelope retrofitting was developed for old governmental school models in Jordan, based on an analysis of the effects of the enhancement of envelope parameters on annual cooling and heating energy saving (walls, roof insulation, roof reflectance, windows, and shading elements). The proposed alternatives to envelope retrofitting for each envelope parameter was analyzed in terms of potential energy saving and initial cost analysis.

See full paper



Flat Roofs Defects – Norwegian Building Sector Perspectives**E Andenæs, A Engebø, T Kvande, R A Bohne and J Lohne**

Institute of civil and environmental engineering, Norwegian University of Science and Technology, Høgskoleringen 7A, 7491 Trondheim, Norway

erlend.andenas@ntnu.no

Flat roof constructions covered with flexible roofing is a common feature on large buildings, as they are robust and require little maintenance. However, faults in flat roof design or their assembly could lead to costly building damages or defects. A preliminary mapping of main risk factors for flat roof defects has been carried out by studying design, assembly, and maintenance practices. This article is based on semi-structured interviews with actors in the Norwegian building sector between September 2017 and March 2018. The interviews did not target a specific subgroup; a broad and explorative approach was instead chosen in order to seek out opinions from all parts of the supply chain. The goal was to map knowledge and attitudes regarding flat roof faults. A point of particular interest concerned the perceived prevalence of substandard constructions due to counterfeit materials or shoddy building practices. It was found that most roof faults could be attributed to aging or design flaws. Counterfeit materials or shoddy workmanship was perceived to be uncommon among large and well-established companies. However, responders from several backgrounds – manufacturer, municipal and university building owners – suspected that such malpractices might be more common among smaller contractors geared towards the non-professional market. As a whole, the Norwegian roofing industry was perceived by respondents as generally trustworthy and compliant with regulations. However, interview responses suggest further research is required on the practices in the non-professional sector.

See full paper



Two-Stage System for Utilization of Renewable Solar Energy in Modern Building Facade Technology

B Bielek, M Krajčák, P Buday and M Macák

Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Radlinského
11, 810 05 Bratislava, Slovak Republic

boris.bielek@stuba.sk

We research a technical solution for utilization of solar energy in modern buildings with double-skin facades. The solution involves thermal conditioning of cold outdoor air in the physical cavity of the double-skin facade and utilizing the warmed up air as primary air for an air heat pump. The system for utilization of solar energy consists of two stages. The 1st stage involves transformation of the short-wave solar radiation to the long-wave heat radiation in the double-skin facade. This contributes to the reduction of heat losses from conditioned rooms because of the lower temperature difference between the rooms and the cavity. In the 2nd stage the thermally conditioned air is fed in the inlet of the air heat pump during heating season. Computer simulations performed for a cavity of a 4-storey double-skin transparent facade have shown that both the intensity of solar radiation and the air flow through the cavity significantly influence the air temperature at the outlet from the cavity. The air temperature rise in the cavity was ranging from 3.7 K for the solar radiation of 150 W/m² and the airflow of 200 m³/min, up to almost 23.0 K for the solar radiation of 600 W/m² and the airflow of 50 m³/min. Even at the least favourable climate conditions such increase in temperature of the primary air leads to a considerable improvement of the performance of the heat pump.

See full paper



The Environmental Performance of a Remote-Region Health Clinic Building, Australia, Based on Instrumental Monitoring**S Burroughs**Dr Steve Burroughs & Associates Consulting, 38 Blackman Brescent, Canberra, ACT
2614, Australia

drsteve@drsteveburroughs.com.au

Both environmental (e.g., energy use) and human sustainability (occupant well-being/productivity) need to be considered in building design and operation. The challenging climatic and socioeconomic conditions in remote regions of Australia mean that achieving sustainability is difficult and costly. Currently, the energy use patterns, thermal performance, and indoor atmospheric quality (IAQ) of remote health clinic buildings are unknown, meaning that there is an information gap in the design and operation of such buildings. This paper reports the results of an investigation into the environmental performance of a clinic in the remote clinic of Numbulwar. Climate variables, energy consumption, and IAQ variables were instrumentally monitored at the clinic from April 2017 to March 2018 at 10-minute intervals, with data uploaded to a cloud database now holding 3 million values. Analyzed temporal variations in the measured variables for the clinic and the relationships between them reveal the performance of the building. The results obtained provide a basis for the formulation of strategic interventions, design guidance, and further investigation, including: (i) the range of indoor atmospheric conditions needs to be narrowed to provide more consistent occupant comfort; (ii) an occupancy profile needs to be developed to determine user behaviours with respect to energy use; (iii) the heat-exhaust/aircon systems need to be reviewed for more efficient use; (iv) the cycling of air, heat, moisture, and pollutants through the building needs to be further investigated; and (v) BIM should be undertaken using the data as input to test future design solutions.

See full paper



PCM Integrated in BiPV Ventilated Façade Concepts: Experimental Test Cell Platform and Initial Full-Scale Measurements

J Curpek¹, M Cekon^{1,2} and J Hraska¹

¹ Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Radlinskeho 11, 810 05 Bratislava, Slovakia

² Centre AdMaS, Faculty of Civil Engineering, Brno University of Technology, Purkynova 139, 612 00 Brno, Czech Republic

jakub.curpek@stuba.sk, mcekon@gmail.com, jozef.hraska@stuba.sk

Recently, a wide range of novel façade solutions directly utilizing solar energy has been described as Building Integrated Photovoltaic (BiPV). However, there are still barriers (e.g. cells' overheating) to overcome in order to promote widespread application of BiPV concepts. Therefore PV/PCM systems have been already studied to improve the performance of PV, however their integration in building (BiPV/PCM) is still not adequately investigated. In this regard, the main objective of this paper is to present one of the viable way of investigation a novel combination of BiPV/PCM. This can utilize PV cells cooling principle at behind of the BiPV layer in ventilated façade. The key research methods are based on the experimental and building energy simulation studies. For this purpose, a specific experimental test platform was developed to provide experimental measurements on ongoing long-term full-scale level in Brno, Czechia. Two types of ventilated BiPV façade are tested there with/without PCM layer behind the PV cells. The paper introduces the test platform which is used for evaluation of specific aspects of integrated PCMs in BiPV management and demonstrates the initial thermal response measurements. The influence of PCMs on the real performance of the BiPV façade and effectivity of application of latent thermal energy storage used on reduction of the peak operating temperatures of the PV modules as well as shifting of air temperature inside the façade cavity is analysed. Finally, the extensive measurements provide real performance data that will be used to verify the building energy simulations.

See full paper



HAM Analysis of Selected Wooden-Framed Walls

P Durica, V Kabatova, P Juras and J Rybarik

Department of Building Engineering and Urban Planning, Faculty of Civil Engineering,
University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia

pavol.durica@fstav.uniza.sk

In this paper, heat and moisture regime of the selected wooden-framed walls is analyzed. These walls meet the nearly-zero energy buildings recommendations. Totally, there are seven different compositions. They differ with thermal insulation (such as mineral wool, phenolic foam, sheep wool, etc.) and outer surface (coating, aerated cladding). The fragments are installed in two air conditioned rooms. This enables the possibility to maintain indoor boundary climate conditions constant or change dynamically. The outdoor climate is real, one of the wall faces east and one towards the south. Each fragment contains several sensors: thermocouple, relative humidity, both through the composition on contact with different materials and heat flow on inner surface. It is a pavilion type of measurement and results can be interpreted for a whole climate season. Based on the measurements it is possible to calibrate the numerical model and set-up non-steady simulations. Conclusion about coupled heat-moisture transport through fragments will be made further.

See full paper



Window Design Strategies for Environmentally Friendly and Energy Efficient Patient Rooms: A Case Study in the Belgian Context

N Eisazadeh, K Allacker and F De Troyer

Department of Architecture, KU Leuven, Kasteelpark Arenberg 1, 3001 Leuven, Belgium
nazanin.eisazadeh@kuleuven.be

With the increasing awareness of sustainable design “operational energy use”, “life cycle environmental impact” and “comfort” are becoming key considerations for design decisions. These three aspects are usually not explored in an integrated way in the early design stage. During this stage however, most far-reaching design decisions are made and the greatest potential to achieve sustainable building designs in a cost-efficient way exists. Hence energy efficiency, environmental performance and comfort should be considered as a fundamental part of early design stage decisions. This paper investigates the influence of various patient room design options on the energy cost, life cycle environmental impact and daylighting. The design parameters investigated are the room geometry, type of glazing and WWR (Window-to-Wall Ratio). The analysis is performed for a case study in Belgium, more specifically a patient room in a hospital design. The existing design is taken as a baseline scenario and via parametric analysis, the influence of alternative design strategies is analysed. Based on the comparative analysis, the paper discusses potential design strategies that allow for energy efficient and environmentally-friendly patient rooms that fulfil comfort requirements for patients.

See full paper



Towards the Façades of the Future: A New Sustainability Assessment Approach

G Gilani¹, O Pons² and A de la Fuente³

¹ Institute of sustainability, Universitat Politècnica de Catalunya (UPC), Jordi Girona 1-3, 08034 Barcelona, Spain

² Barcelona Tech (UPC), School of Architecture of Barcelona (ETSAB), Department of Architectural Technology I, Av. Diagonal 649, Barcelona 08028, Spain

³ Department of Civil and Environmental Engineering, Universitat Politècnica de Catalunya (UPC), Jordi Girona 1-3, 08034 Barcelona, Spain

g.gilani2015@gmail.com

While the majority of the recent studies report on sustainability assessment of buildings as a whole, research on the sustainable performance of building independent elements (e.g., envelope and façades) is scarce. Façades, as the first line of defense against the undesirable external impact, may contribute to the building sustainability by reducing the amount of energy consumption and providing thermal comfort for the inhabitants, thus minimizing the environmental impact on both the building and on the environment. Despite the significance of this issue, there are a few studies that focus on sustainability assessment of façades that consider economic, environmental and social aspects; however, these aspects are generally taken into account in a decoupled manner and, often, not objectively measured. In this respect, a set of criteria and indicators for assessing sustainability of residential façade systems is presented and discussed in detail herein. In addition, a new model for assessing objectively sustainability of building façades is also presented. This approach has been obtained by using MIVES, a Multi-Criteria Decision Making model that integrates the main sustainability requirements (economic, environmental and social) and includes the concept of value functions.

See full paper



Thermal Performance of Window with Vacuum Glazing. Case Study

I Chmúrny and D Szabó

Department of Building Construction, Slovak University of Technology, Radlinského 11,
810 05 Bratislava, Slovakia

ivan.chmurny@stuba.sk, daniel.szabo@stuba.sk

This document deals with the determination of thermal transmission properties of wood-aluminium window with vacuum glazing. Test measurements are performed with guarded hot-box method at defined temperature difference. They describe how the support pillars influence temperature distribution on the surface and how the edge vacuum glazing influence the heat flow through window. The deformation of the temperature field due to support pillars is surprisingly small and its range is from 0.40 K to 0.51 K with temperature difference on both sides of approximately 33 K. Decrease of internal surface temperature from the middle of glass to the edge is about $18.92^{\circ}\text{C} - 12.37^{\circ}\text{C} = 6.55\text{ K}$, and so it is considerable effect. The effect of the edge on the glazing is not explicitly quantified in the term of heat flow in this document, but is implicitly documented by means of surface temperature. Thermography was used to check if there are touching points between glasses where distance is from 0.15 to 0.2 mm. The vacuum glazing measured in this work was a sample, which was fabricated in Asian producer. The window was tested two years after delivery from the producer.

See full paper



Implications of Model Complexity for the Simulated Thermal Behavior of a Casement Window

S N Khosravi¹, O Šikula², U Pont¹ and A Mahdavi¹

¹ Department of Building Physics and Building Ecology, TU Vienna, Austria

² Institute of Building Services, Brno University of Technology, Czech Republic

shiva.khosravi@tuwien.ac.at

Windows have been a subject of interest for research in building industry due to their multifaceted and significant implications for indoor environmental quality and energy use. In this context, the present contribution explores the retrofit opportunity toward retrofit of casement windows via application of vacuum glazing. The first scenario included conductive and convective heat transfer processes. The second, more detailed scenario took, in addition, the effects of (long-wave) radiation phenomena into account. The main objective of the present contribution is thus to contrast the results obtained from primarily conductive and convective computations with those that involve a detailed coupled conductive, convective, and radiation simulation. The study benefits from a CFD (Computational Fluid Dynamics) model to evaluate the airflow patterns (temperature and velocity) within the window's interstitial space by assuming isothermal boundary conditions. Based on simulation results, the thermal performance of the retrofitted casement window (with vacuum glass applied as external pane) can be compared to the conventional construction. Thus, benefits in terms of reduced energy use and surface condensation risk can be documented.

See full paper



Air Handling Unit with Heat Pump

M Kny, V Mazanec, D Adamovský and J Včelák

CTU in Prague, University Centre for Energy Efficient Buildings, Trinecká 1024, 273 43
Buštěhrad, Czech Republic

martin.kny@cvut.cz

The paper focuses on the design, implementation and measurement of parameters of an air handling unit (AHU) with the Peltier cells. This is a small local modular AHU for fresh air flows of 50 to 200 m³/hr. The unit is designed for ventilation of residential and administrative buildings. Computer simulations were utilized designing the unit (including CFD), and many measurements were performed. The design of the AHU uses the Peltier effect, which transfers the heat from the exhaust air drawn from the room to the fresh supply air (heating mode). In reverse, the unit then allows for pre-cooling of the supply air (cooling mode). The air handling unit with the Peltier element does not achieve the high efficiency of the compressor cycle units, but is much simpler and has longer life expectancy.

See full paper



Optimization of Distance Rings in Panel Radiators

T Legner and J Bašta

Czech Technical University in Prague, Czech Republic

tomas.legner@fs.cvut.cz, jiri.basta@fs.cvut.cz

The aim of this paper is to introduce the issue of distance rings in panel heating radiators, which are an integral part of their construction and which influence the flow of water in the radiators. A new way of meshing the simulation model in Ansys Meshing, including the boundary layer modelling, is described. In the simulation model it is possible to turn the distance ring and observe the effect in changes to the velocity and temperature fields. In addition, research into my own shape of the distance ring is described and whether there is a greater influence from a change in the geometry on the temperature field than just turning it. In the end of the contribution the results of a mathematical simulation of the heating radiator at low operating temperatures are discussed.

See full paper



Experimental Assessment of the Façade-Integrated Thermoelectric Air-Conditioning Unit towards Development of the Autonomous Curtain Walling Module

T Matuska¹, V Zmrhal², V Zavřel² and P Slanina³

¹ Czech Technical University in Prague, UCEEB, Czech Republic

² Czech Technical University in Prague, Faculty of Mechanical Engineering, Czech Republic

³ SKANSKA a.s., Department of Curtain Walling and Facades, Czech Republic
vojtech.zavrel@fs.cvut.cz

This paper introduces an innovative concept for adaptive wall-curtain façade modules. The façade module integrates functions of heating, cooling, ventilation, lighting, shading as well as renewable energy storage and generation in order to enable autonomous adaptation of each individual façade module to local outdoor and indoor conditions. This paper is focused on the development of the façade-integrated air-conditioning system. Since the wall-curtain façade construction offers only limited space, the solution requires minimalistic size of the air-conditioning system. For this purpose, the application of thermoelectrical cells was investigated and the first prototype of thermoelectrical air-conditioning (mock-up) unit was developed and tested. This paper demonstrates the energy performance of the experimental setup and provides recommendations for further development process.

See full paper



Performance of Unglazed Photovoltaic-Thermal Collectors for Cooling Purpose

T Matuska, N Pokorný and V Shemelin

Czech Technical University in Prague, UCEEB, Czech Republic

tomas.matuska@fs.cvut.cz

Unglazed photovoltaic-thermal (PVT) collectors for combined usable heat and electricity production are still expanding on the market. Besides the summer heat production and whole year electricity production the unglazed PVT collectors can be used also for night cooling (sky radiation and wind convection heat exchange). Different unglazed PVT collectors have been experimentally tested for verification of reliable model for night cooling operation. Based on the results, the model has been implemented into simulation software TRNSYS. Simulation analyses of the cooling performance for different climate and operation conditions have been performed. While best of tested unglazed PVT collectors can achieve average specific cooling power around 110 W/m^2 ($80 \text{ kWh/m}^2\text{.season}$) at chilled water temperature 20°C in the climate conditions of central and northern Europe, in the climate conditions of south Europe these unglazed PVT collectors achieve not more than 38 W/m^2 ($27 \text{ kWh/m}^2\text{.season}$) during summer season (June–August).

See full paper



Influence of User Electricity Load Profile and Calculation Time Step on the Photovoltaic System Balance

J Novotny^{1,2} and T Matuska²

¹ Faculty of Mechanical Engineering, Czech Technical University in Prague

² University Centre for Energy Efficient Buildings of Technical University in Prague

jiri.novotny@fs.cvut.cz

Realistic energy balance of photovoltaic system has a direct impact on realistic economic evaluation of operation costs for given building. To estimate the realistic electricity power profile with a short-time step, a generator based on appliances power, occupancy and external daylight presence has been developed and used for simulations. Generator allows to create different power profiles for the whole year (all days identical, workdays-weekends, 365 different days) with given time-step resolution (from 1 minute to 1 day). Paper presents and analyses the results from parametric simulations of PV production and building electricity loads balance with different times-steps. Monthly calculation approach used as a standard methodology for building performance evaluation significantly overestimates the solar fraction of PV systems. Only calculations with time steps shorter than 1 hour lead to results close to reality. A methodology for monthly balance correction to realistic results based on yearly PV production to building consumption ratio will be presented.

See full paper



Environmental Benefits of Timber-Concrete Prefabricated Construction System for Apartment Buildings – a Simplified Comparative LCA Study

P Ryklová, Š Mančík and A Lupíšek

University Centre for Energy Efficient Buildings of Technical University in Prague, Czech Republic

pavla.ryklova@cvut.cz; stepan.mancik@cvut.cz, antonin.lupisek@cvut.cz

The aim of a research project TiCo (Timber Concrete) is to create a standardized flexible construction system for multifamily apartment buildings for central European climatic conditions with low environmental impact. It exploits advantages of advanced prefabrication and favourable material properties of its main elements. Prefabricated structural system was designed using concrete frame with thin columns and lightweight ceilings with reinforcing core. Façades and interior partition walls were designed from prefabricated timber frame panels. The paper presents a simplified comparative LCA study of the designed TiCo building system and conventional building solutions. The compared variants had the same key parameters – load bearing capacity and heat transfer coefficients of building's envelope. The analyses include load-bearing structures, façade, partition walls, foundations and roof. The others like HVAC systems, floors, doors, windows or tin work were not included. A simplified comparative LCA is based on procedure described in method SBToolCZ, which evaluates the quality of buildings in terms of sustainability. The assessment covered embodied environmental impacts of the construction system structures with their replacement based of their service lives. Prefabricated concrete frame structure with timber envelope was found environmentally friendlier compared to conventional solutions. The combination of the concrete load-bearing structure and lightweight timber frame panels that benefits from favourable characteristics of both materials for the given purpose appropriately used in the construction appeared to be an efficient way of minimizing building's environmental impact.

See full paper



Attractiveness of Using Photovoltaic Panels in a Building Connected to a Mainly Renewable Electricity Grid

M R M Saade¹, M G da Silva² and V Gomes¹

¹ University of Campinas, School of Civil Engineering, Architecture and Urbanism,
Rua Saturnino de Brito s/n, Cidade Universitária Zeferino Vaz, Campinas, SP, Brazil,
13083-889

² Federal University of Espírito Santo, Brazil

vangomes@unicamp.br

Photovoltaic (PV) panels contribute to overall building's loads, but generally have their impacts offset at the operational stage. For increasingly renewable electricity grids, PV's contribution to lowering non-renewable energy becomes less significant. This paper aims at investigating the non-renewable cumulative energy demand (CED_{nren}) and global warming potential (GWP) payback times associated to on-site PV generation in the highly renewable Brazilian grid, considering a 50-year building service life. Operational energy consumption was simulated in Energy Plus. CED_{nren} and GWP were calculated through the CED method and CML-IA, respectively. SimaPro 7.3 and Ecoinvent 2.2 supported performed LCAs. Different PV settings were analyzed to rank the most effective technological options. Amorphous and single-Si panels performed worst (around 17 years of non-renewable CED payback time, whilst for GWP the payback time was much shorter for all technologies). PV's production and replacement loads played a significant role, therefore technological investments to increase panels' durability and improve manufacturing efficiency could ensure its attractiveness.

See full paper



Potential Benefits of PV-Shading System in Office Buildings and Semi-Continental Climate Conditions

N Skandalos, J Tywoniak and K Stanek

University Centre for Energy Efficient Buildings, Czech Technical University in Prague
Trinecká 1024, 273 43 Buštěhrad, Czech Republic

nikolaos.skandalos@cvut.cz

Solar PV shading devices are good solutions to control daylight and reduce the unwanted solar gains, while generate electricity at the same time. Since thermal, electrical and daylighting performance competing each other, it is imperative to consider specific design criteria to optimize and allow energy efficient level of thermal and visual performance. In this context, the study focus on the optimum design of PV shading devices for typical office building with high fenestration ratio and climate conditions of Prague. TRNsys simulation environment was used for the evaluation of the power and thermal performance of the PV shadings considering various tilt angles, projection depth and orientations. Ecotect/Daysim software tools were used to evaluate the daylighting performance and lighting energy use. Useful Daylight Illuminance (*UDI*) and Discomfort Glare Probability (*DGP*) indices were also calculated for indoor visual comfort analysis according to the design configuration. Results were overall evaluated to reveal the potential energy benefits compared to the non-shaded case. The study serves as a guide for the optimum design of PV shading systems.

See full paper



Effects of Early Structural Changes of Engineered Soils on Green Roof and Bioretention Performance

**M Snehota^{1,2}, J Hanzlikova^{1,2}, P Heckova^{1,2}, J Sacha^{1,2}, V Jelinkova¹
and A Kaestner³**

¹ Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic; ² University Centre for Energy Efficient Buildings, Czech Technical University in Prague, Czech Republic

³ Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen, Switzerland

michal.snehota@fsv.cvut.cz, jitka.hanzlikova@cvut.cz, petra.heckova@cvut.cz, sachaj.jan@centrum.cz, vladimira.jelinkova@cvut.cz, anders.kaestner@psi.ch

Engineered soils play an important role in urban hydrology e.g. in the functioning of green roofs and storm water bioretention beds. Water infiltration, colloid transport and heat transport are affected by changes in pore system geometry particularly due to development of macropores and clogging by particles. The rate of pedogenesis is often faster than in natural soils due to higher loads of particles as well as by extreme water regimes. In the presented project we assess the temporal changes of hydraulic properties of engineered soils in typical bioretention beds and green roofs by conducting field scale experiments. The aim is to elucidate changes in hydraulic properties by studying the structural changes of soils at the microscale by invasive and noninvasive methods. The outcomes of the research will lead to improved design and management procedures for green roofs and bioretention beds.

See full paper



Environmental Assessment of Latent Heat Storage Technology

K Struhala, M Ostrý and S Bantová

Brno University of Technology, Faculty of Civil Engineering, Veveří 95, Brno 602 00,
Czech Republic

ostrym.m@fce.vutbr.cz

The potential for the use of renewable energy sources in heating or cooling systems increases with the possibility to store heat or cold when they are available. Latent heat storage (LHS) technology using phase change materials (PCMs) has significantly higher storage density compared to sensible heat storage. The solid-liquid phase change of PCMs with appropriate phase change temperature is preferred for building applications. In practice, there is often a lack of credible information about properties of LHS materials and their environmental impacts. Most of the common methods for evaluation of environmental impacts are based on Life-Cycle Assessment (LCA) principles. LCA is developed for several decades already. It can be used for evaluation of any product system. In this paper it is used for evaluation of environmental aspects of LHS technology, specifically selected heat storage materials.

See full paper



Reducing Energy Consumption for Air-Conditioning by Commissioning and Optimized System Operation

J Šimek¹, M Lain^{1,2} and J L M Hensen³

¹ Czech Technical University in Prague, Czech Republic

² University Centre for Energy Efficient Buildings of Technical University in Prague,
Czech Republic

³ Eindhoven University of Technology, Netherlands

jakub.simek@fs.cvut.cz, milos.lain@fs.cvut.cz, j.hensen@tue.nl

The contribution of buildings towards energy consumption has dramatically increased over the past decade. According to the EC's Joint Research Centre, HVAC systems in Europe were estimated to account for approximately 11% of electricity consumed in Europe [1] and with associated CO₂ emissions highly contribute to global climate change. This paper deals with the electricity consumption of air-conditioning systems in buildings in the Czech Republic. The paper presents results of actual measurements in 15 mostly office buildings over a 5 year period. The extensive analysis of measured data is presented in graphs and tables. A considerable difference in the electricity consumptions for cooling between the various administrative buildings is identified. The advanced commissioning of air-conditioning systems and its general application in the Czech buildings is presented in the paper as well. Energy consumption measurements, proper operation and application of advanced commissioning are identified as important methods tool to reduce energy consumption of air-conditioning systems in existing buildings.

See full paper



Simple Free Use Simulation Software for Buildings with Photovoltaic System and Battery

P Wolf and S Kichou

University Centre for Energy Efficient Buildings, Czech Technical University in Prague,
Trinecká 1024, 273 43 Buštěhrad, Czech Republic

petr.wolf@cvut.cz , sofiane.kichou@cvut.cz

The paper describes proposed techniques used for simple simulation of a hybrid energy system in a building. An interactive software tool is presented that can be downloaded and used for any purpose free of charge. Based on selected household electrical equipment, solar irradiance, PV system design and ESS parameters an annual simulation is made based on hourly time resolution. The outputs presented in charts as well as tables show the distribution of energy sources (grid, PV), the effect of ESS operation, self-sufficiency of PV system and its utilization of PV throughout the year. The simulation is real-time based so the system design can be easily manually optimized to achieve specific goals (e.g. specified self-sufficiency at minimal costs). As the simulation is based on Excel sheets, it can be easily accustomed by users with specific requirements.

See full paper



Determination of Moisture Buffering Capabilities of Common Furniture Materials

J Zemitis and A Borodinecs

Riga Technical University; Institute of Heat, Gas and Water Technology; Riga; Latvia;
Kipsalas street 6A; LV-1048

Jurgis.zemitis@rtu.lv

According to previous existing studies, the building materials can have a high impact on relative humidity fluctuations in a room by adsorption/desorption processes. The aim of this paper is focused to determine the influence of commonly used furniture materials to indoor air relative humidity. The measurements were performed in a controlled environment of the climatic chamber. During the measurements, a stable indoor temperature together with a constant air moistening was ensured. The indoor air parameters were measured with data loggers as well as the periodical weighting of materials was performed, to determine the moisture content of materials. The results showed that the common furniture materials have a very significant impact on indoor air relative humidity. The calculations of the influence were performed according to the mass balance equation comparing the predicted results without considering the influence of materials to the actual measured results from real case studies, therefore estimating the adsorption capabilities of these materials. The influence of these materials to the stabilization of indoor relative humidity can be expressed as a coefficient in mass balance equation depending on the type of material, area, and thickness of material, initial moisture content, and indoor air parameters. The findings of these results can be used in the design stage of indoor climatic systems to more precisely predict the relative humidity.

See full paper



Energy

Waste Water Recovery System with Heat Pump for Hot Water Preparation

R Červín¹ and T Matuška²

¹ Faculty of Mechanical Engineering CTU in Prague

² University Centre for Energy Efficient Buildings of CTU in Prague

radek.cervin@fs.cvut.cz

Waste water heat recovery is currently one of the possible ways how to reduce energy performance of buildings. The mathematical model using specific heat pump parameters is presented in this article. The aim was to verify efficiency of the waste water recovery system with heat pump for domestic hot water heating in family houses. The model enabled to evaluate heat recovery effectiveness during a day cycle. The first set of simulations of a typical day cycle has shown that the heat pump with recuperation of waste water is not effective solution for family houses. However, it might be interesting for the objects with larger consumptions. Another simulations for these objects were performed and more promising results were reached.

See full paper



I-ZEB: Design and Development of a ZEB Test-Laboratory for an Integrated Evaluation of Building Technologies

**L Danza, L Belussi, B Barozzi, A Bellazzi, A Devitofrancesco,
M Depalma, G Guazzi, I Meroni, C Maffè, M Ghellere, F Salamone,
F Scamoni and C Scrosati**

Construction Technologies Institute, National Research Council of Italy (ITC-CNR),
Via Lombardia, 49, 20098 San Giuliano Milanese (MI)

ludovico.danza@itc.cnr.it

Energy efficiency of buildings is a critical issue for international and national policy. The European Directives provide strict requirements for buildings, imposing the near Zero Energy Building (nZEB) standard for new or refurbished public and private buildings starting from 2018 and 2020, respectively. Furthermore, Zero Energy Building (ZEB) is recognized as a standard in order to improve the energy efficiency of the building sector. The collaboration of the professional and industrial sectors along with the scientific research allows to face these challenges. Within a research project, called I-ZEB, a ZEB test-laboratory where the stakeholders can test their solutions is designed and developed. The facility is designed in compliance with ZEB standard and is suitable for performing researches on new building technologies and their interaction with the built environment. The paper describes the design, the testing and the validation phases of the facility. High performing envelope, efficient HVAC, renewable energy source systems and advance control logics are the technical pillars of I-ZEB. Several characterization tests, including thermal, acoustic and environmental performance, have been carried out in order to detect the most suitable technical solutions. Moreover, the results will be tested and validated through a continuous monitoring of energy and environmental variables within the laboratory.

See full paper



DataRen, a Territorial Energy Demand Modelling Tool

F de Oliveira, S Schneider and P Hollmuller

Energy System Group, Institute for Environmental Sciences (ISE), Department F.-A.
Forel for Environmental and Aquatic Sciences (DEFSE), University of Geneva
stefan.schneider@unige.ch

This paper presents a tool allowing for characterization of heat, electricity and cooling demand for any portion of the territory of the Canton of Geneva (Switzerland). This project is conducted in cooperation with the local energy utility company *SerVICES Industriels de Genève* and its final goal is to offer to all stakeholders a uniform spatio-temporal database to be used for the purpose of territorial energy planning. The added value is to consolidate the various data and estimations models into a single data container and to share the resulting data (GIS and hourly load curves) on a web-service platform. The model behind the tool operates in two steps. First the yearly demand of the various energy services (space heating, domestic hot water production, electricity, comfort cooling and process cooling) are estimated at building level, whenever possible using energy bills. Data gaps are filled using statistical extrapolations models. In a second step, these annual aggregated demands (at district level) are characterized in terms of hourly dynamic, for a common reference year, by re-scaling monitored load curves collected on various case studies. Finally, for a chosen district the tool evaluates the impact on energy demand of some prospective scenarios, as adding of new buildings and / or retrofitting existing ones.

See full paper



A Revolutionary Study Commons and University Library Extension, The Chinese University of Hong Kong

S M Fung¹ and T Yuen²

¹ Director, Campus Development Office, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, smfung@cuhk.edu.hk

² Architect, Campus Development Office, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong, thomasyuen@cuhk.edu.hk

thomasyuen@cuhk.edu.hk

The Library Extension completed in 2012 featured a minimalist, sustainable, preservative and conservative design that cleverly integrates a love of nature with respect of history. It echoed with the University's Campus Master Plan and demonstrated how development needs were balanced with preservation concerns. The iconic University Mall and Garden dating back to the 1960s were preserved with an innovative design to provide about 4,500 m² of study area and car parking at basement level. The new extension thus maintained a similar height to the original library building and aligned to the iconic axis along the University Mall. The Mall Garden and Landscape were well preserved with skillful design of skylights under the existing pool. Garden features were surveyed and restored to their original appearances after the basement construction. The campus' much loved house swifts, residing previously on the eaves, were also migrated to the south façade with the introduction of artificial nests. While Green Building design and renewable energy innovations were fully adopted to achieve the highest HKBEAM Platinum standard, the project has provided generous Learning and Research Commons with advanced IT infrastructure which promote causal interactions and knowledge transfer.

See full paper



Use of Heat from Wastewater

K Hrabová¹, T Hrdlička¹ and M Tlašek²

¹ Brno University of Technology, Czech Republic

² IVAR CS, Czech Republic

kristyna.hrabova@usi.vutbr.cz, tomas.hrdlicka@usi.vutbr.cz, tlašek@ivarcs.cz

There are increasing demands on energy efficiency at all areas of life e.g. heating, cooling and hot water supply. Using waste water is meeting requirements of sustainability and environmental protection. Waste water has great energy potential. The article deals with the optimization of sewer heat exchanger and economic efficiency. Heat exchanger effect is depending on shape and geometry of heat exchanger. Also temperature of waste water affects heat exchanger effect. Usual temperature of sewage is about 20 degrees Celsius in summer and about 10 degrees Celsius in winter. Cooling for a maximum about 1 degrees Celsius and flow at least 10 liters per second is required for seamless operation. To pass requirement of minimum flow is this system suitable for bigger buildings. It is also necessary for positive economic effect. For proper design and optimization it is necessary to use three basic methods: diagnostics, heat balance calculations and modelling. Numeric simulations are made for selection of the best sewer heat recovery. Recovered heat energy was used for heating, cooling also for hot water supply. Positive economic effect is provided in case study of administrative building.

See full paper



Parametric Study: Impact of Selected Factors on the Energy Demand of a Family House

P Juras¹, P Durica¹ and J Jandacka²

¹ Department of Building Engineering and Urban Planning, Faculty of Civil Engineering, University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia

² Department of Power Engineering, Faculty of Mechanical Engineering, University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia

peter.juras@fstav.uniza.sk

Results of a parametric study, which deals with energy demand of family house with different shape factors and thermal properties of the building envelopes will be presented. Basic shape is a single-floored bungalow. Partly two-story and complete two-story house with flat roof are alternatives. Different building envelopes are considered, from the project, upgraded to low-energy house up to nearly-zero energy house. Air change ratio respects required indoor air quality. The natural ventilation and mechanical ventilation with heat recovery were analyzed. Pellets, wood, electric, gas and heat pump were considered as heat sources. Also a combination with solar collectors to decrease energy for hot water preparation was considered. Presented results are in form of delivered energy and primary energy.

See full paper



The Assessment of Construction Details in Terms of 3D Thermal Fields and the Impact on Building Design

M Kalousek and M Novák

Brno University of Technology, Faculty of Civil Engineering, Veveri 95, 602 00 Brno
kalousek.m@fce.vutbr.cz

Thermal bridge is a very common and undesirable phenomenon in a building. Thermal joint (bridge) is usually based on material or geometry reasons or their combinations. Many types (connection of window – wall, pillar – wall), can be calculated and evaluated sufficiently in 2D section, but in some types it is necessary to take into account 3D heat conduction. For example: a corner with ceiling (roof) and two walls where is strong deformation of isotherms and the internal surface temperature is definitely lower than in 2D section. According to the Czech Technical Standard it is necessary to fulfil law requirement – Temperature Factor at internal surface lowest temperature „at each location“. Recommendation is solving of “differential equation multi-dimensional of thermal field”. In this case of “building corner” project engineer has to decide for 3D modelling. In the contribution there is presented a mistake in 2D model, the situation when it is necessary to use 3D model. Additionally, there are recommendations to eliminate the risk of condensation and mould.

See full paper



Renewable Energy Supply for Remote Station Located in Antarctica – Simulations Based on Real Measured Data

S Kichou¹, P Wolf¹ and P Kapler²

¹ University Centre for Energy Efficient Buildings, Czech Technical University in Prague, Trinecká 1024, 273 43 Buštěhrad, Czech Republic.

² Department of Geography, Masaryk University, Kotlářská 267/2, 611 37 Brno, Czech Republic.

sofiane.kichou@cvut.cz, petr.wolf@cvut.cz, kapler@sci.muni.cz

Photovoltaic (PV) installation with energy control and energy storage systems (ESS) are becoming more popular to be used inside buildings. They can assure stable energy supply as well as energy savings. A proper system design is necessary to ensure optimal energy supply and cost savings. The present work describes current energy demands and sources of Johann Gregor Mendel Station operated by Masaryk University in Brno and suggests a new generation sources based on PV. The energy for the station is being provided by oil generators, PV system and wind turbines. Since the beginning of 2018 a new system for measuring detailed energy demand, irradiation and wind speed has been installed in that location. Thus, based on the in-site collected data, possible system sizes are suggested in order to make the station fully operating by means of renewable energy sources.

See full paper



Retro-Commissioning – Effective Energy Conservation Initiatives in Existing Buildings

K W Kong¹, K W Lam¹, C Chan² and P Sat²

¹ Energy Efficiency Office, 7/F, Electrical and Mechanical Services Department, 3 Kai Shing Street, Kowloon, Hong Kong

² Hong Kong Green Building Council, 1/F, Jockey Club Environmental Building, 77 Tat Chee Avenue, Kowloon Tong, Hong Kong

kwkong@emsd.gov.hk, lamkw@emsd.gov.hk, cary.chan@hkgbc.org.hk,
paul.sat@hkgbc.org.hk

Hong Kong is a densely populated metropolitan city crowded with more than 7 million people. of the 42,000 buildings in Hong Kong, more than half (55%) of Hong Kong's total annual energy end-use is in the form of electricity consumption and buildings take up about 90% of our total electricity consumption. Thus, energy saving in buildings is a key factor of addressing climate change and associated environmental issues of Hong Kong. In January 2017, the Environment Bureau of Hong Kong Special Administration Region Government (HKSARG) published "Hong Kong's Climate Action Plan 2030+" which set target to reduce our carbon intensity by 65-70% by 2030 compared with the 2005 level. With this ambitious vision, the whole community have to further endeavour to achieve energy conservation with concrete supporting measures. Electrical and Mechanical Services Department (EMSD) of HKSARG is actively pursuing the cost-effective program of "Retro-commissioning (RCx)", new energy saving initiative, to further encourage energy conservation works in existing buildings. RCx is a cost-effective and systematic process to periodically check the energy efficiency performance of existing building. EMSD has carried out numbers of pilot projects on both government and private buildings with Hong Kong Green Building Council (HKGBC); launched the "Technical Guidelines on Retro-commissioning [TG(RCx)]"; led and co-organized with different stakeholders on showcasing the government-industry collaboration and promoting effort of RCx training for the industry. The paper will introduce the framework and technical approach of TG(RCx), share the latest development and implementation programme of RCx in Hong Kong.

See full paper



Solar Aperture of a Building Enclosure: The Case Study of a Well-Insulated Family House in Semi-Continental Climate

P Kopecký and K Sojková

University Centre for Energy Efficient Buildings, Trinecká 1024, Buštěhrad

pavel.kopecky@fsv.cvut.cz

As thermal insulation of building enclosure has substantially improved over the last decades, solar heat gains comprise more important part in thermal balance of a building in semi-continental climate, often leading to overheating. The quality of the whole building enclosure should be assessed by its ability to transmit solar heat gains. Such thermal characteristic need to aggregate properties like glazing area in each facade, total solar energy transmittance of glazing, the efficiency of fixed shading devices and the operation of movable shading devices. In this paper, the surrogate horizontal effective collector area is used for the characterization of solar heat gains through a building enclosure. The parameter is called the solar aperture of a building enclosure. First, the formula for solar aperture is derived. Then, building energy simulation of a model family house is performed. The correlation of the solar aperture with overheating and space heating demand is analysed. Based on the analysis, the recommended trade-off values of the specific solar aperture are proposed for family houses in semi-continental climate. The trade-off values of the solar aperture will lead to reasonable promotion of solar heat gains during cold season and significant reduction of solar heat gains during warm season.

See full paper



Carbon Dioxide Emissions from Operation of Czech Building Stock and Potential for Their Reduction

A Lupíšek

Czech Technical University in Prague, University Centre for Energy Efficient Buildings,
Trinecká 1024, Buštěhrad, 273 43, Czechia

antonin.lupisek@cvut.cz

The paper presents a study that modelled potential for savings of CO₂ emissions from the Czech building stock in ten scenarios. Input data in scenarios were taken from analyses of energy saving potentials of Czech building stock from NGO Chance for Buildings. The results provided values of modelled CO₂ emissions of the Czech building stock for each year in period 2016–2075. Cumulative data for periods 2015–2030, 2031–2050 and 2051–2075 were compared to the proposed national carbon budget coming from the UN Emissions Gap Report. The study estimated production of CO₂ from Czech building stock in 2016 at 44.57 Mt, which represented share of 43% in the total national CO₂ production. The scenario S5 in RCP 8.5 showed potential for annual reduction of CO₂ emissions from current 44.57 to 15.29 Mt in 2075 (reduction by 66%). The needed reduction of CO₂ emissions calculated from the global carbon budget for climatic goal 2° is much larger. It is very likely, that even the most stringent of the proposed energy saving scenarios would not be sufficient for the Czech building stock to comply with the Paris Agreement.

See full paper



Identification of Characteristic Heat Load Profiles of Different Usage Units in Non-Residential Buildings

C Matschi, G Vogt and I Nemeth

Hochschule Ansbach, An der Hochschule 1 91555 Feuchtwangen, Germany

christoph.matschi@hs-ansbach.de, gernot.vogt@hs-ansbach.de, isabell.nemeth@hs-ansbach.de

For energy-efficient design of district heating networks and their components, knowledge about load profiles and the peak simultaneity are of crucial importance. Heating load profiles are needed in high temporal and spatial resolution as well as information about their composition. Due to high computational and temporal effort for transient calculations of a whole district heating network a less complex method is needed. For this reason different areas of use of non-residential buildings are analyzed separately to identify their characteristic variations and main influences on their individual load profiles to finally superpose their load profile in one overall building /district heat load profile. In a first step similar use areas in four buildings are calculated transiently and the deviation of the results were analyzed. Additionally, the building age and the associated structural-physical parameters are varied to get results for different building age classes. In a second step the profiles are superposed up to the district scale by using the area as scale factor. The gained district heat load profile is compared to time series of the observed consumption in order to assess the reliability of the method. The first results show promising conformity of modelled and measured energy demand. So the method will be applied to several buildings with varying structural-physical parameters and geometries.

See full paper



Mapping of Cities Wastewater Heating/Cooling Capacity

N Meeten

Applied Energy, 18A Aston Street, Blenheim 7201, New Zealand
nick@appliedenergy.co.nz

This paper is not a research paper, but is provided as support information for an oral conference presentation. It is intended to provide background information to the topic of using wastewater as a thermal source for heating & cooling buildings and describe innovative work which has been undertaken in New Zealand in mapping the distribution and capacity of thermal energy within wastewater networks. This mapping work is also applicable in Central European cities and so relevant to Sustainable Building.

Approximately 20%–30% of all the energy used in New Zealand households is used in domestic hot water systems. This heat energy then flows ‘down the drain’ and is collected within a city’s wastewater network. So flowing through cities’ sewers, wastewater is a hidden and seldom used source of thermal energy, contained within infrastructure which is already existing. Its flow is constant irrespective of the seasons, and its availability is independent of wind or sun.

There is a very large thermal capacity available, which is currently largely unused. Wastewater can be used for heating and also for cooling of commercial buildings, apartment buildings or district energy schemes. This can allow buildings to stop using fossil fuels and the good thermal characteristics of wastewater offer significant increases in the electrical efficiency of building heating & air conditioning systems, with associated savings in potable water when wet cooling towers are eliminated.

The large thermal capacity available within the wastewater network can be modelled and mapped, to allow cities to start planning to take advantage of this resource and make significant gains in efficiency.

The oral presentation will show examples of cities who have had wastewater network energy mapping done, and a range of case studies of how wastewater heating & cooling energy is being used. An example of the outcomes from these mapping studies from Christchurch City in New Zealand (population 400,000) showed that there is sufficient heat available from the wastewater network to heat approximately 10,000 houses in the city.

See full paper



Experimental Verification of Indirect Adiabatic Cooling by Ventilation Air

O Nehasil and D Adamovský

CTU in Prague, Faculty of Civil Engineering, Department of Indoor Environmental and
Building Services Engineering, Czech Republic

ondrej.nehasil@fsv.cvut.cz

Current efforts to reduce the energy consumption of buildings leads to savings in all categories of their operation. A traditional energy saving tool is low-energy cooling, based on the alternation of day/night temperatures, cold storage, or the use of high-temperature cold sources such as Earth's semi-solid or groundwater. This paper deals with the less widespread method for cooling buildings, based on latent heat removal for converting water to vapour.

Within three years, approximately 150 operating states were measured for different temperatures and airflows and various types and numbers of humidifiers, as well as nozzle pressures and types of heat exchangers. The paper outlines the results of these experiments and shows the available cooling capacity coupled to the ventilation air. The fact is that cooling power increases with increasing outdoor temperature, which makes indirect evaporative cooling an interesting method of providing cold during the times when it is under greatest demand.

See full paper



The Impacts of the Exterior Glazed Structures and Orientation on the Energy Consumption of the Building

T Odineca¹, A Borodinecs¹, A Korjamins² and D Zajecs¹

¹ Institute of Heat, Gas and Water Technology, Riga Technical University

² Institute of Materials and Structures of Riga Technical University

tatjana.odineca@rtu.lv

Buildings use about 40% of the national energy consumption, and approximately 25–30% of this energy is wasted due to inefficient windows. Installation of energy efficient glazing allows significant reduction of cooling load. While increase of heat consumption can be observed in heating period due to significant reduction of solar heat gains. On the basis of computer simulations there were found dependences between overall energy efficiency of the building and such parameters as its orientation, urbanization, and the types of glazing. Building energy modelling (BEM) allows to predict the energy consumption of the building, to find and correct the weak spots in terms of energy consumption and to find the most effective way to use energy saving technologies. The IDA-ICE, chosen as the BEM in the research, is a whole-year detailed and dynamic multi-zone simulation application for study of thermal indoor climate and the entire building energy consumption. The main advantage of the software package is a detailed report for each of the building zones and for the whole building, which includes calculation of heat flows and inflows, maintained temperatures, sources of heat losses and energy costs to maintain a comfort temperature. The variable data are the type of glazing (different window types chosen, with special emphasis on g-value of glass and coefficient of shading) and building's orientation to the world sides. The research demonstrates the effectiveness of using particular glazing types depending on the building conditions. The developed recommendations allow to reduce energy consumption in existing buildings and to reduce construction costs of new office buildings at the design stage.

See full paper



Effect of Traditional Persian Materials and Parametric Design on the Thermal Performance of a Generic Building in Mediterranean Climate

N R M Sakiyama^{1,2}, S B M Hejazi¹, C C de Oliveira², J Frick¹ and H Garrecht¹

¹ University of Stuttgart, Stuttgart, Germany

² Federal University of Jequitinhonha and Mucury Valey, Teófilo Otoni, Brazil

nayara.sakiyama@mpa.uni-stuttgart.de

Concerns related to buildings' green-house emissions in recent years lead to the increase of architectural adaptation to local environment. While passive conditioning strategies emphasising natural ventilation are common alternatives to achieve indoor comfort in hot and humid climate, they are not widely used in temperate climates. In this context, this paper presents a computer simulation study carried out through Archsim plug-in of Grasshopper/Rhinoceros. The object of study consists of a single family housing unit (flat) with an area of 31.25 m² and a height of 2.80 m, with one user, under naturally ventilated conditions. As a reference case, the model used the climate of the city of Yazd in Iran and the simulations assessed parameters such as window-to-floor area ratios of 10% and 20%, as well as the thermal transmittance of exterior walls, considering an envelope with insulation materials, as a common European configuration, and an envelope with Persian materials, such as adobe. Two different Mediterranean climates, Palermo and Valencia, were investigated and the influence of these parameters at the building thermal performance was evaluated using cooling and heating degree-hours indicator, using as thermal comfort limits the Operative Temperature criteria established by ISO 7730. Using Persian materials at the model envelope increased its thermal inertia, thus reducing the temperature variation in the internal environment and improving its interior comfort, especially during the warmest seasons.

See full paper



A Heat Demand Load Curve Model of the Swiss National Territory

S Schneider¹, P Hollmuller¹, J Chambers² and M Patel²

¹ Energy System Group, Institute for Environmental Sciences (ISE), Department F.-A. Forel for Environmental and Aquatic Sciences (DEFSE), University of Geneva

² Faculty of Science, Department F.-A. Forel for Environmental and Aquatic Sciences (DEFSE), Institute for Environmental Sciences (ISE), University of Geneva, Geneva, Switzerland

stefan.schneider@unige.ch

This paper presents a bottom up model simulating the hourly heat demand load curve for space heating and domestic hot water production for Swiss buildings listed in the national building and dwelling register. The model was calibrated on the actual heat demand load curves of several building types and predicts the demand as function of external temperature and solar irradiation. In addition, it includes stochastic deviations to accurately reproduce the aggregated load of large building groups. Using a climatic database covering the whole Swiss territory, the model takes account of the diverse weather conditions and climate types. The aggregated simulated load curve is compared with the measurements from a large district heating network, demonstrating that key indicators such as peak load and ranked loads are very well reproduced. To disseminate the results, a GIS database was setup that estimates the aggregated heat demand load curve for any portion of the Swiss national territory. The proposed approach addresses the challenge of large territorial scale simulation using only limited information available on its building stock. The model can be easily adapted to generate load curves for other EU regions provided the required information is available for the building stock.

See full paper



A Zero Energy House for and by Frank Gehry

M Schuler¹, K Dvořáková¹ and Z Malík^{1,2,3}

¹ Transsolar Energietechnik GmbH, Stuttgart, Germany

² CTU in Prague, Faculty of Civil Engineering, Department of Building Structures, Prague, Czech Republic

³ CTU in Prague, University Centre for Energy Efficient Buildings, Buštěhrad, Czech Republic

schuler@transsolar.com

This paper presents an energy concept of set of two residential buildings: a main house and a guest house in Santa Monica, California of total floor area of 836 m². The aim of this concept was to create a built environment with high comfort for users and the lowest possible impact on the environment. The architect and owner of the project Frank Gehry (88), see this as his statement in the discussion on sustainability. A site potential analysis has been performed, which then led to the proposal of optimal systems. For the energy supply a PV, highly efficient reversible heat pump/chiller with heat source/ surplus heat sink by closed loop geothermal system as well as evacuated tube thermal collectors have been proposed. To increase internal comfort, movable ventilated internal shades, a wind driven solar chimney supported cross ventilation and an air quality controlled natural ventilation, or a radiant floor conditioning with high cooling and low heating temperatures are used. The concept also includes an individual zone adjustment possibility by gravity wall systems. To optimize the whole system, a set of simulations and mockup tests has been carried out. The results are then compared in this paper with the measurement results from the occupied building operation and further optimization possibilities are presented.

See full paper



The Influence of Heat Gains on the Heating System Design

J Spurny and M Kabrhel

Department of Indoor Environmental and Building Services Engineering, Czech
Technical University in Prague, Czech Republic

spurny.kuba@seznam.cz, michal.kabrhel@fsv.cvut.cz

The article deals with the influence of heat loss of the distribution piping system and the related cooling of the heating water on the design of two-pipe counter-current heating system. The heat loss of the heating water distribution system to the heated room were observed on a reference family house. Consideration of heat gains is particularly important for low energy houses. Moreover, the consequences of heat gains to the room and its effect to the required radiator power output design were solved for case when the piping distribution system is placed visible on the wall and without thermal insulation. The effect is also evident with thermal insulation or embedded pipelines. Furthermore, mass flows and temperature gradients at the same mean temperature were observed on all radiators. This calculation was compared to the results of classic calculation design.

See full paper



A Feasibility Study on the Waste-to-Biogas SOFC-Based Multi-Generation with Energy Storage System for Building Applications in China

S Zhang¹, Q Wang², L Hu³, W Shi⁴ and M Qu²

¹ Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong S.A.R. (China)

² Department of Architecture, University of Cambridge, Cambridge, UK

³ School of Mechanical, Aerospace and Civil Engineering, University of Manchester, Manchester, UK

⁴ Department of Chemical Engineering, University of Cambridge, Cambridge, UK
canaan.zhang@connect.polyu.hk

The Waste-to-Energy Multi-generation system provides a feasible distributed waste recycling and energy saving solution for green buildings. However, the fluctuations in electricity demands and dynamic built environment obstruct its marketization. This study optimizes the existing waste-biogas-SOFC multi-generation configuration with energy storage systems. The research employs the operation data from an international airport in Southern China as a case study. The study compares the proposed system and that of previous SOFC-based systems in terms of economic and environmental benefits. The results show that the demand and supply of energy is balanced and higher energy efficiency and a significant reduction in the Greenhouse Gas (GHG) emission is achieved. The system presents a solid performance in payback and lifecycle cost (LCC) analysis and also satisfactory resistance to financial risks. Finally, this study draws the conclusion that the energy storage system could be utilized to optimize the existing SOFC multi-generation system.

See full paper



Sustainable Urban Development

Material Efficiency of Housing in Times of Demographic Change – Evidence from Case Study Research into two German Municipalities

A Blum and R Gutting

Leibniz Institute of Ecological Urban and Regional Development, Dresden, Germany
a.blum@ioer.de

Housing and construction have a significant impact on the consumption of resources of any society. At the same time, on all policy levels strategy documents towards sustainable development highlight the importance of improvements in resource efficiency. Against this background, this contribution presents results of research on the impact of demographic trends and changing user preferences on the use of resources within the housing sector with a focus on construction materials. The material intensity of different types of housing (in particular detached homes vs. apartment buildings) are quantified under different development scenarios drawn on the basis of two medium sized German case study municipalities showing declining and stagnating population development. Among other, the results indicate that the per capita stock of construction materials within the housing sector remains either stable or may even increase despite a falling population. With respect to alternative development scenarios, our results show, that under the condition of a stable or growing population a shift of housing supply from single-family (detached) homes towards a higher share of multi-unit residential buildings can contribute to a more efficient use of materials. An interesting option under the condition of a declining population is the conversion of a potentially growing number of vacant single-family homes into smaller multi-unit/multi-purpose residential buildings since it can help to avoid vacancy and keep otherwise wasted resources in use.

See full paper



From Assessment to Implementation: Design Considerations for Scalable Decision-Support Solutions in Sustainable Urban Development

V Bukovszki¹, D Apró², A Khoja³, N Essig⁴ and A Reith⁵

¹ 38 Kisfaludy utca, Budapest 1082, Hungary, bukovszki.viktor@abud.hu

² 8 Türr István utca, Budapest 1052, Hungary, aprodiana@gmail.com

³ 4 Untere Sandstrasse, 96049 Bamberg, Germany, Khoja@essigplan.com

⁴ 4 Untere Sandstrasse, 96049 Bamberg, Germany, essig@essigplan.com

⁵ 38 Kisfaludy utca, Budapest 1082, Hungary, reith.andras@abud.hu

bukovszki.viktor@abud.hu

Cities have to face the challenges of steady population growth, the related increase in energy and resource demands, intensifying climate change impacts and rapid technological development. To handle these complex challenges and promote sustainable development, the smart city approach – data-driven planning based on emergent ICT technologies – has been gaining prevalence. However, the lack of shared standards, frameworks, and evidence-based decision-support tools limit the collaboration among smart city actors and the utility of the mainly business-driven technical solutions. This study explores the scalability of indicator systems into a shared framework for smart and sustainable cities by practice-based research during the development of the SmartCEPS project. SmartCEPS is an assessment system and maturity model based on key performance indicators (KPIs) for small- and medium-size European cities. In its architecture, indicators are organized in a causal network capable of capturing synergies, co-benefits and payoffs of decisions; structural metadata provides the means for a gradual customisation of the system; and finally, the indicator pool is scalable by complexity, ensuring different levels of detail in assessments. The study concludes that gradual customisation, network organisation, and open-ended scalability are the proxies for developing decision-support instruments from KPIs.

See full paper



A Systemic Approach for the Optimization of Urban Surfaces Usage

S Croce^{1,2}, D Vettorato¹ and R Paparella²

¹ Institute for Renewable Energy, Eurac Research, Bolzano, Italy

² Department of Civil, Environmental and Architectural Engineering, University of Padova, Padova, Italy

silvia.croce@eurac.edu

This paper proposes a method to support the sustainable development of existing cities through the optimization of the usage of their urban surfaces (i.e. roofs, facades, streets, public spaces, etc.). Adaptation and mitigation strategies aimed at improving resiliency and sustainability of urban areas are highly related to the utilization of these surfaces. The current trends demonstrate the lack of a systemic approach able to integrate multiple possible functions and avoid sub-optimal solutions by considering the physical and morphological characteristics of the urban environment. For example, in cities, conflicts are arising between the surface uses for renewable energy production, urban agriculture, and green solutions.

This study aims at systematizing the existing approaches and proposing a novel method to support the effective application of these solutions. In particular, an analytical procedure is presented to support the integration of different surface uses aiming at the maximization of throughputs, while avoiding conflicts. The method has been tested in a district in Bolzano (Italy) and it is replicable in areas with different morphological characteristics and climate conditions. The final configuration, in which several solutions have been systematically applied and integrated, demonstrate the potentialities of the proposed approach. Outdoor thermal comfort in the district is improved, with a reduction of Universal Thermal Climate Index (UTCI) up to -5.8°C , by simultaneously guaranteeing the production of renewable energy through solar active systems, and the preservation and expansion of existing green areas.

See full paper



Building-Integrated Photovoltaics and Urban Environment from the Perspective of Sustainable Architecture

M Čeněk and D Hlaváček

Department of Architectural Design II., Faculty of Architecture, Czech Technical
University in Prague, Thákurova 9, 166 34 Prague 6, Czech Republic

martin.cenek@fa.cvut.cz, dhlavacek@fa.cvut.cz

Built environment is one of the major causes of the negative impact that human activity has on the environment. Building design should adopt such strategies that would help relieve this situation. Architects should therefore be able to grasp and implement all aspects of sustainable design, including cutting edge technologies, in a holistic and integral fashion. Building-Integrated Photovoltaics (BIPV) represents an important field to explore, since photovoltaic systems have an enormous potential within the context of architectural and urban design. Their implementation though has to be part of the integral design process which is essential for the creation of quality sustainable architecture. Since the world urban population is constantly growing, sustainable approaches to architectural design need to be adopted with urgency in urban environment. Existing urban environment however presents great challenges to the implementation of any new technology. In an urban context we need not only design new buildings, but since the urban tissue is already in place, care must be taken not to damage the historical and architectural values. Furthermore, urban environment has many variations and offers a broad scope of possibilities for various approaches to BIPV. The aim of this paper is to demonstrate the possibilities of BIPV in relationship to sustainable architecture and urban environment, focusing on explaining the necessity to provide architects with a methodology of working with advanced photovoltaic systems in architectural design, introducing the departure points for this intention, and demonstrating how such a methodology – a Design Manual – will be created.

See full paper



Exploring Concept of Sustainability through Understanding Traditional Resource Management Practices: Case of Thar Desert, India

D Ghosh Saxena

IDEATE, New Delhi, India

deepika@ideatedesignstudio.com

The Brundtland Report published in 1980s, for the United Nations Organization, mentioned the concept of sustainability for the first time. It explained the concept as it is understood in modern times. However, while the term itself may not be very old, but is the core idea of sustainability and sustainable development also so recent? Or has it been central to the historic cities and developments which have managed to survive for centuries. Following paper examines various components, principles and parameters of sustainability, as defined in contemporary discourse, in a specific geographical context. The background is set in Indian subcontinent's desert landscape- Thar, an arid and semi-arid geographic region. It explores knowledge systems developed and still practiced by native communities, over generations, to brave tough climatic condition and have shaped unique habitat in this/such resource parched geographies. The paper highlights the core values of sustainability as understood by the native communities of Thar and the nature of development it eventually shaped here as a product of this understanding. Finally, it concludes the merits in taking clues from traditional practices of resource management and strengthening the role of communities towards a more sensitive and sustainable future.

See full paper



Ecosystem Services Assessment Methods for Integrated Processes of Urban Planning. The Experience of LIFE SAM4CP Towards Sustainable and Smart Communities

C Giaimo and S Salata

Interuniversity Department of Regional and Urban Studies and Planning – DIST,
Politecnico di Torino, Viale Pier Andrea Mattioli, 39 – 10125 Torino (TO – ITALY)

carolina.giaimo@polito.it

Evaluation of Ecosystem Services (ES) supports the knowledge and the ability of politicians, administrators, planners and stakeholders to define urban regeneration strategies rather than sustainable spatial planning and design practices responding to climate change conditions and addressing the wellbeing of local communities. The analysis of ES allows for the study of the relationship between urban morphology and land cover/land use to define priorities that maximize the ability of urban systems to deliver multiple benefits (e.g. to store carbon and improve air quality). The recent research innovations made by DIST – Politecnico di Torino for LIFE + Program SAM4CP (2014-2018), moves towards the implementation of a theoretical and practical framework that integrates the process of planning and decision making with the analysis and assessments of ES. The framework has been conceived to support Municipalities to settle policies and monitoring procedures oriented at defining Nature-Based solutions (e.g. restoration strategies) assuming an urban ecology perspective. The project aims at providing a digital tool – a Simulator delivered to Local authorities – to evaluate the ES assessment in different land use scenarios to determine the environmental and economic costs, or benefits, that arise from alternative planning configurations. The evaluation of ES in a case of study area shows that the effective integration of ES evaluation and planning actions is a straightforward method that create awareness and increase the sustainability during decision-making phases for the planning process. The Simulator is available for free on the project website – www.sam4cp.eu – to allow administrators and public officials, as well as spatial planners, interested in such a kind of evaluation, to experiment and apply this methodology.

See full paper



Study on Spatial Evolution of Chinese Green Building

T Hao¹ and J Wang²

¹ Department of Urban Planning and Design, The University of Hong Kong, Pokfulam, Hong Kong SAR, China

² Henan Environmental Protection Science Academy, Zhengzhou, China

tphao18@hku.hk

Green building is an important part of ecological civilization construction in China, which is also a significant reflection of national developing under a new type of urbanization [1]. Since 2006, the number and total gross floor area of green building has achieved major development with the promulgation and implement of national and local standards and promotions of green building. However, this rapid development shows an obvious regional difference and imbalance. This paper conducts a quantitative study by using geospatial statistics theory and geographic information system technique. It aims to explore characteristics and the driven factor of green buildings' spatial evolution so that the development level of green building could be evaluated based on much more scientific and reasonable method. It also aims at providing theory supporting as well as reference for policy making to stimulate green building development in a more balanced way.

See full paper



Challenges and Opportunities of Urban Fabrics for Sustainable Planning In Cuenca (Ecuador)

M A Hermida, D Cobo and C Neira

Universidad de Cuenca, Departamento de Espacio y Población, LlactaLAB-Ciudades
Sustentables, Facultad de Arquitectura y Urbanismo, Cuenca, Ecuador.

augusta.hermida@ucuenca.edu.ec

In recent years attention has been given to the reduction of greenhouse gas emissions, causing climate change, without recognizing the importance of urban form. In Latin American cities, spatial dynamics, urban fabrics and territorial distribution, among others, are not always considered when plans are developed. The cities of Ecuador, particularly Cuenca, show processes of dispersion as a result of their own growth disconnected from urban centers, which is evidenced by the high rate of use of the private vehicle per capita and implies a high consumption of fossil energy and environmental pollution. Additionally, urban fabrics affect the functioning and social dynamics of a city and therefore have a direct relationship with planning. With this background, this project seeks to identify and categorize different urban fabrics in the city of Cuenca using a visual methodology that takes into account street and block patterns; patterns of parcelization and land use; building form, scale and placement on lots; street and parking design; and typical relationships between “green” and “gray” landscape components. As a result, eighteen urban fabrics were identified in the city, with different challenges and opportunities for sustainability. The produced knowledge allowed the generation of sustainable and resilient planning recommendations and opened a wide field of possibilities for future research.

See full paper



Periurban Urbanization and Travel Choice Behaviour: Problem or Solution?

M A Hermida, D Astudillo and F León

Universidad de Cuenca, Departamento de Espacio y Población, LactaLAB-Ciudades
Sustentables, Facultad de Arquitectura y Urbanismo, Cuenca, Ecuador

augusta.hermida@ucuenca.edu.ec

In 21st century cities, an adequate urban design represents a great opportunity to reduce the number of trips and distances travelled. It is also known that improving city design and transportation networks could reduce carbon emissions more than replacing all fossil fuels with renewable energies. With this background, it seems fundamental to focus on the systemic relationship between urban forms and travel choices behaviours. In the case of the city of Cuenca (Ecuador,) in the last 5 years, more than 70 mono-functional urbanization and condos, many of them being gated-communities, have been built outside the urban limits. These form of urbanization is supported both by public and private promoters. Due to this situation, this research project seeks to determine the relationship between the location of these urbanizations and condos, with the travel choice behaviour of users. Geographic information systems, Q methodology, travel diaries and qualitative methods were used for data collection and spatial representation. Three discourses were found, people who preferred the proximity to nature and open spaces, other who gave more importance to efficient mobility and the last ones for whom security was the most important aspect. This work opens possibilities for further research on the importance of urban form for sustainable planning and mobility.

See full paper



Communities Shaping Sustainable Cities

J Hořická

Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7/2077,
166 29 Prague 6, Czech Republic

jana.horicka@fsv.cvut.cz

The contribution introduces significance of local communities in global context of sustainable urban development. Since last decades, urban regeneration, redevelopment and improvements of stabilized localities has become the subject of attention, as the limits of land use and urban expansion has been understood and generally accepted. Recently, the role of community and citizens has been emphasized in international strategies, for instance UN 2030 Sustainable Development Goals (2015) or UNESCO Strategic Objectives of the World Heritage Convention, so called Five C's (the fifth C representing Community added in 2007). Bottom-up initiatives and community activities have become important in urban revitalization and regeneration. The contribution aims to describe the activities and roles of various stakeholders, based on analysis of application project in Prague, Czech Republic inspired with a project in Basel, Switzerland, and characteristics of the evolution process heading towards community activation, which is important for the integrated planning processes, involving an interdisciplinary team and active public participation.

See full paper



Measuring Livability at the Neighborhood Scale – Development of Indicators and Methods for the Comparison between Neighborhoods and Best Practice within the Chosen City

H-H Chen¹ and U Dietrich

¹ REAP Research Group, HafenCity University Hamburg, Germany

udo.dietrich@hcu-hamburg.de, hsiao-hui.chen@hcu-hamburg.de

A method that allows an assessment of the livability by comparing different neighborhoods with each other as well as with the best practice was developed in this paper. First of all, a set of 51 indicators comprising the categories of connectivity, traffic, public transportation and bicycle infrastructure, urban form, density, land use, open space coverage ratio, potential for PV, green roof and materials were defined. The values for these indicators were investigated for 36 neighborhoods in the city of Hamburg, Germany. Secondly, some neighborhoods were chosen as the most livable neighborhoods and the average of their results was used for indicating the best practice in Hamburg. This approach allows users to compare their chosen neighborhoods with the best practice of their own city. Thirdly, each absolute indicator value was transferred into a relative one, where 0 % represents the lowest found value and 100 % the highest one. Fourthly, each indicator was assigned with a character. If the smaller percentage the better, like percentage of buildings near a noisy street, this character is “S”. If the bigger percentage the better, like frequency of public travel, the character is “B”. If the closer to the best practice the better, like inhabitants per hectare, the character is “R”. Thus, the ideal neighborhood would show 0 % for character S, 100 % for B and the best practice for R. Finally, the results are presented in the radar charts in order to facilitate the comparison.

See full paper



GIS-3D Platform to Help Decision Making for Energy Rehabilitation in Urban Environments

J L Izkara, A Egusquiza and A Villanueva

Building Technologies Division, Tecnalia Research & Innovation, Spain

joseluis.izkara@tecnalia.com

One of the main current challenges of European cities is to become energy self-sufficient entities. One of the vectors for this challenge is to improve the energy efficiency of the buildings and to promote the generation of renewable energies in the urban environment. The article describes a tool based on GIS-3D technologies to support the identification of the energy rehabilitation potential of neighbourhoods based on the introduction of renewable energies. The platform is based on a urban 3D model that collects the geometry of buildings, together with relevant information for the identification of rehabilitation opportunities (e.g. surfaces, heights, orientations and slopes). The project includes the generation of a cloud-based repository, which incorporates active and passive innovative solutions with metrics that allow the comparison of the solutions and the applicability of them to the real environment. The identification of rehabilitation opportunities combines information resulting from the diagnosis of the current energy performance of the district's buildings with the potential for renewable generation in the area. A multicriteria analysis process facilitates the identification of the most appropriate rehabilitation solutions for the analysed environment based on different criteria as energy, cost or applicability. The result can be visualized through a web tool that combines 2D and 3D information, with comparative information in a quantitative and geo-referenced manner. The flexibility of the architecture allows the application of the same approach to different urban challenges as the application of energy conservation measures to protected historic urban areas.

See full paper



Can Buildings Save and Improve Municipal Infrastructure?

W Kujawski

Integrated Solutions Group, Ottawa, Canada
wk.kujawski@gmail.com

Architects, while creating the built environment, expand their knowledge by learning that buildings are more than places to live, work and play. Buildings can create a sense of community and add to the character of neighborhoods and cities. They can also support communities by either directly contributing to the infrastructure requirements or indirectly by reducing their demands and creating supply and treatment systems, thus increasing capacity in community energy, water treatment and stormwater systems for others. They can also reduce wastage by recapturing heat lost through inefficient systems, sewers, and by using municipal waste as a fuel source. Buildings can use a lot of energy delivered by conventional energy sources. The reduction potential for their high energy (and water) demand always represents an opportunity to decrease the potential impacts on municipal infrastructure. It is also a significant part of the challenge to reduce or cut emissions, mitigate the effects of climate change and save on resources. The paper explains how buildings can mitigate such impacts while also acting as contributors to the infrastructure. The examples demonstrate various urban and building related design concepts combined with some essential aspects of costs and savings incurring in sustainable buildings and communities. When buildings act as infrastructure they can benefit not just the developer, occupant or owner, they can also spread those benefits to the neighborhood and community and much further- to the entire planet.

See full paper



Sustainable Campus Development in the Context of a Private Higher Education Institution in Hong Kong, a Case Study at the Hang Seng University of Hong Kong

H H Y Lee

Campus Development and Management Office, The Hang Seng University of Hong Kong, Hang Shin Link, Siu Lek Yuen, Shatin, New Territories, Hong Kong

hackmanlee@hsu.edu.hk

There was a trend of increasing private higher education institutions in Hong Kong, some higher education institutions implemented sustainable campus development despite of financial difficulties with main aim to continue the concepts and values of sustainability for the achievement of purpose of education for diffusion to the society. This paper reviewed sustainable campus development by looking at the physical environmental aspects, organizational changes and operational barriers. Moreover, different green building rating systems were discussed. It also summarized the impacts after completion of a sustainable campus development at the Hang Seng University of Hong Kong including changes in habits and behaviour, organizational re-structuring, enhancement of sustainable attributes to policy and strategic plans as well as external influences and relationships. The results demonstrated how a sustainable campus development could transform concepts, values and attitudes in relation to sustainability on individual, organizations and the society for practices.

See full paper



The Integration of Sustainable Cities in the Marshes (Iraq)

A A Rashid Kbah

AL Muthanna University, collage of Eng. Architectural Dept. IQ
ahmed.architect@mu.edu.iq

The extensive marshlands of Mesopotamia represent a unique component of our global heritage and resources. The seas of reed beds were home to ancient communities rooted in the dawn of human history. The wetlands are the locale in which human civilization began with the Sumerian culture more than 5,000 years ago. Scholars regard the marshes as the site of the biblical "Garden of Eden," the "Great Flood," and the birthplace of the patriarch Abraham. On the shores of the marshes, the legendary Epic of Gilgamesh was enacted. World-renowned archaeological sites on the fringes of the marshes include Ur, Uruk, Eridu, Larsa, Lagash and Nina. The current marsh dwellers are our only link with this rich cultural past. Following the end of the Gulf War in 1991, the marsh dwellers were important elements in the uprising. To end the rebellion, the regime implemented an intensive system of drainage and water diversion structures that desiccated over 90% of the marshes. The reed beds were also burned and poison introduced to the waters. It is estimated that more than 500,000 were displaced, 95,000 of them to Iran, 300,000 internally displaced, and the remainder to other countries. By January 2003, the majority of the marshes were wastelands. From this point and to re settling the local community the research trying to present a sustainable village in the marshes that can be built from local materials and depend on the local society.

See full paper



Planning and Implementing Low Carbon-Communities in Canada

J Skopek¹, S Pope² and S Bucking³

¹ JLL, 165 Kenilworth Avenue, Toronto, Ontario, Canada M4L 3S7

² CSV ARCHITECTS, 402-1066 Somerset West, Ottawa, Ontario, K1Y 4T3

³ Carleton University, 1125 Colonel By Drive, Ottawa, Ontario, K1S 5B6

jiri.skopek@am.jll.com

Given the urgency to mitigate climate change, an efficient and effective approach is to reduce carbon reduction at the community level. This is more cost-effective than addressing buildings individually because it opens opportunities for both cost-effective economies of scale to deploy renewable energy and other technologies.

While there are currently several low/near net zero-community pilots in existence or in the making, they usually occur in specialized circumstances such as residential subdivisions or model communities, and they tend to focus on technology fixes. To achieve climate change mitigation goals, a more holistic approach is needed that consists of a planning process for existing communities, which integrates energy and resiliency, and involves the utilities. This paper explores common barriers to an integrated process and examines the advantages of a utility-led approach.

See full paper



Urban Decay in Central Hill, Port Elizabeth

F Swanepoel and J Smallwood

Nelson Mandela University, PO Box 77000, Port Elizabeth, South Africa, 6031
john.smallwood@mandela.ac.za

Urban decay has caused the destruction of many neighbourhoods in many great cities, and Central Hill in Port Elizabeth is no exception. Given the reports in the media, and the visible urban decay in areas of Central Hill, a qualitative study entailing interviews was undertaken to determine the status quo, and the relationship, if any between various issues relating to urban decay. Findings include: that urban regeneration has had an impact, however urban decay is still occurring; there are five key issues in terms of mitigating urban decay through the management of the area; there are thirteen qualities that make a building uninhabitable; the raiding of abandoned buildings cause urban decay; there are five key aspects of a building require regular maintenance, and building owners can receive enough income to maintain their buildings if they ask fair market related rentals. Conclusions include that the cause of urban decay cannot be pinned to one specific event or incident, but is a result of many factors. Recommendations include: the development of an overarching strategy; optimum management of the area by all stakeholders; optimum policing; adequate maintenance of buildings; market-related rentals; development and enforcement of municipal bylaws, and municipal incentives for maintaining buildings in an optimum state.

See full paper



System Model for Prediction of Energy Consumption in Cities

D Vytlačil

Department of Engineering Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague, Czech Republic

vytlacil@fsv.cvut.cz

The number of inhabitants in cities has been increasing in the past years and this tendency will be in the future even more significant. We need a tool for the prediction of the energy consumption. The paper describes the system model that includes sub models: the energy consumed for housing, inhabitants services, city services and transport. These sub models are interconnected to one system. The solution is based on the system dynamics methodology which is suitable tool for solving problems of economic and technical systems. Special focus is given on the description of the energy consumptions in the residential houses, in the buildings providing city service and on the migration of people from rural area and small cities to big cities. The number of inhabitants influences the energy consumption and the density that is connected to the energy consumption for the transport. The simulation includes the refurbishment of the existing building stock. Main output parameter is the energy consumption in the sub models and in the whole city. The model can help to improve the strategy decision making concerning city development.

See full paper



Retrofitting of Existing Buildings

OptEEmAL: Decision-Support Tool for the Design of Energy Retrofitting Projects at District Level

**M A García-Fuentes¹, G Hernández¹, V Serna¹, S Martín¹, S Álvarez¹,
G N Lilis², G Giannakis², K Katsigarakis², L Mabe³, X Oregi³,
D Manjarres³, H El Ridouane⁴ and L De Tommasi⁴**

¹ CARTIF Technology Centre, Energy Division, Valladolid, Spain

² Technical University of Crete, Chania, Greece

³ Tecnalia Research and Innovation, Bizkaia, Spain

⁴ United Technologies Research Centre Ireland Ltd, Cork, Ireland

miggar@cartif.es

Designing energy retrofitting actions poses an elevated number of problems, as the definition of the baseline, selection of indicators to measure performance, modelling, setting objectives, etc. This is time-consuming and it can result in a number of inaccuracies, leading to inadequate decisions. While these problems are present at building level, they are multiplied at district level, where there are complex interactions to analyse, simulate and improve. OptEEmAL proposes a solution as a decision-support tool for the design of energy retrofitting projects at district level. Based on specific input data (IFC(s), CityGML, etc.), the platform will automatically simulate the baseline scenario and launch an optimisation process where a series of Energy Conservation Measures (ECMs) will be applied to this scenario. Its performance will be evaluated through a holistic set of indicators to obtain the best combination of ECMs that complies with user's objectives. A great reduction in time and higher accuracy in the models are experienced, since they are automatically created and checked. A subjective problem is transformed into a mathematical problem; it simplifies it and ensures a more robust decision-making. This paper will present a case where the platform has been tested.

See full paper



Retrofitting Hospitals: A Parametric Design Approach to Optimize Energy Efficiency

J Gaspari, K Fabbri and L Gabrielli

University of Bologna, Department of Architecture, via dell'Università 50, Cesena

jacopo.gaspari@unibo.it ; kristian.fabbri@unibo.it; lindagabrielli.lg@gmail.com

Despite many progress have been done in the renovation of the existing stock, retrofitting hospitals and other strategic buildings still represent a very challenging issue both for their complex articulation and for the need to maintain acceptable operational level. The paper reports a research activity, run at the Department of Architecture in cooperation with S. Orsola Hospital in Bologna, aimed at investigating innovative strategies for retrofitting to meet the highest energy efficiency standards at national level. The main goal of the administration was to set a renovation plan – taking into account some limitations concerning the existing building features and the budget availabilities – able to remarkably reduce energy demand while creating the minimum disruption for end users. The starting position of the research was to preserve the historical image of the building while defining a strategy to insulate it from inside. The novelty of design approach lied in defining a basic working unit which was associated to the typical room of the stay division that was used to analyse the starting conditions (indoor comfort and environmental parameters) and simulate via software modelling the potential improvements. This led to define a step by step strategy that was translated into global intervention scenarios while the basic working unit was properly re-designed and validated. This approach allowed to define a parametric strategy able to predict the impacts of renovation on each floor, on each wing and on the system as a whole while assigning a specific unit cost and a reliable renovation timing.

See full paper



Typology of Unclassified Buildings and Specifics of Input Parameters for Energy Audits in Latvia

A Geikins, A Borodinecs, G Daksa, R Bogdanovics and D Zajecs

Institute of Heat, Gas and Water Technology, Riga Technical University
anatolijs.borodinecs@rtu.lv

The aim of the study is to analysis renovation solutions for unclassified buildings. According to Latvian law definition, unclassified buildings are prisons, security forces, police and fire services buildings including barracks, warehouse etc. Such buildings has completely different heat gains and heat losses balance and usage profile in comparison to traditional public and apartment buildings. Unclassified buildings could have higher internal heat and moisture loads, more strict requirements to dress code (CLO level), human metabolic equivalent and limited possibility for staff adaptation to IAQ parameters. The one of important factors is safety of energy supply and operation of HVAC systems. Although the energy security is a top priority for unclassified buildings, it should not be a barrier for implementation of renewable energy sources and innovative energy efficient retrofitting solutions in unclassified buildings.

See full paper



Development of a Modular Retrofitting System for Residential Buildings and Experience from Pilot Installation

P Hejtmánek, K Sojková, M Volf and A Lupíšek

Czech Technical University in Prague, University Centre for Energy Efficient buildings,
Trinecká 1024, 273 43 Bustehrad, Czech Republic

antonin.lupisek@fsv.cvut.cz

In order to significantly reduce energy consumption of its building stock, Europe has to focus on energy retrofitting of existing buildings. A usual building retrofitting process is very labour intensive and time consuming. It usually takes several weeks or even months to replace old windows by new, install new thermal insulation layers on the external walls and roofs of buildings and renew the heat distribution systems or to attach renewable energy sources on the building's envelope. To make refurbishment more efficient and allow its scaling up, a European project Development and Advanced Prefabrication of Innovative, Multifunctional Building Envelope Elements for Modular Retrofitting and Connections (MORE-CONNECT) has been initiated under H2020 program. This project developed a system of prefabricated retrofitting modules, that enable to cut primary energy consumption of a typical residential building by 80 %, reduce on-site installation time below two weeks and improve the indoor environmental quality. At the same moment, the project aimed on implementation of systemic quality control over the whole design, pre-production, production and installation process in order to significantly reduce the number of warranty claims by the clients. The paper describes the design process of the modular retrofitting system and a pilot installation made on a mock-up building to test the concept, and presents the experience made.

See full paper



New European Document on Assessment of Existing Structures and Building Stock

M Holický

Klokner institute, CVUT in Prague, Šolínova 7 Prague 6, Czech Republic
milan.holicky@cvut.cz

The upcoming CEN Technical Specification (TS) on assessment of existing structures and building stock is related to the fundamental concepts and requirements of the current generation of EN Eurocodes. The final draft of the Technical Specification was already submitted to the technical committee CEN TC250 in April 2018. The document concerns all types of building stock, buildings, bridges and construction works, including geotechnical structures, exposed to all kinds of actions. It contains requirements, general framework of assessment, data updating, structural analysis, different verification methods (partial factors, probabilistic methods, risk assessment), past performance, interventions, annexes (flowchart, target reliability and partial factor methods, assessment of heritage building stock). The submitted contribution provides background information on the principles accepted in the final draft of TS and practical examples of applications to assessment of existing building stock. Particular attention is given to operational assessment methods of existing buildings taking into account actual material properties and actions.

See full paper



Thermal Retrofitting of Dormitory Under Historic Protection – Case Study

J Kwiatkowski, J Sowa and A Wiszniewski

Warsaw University of Technology, Faculty of Building Services, Hydro and Environmental Engineering, 20 Nowowiejska Street, 00-653 Warsaw, Poland

jerzy.kwiatkowski@pw.edu.pl

The Recast of the Directive on the Energy Performance of Buildings (the EPB Directive) came into force on 9 June 2010. EU member states should until 9 June 2012, publish the relevant laws and administrative regulations necessary to implement its provisions. One of the main requirements of the directive is to set a definition of nearly zero energy building (nZEB). Most of the EU member states have already set a definition of nZEB for new buildings and some of the countries also done it for existing buildings. The thermal modernization of existing buildings is a key element in decreasing energy consumption in building sector. In general such a modernization is connected with insulation of external partitions, exchange of windows or improving heating system efficiency. The problem occurs when a building is under historic protection. In this case most of typical thermos-modernization measures cannot be applied. In the paper a case study of dormitory building retrofitting to a proposed nZEB standard will be presented. The aim of the paper is to present what measures can be used in order to decrease energy consumption in existing buildings. Building chosen for analysis is under historic protection which makes the work even more difficult. It will be proved that used solutions were chosen not only to reduce energy demand or increase energy production from renewable energy sources, but also to increase thermal comfort within building.

A Multi-Step Design Framework Based on Life Cycle Thinking for the Holistic Renovation of the Existing Buildings Stock

C Passoni¹, A Marini¹, A Belleri¹ and C Menna²

¹ Department of Engineering and Applied Science, University of Bergamo, via Marconi 5, 24044, Dalmine (BG), Italy

² Department of Structures for Engineering and Architecture, University of Naples Federico II, via Claudio 21, 80125, Napoli (NA), Italy

chiara.passoni@unibg.it

In recent years, the transition to a sustainable society has highlighted the importance of tackling a holistic renovation of the existing building stock, able to contextually solve its structural, energy, and architectural deficiencies. Nevertheless, in practice, the cost of the intervention, the building downtime, and the potential relocation of the inhabitants have been recognized as major barriers to the renovation. To overcome such barriers and foster sustainability, eco-efficiency, and resilience, new design approaches and solutions sets have been proposed. However, given the lack of a global vision of current regulations, a design framework able to conjugate technical and functional performances with principles of sustainability and feasibility is still required. In this paper, a new multi-step design framework is proposed, which, for the first time: 1) adapt the three pillars of sustainability to the renovation of the existing buildings interpreting them as reduction of environmental impacts, increase of safety and resilience, and overcoming of the major barriers to the renovation; 2) introduce a new Life Cycle perspective that also considers impacts and loss associated to structural decay and vulnerability of existing buildings; 3) shift from an ex-post perspective to an ex-ante framework, to be used since the initial design steps.

See full paper



Internal Ventilated Plinth as One of the Possible Solution for Moist Buildings

J Pazderka, P Hájek, H Žáková and M Nývlt

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czechia

jiri.pazderka@fsv.cvut.cz

Additional protection of aged buildings against rising moisture is one of the most important measures to ensure their long-time durability and sustainable user properties. One of the remediation methods is the ventilated wall (air cavity created by additional thin wall), located in the interior of the building but ventilated to the exterior. The aim of this remediation measure is to reduce the amount of rising water which increases moisture level in building walls (in case of malfunctioning or missing waterproofing layer). The paper presents innovative technical solution in this field. The technical solution relates to an internal ventilated segmental plinth, which is formed by an assembly of shaped boards with a thermal insulation layer applied to their back sides and being provided with side plates for their butt joining one next to the other alongside the inner side of the building maintained exterior wall. The boards form a continuous air cavity enabling intense diffusion of water vapor from the adjoining moist wall. This patented solution is very simple, low cost and can be done from environmentally friendly materials.

See full paper



A Bibliometric Analysis on Costs Estimation of Building Retrofit

F Re Cecconi, N Moretti and M C Dejacó

Department of Architecture, Built Environment and Construction Engineering
Politecnico di Milano, via G. Ponzio 31, 20133 Milan, Italy

Corresponding author: nicola.moretti@polimi.it

Buildings are responsible for approximately 40% of energy consumptions and 36% of CO₂ emissions in the EU. In developed countries, any intervention carried out for buildings' sustainability improvement is related to energy retrofit. Energy retrofit can be considered as a subset of sustainability management and is one of the key issues to be taken into account for the setup of an effective asset and portfolio management strategy. Among asset management core functions, sustainability management is one of those which must be encompassed in a strategic framework for effectively reaching the goals of the organisation. Within this context, sustainability of buildings should be evaluated according to the environmental, economic and social point of view. These different issues require specific assessment methodologies and metrics. Therefore, in this article, a bibliometric analysis on costs estimation is presented, focusing on Life Cycle Costing methodology for energy retrofit interventions. Articles have been investigated through bibliometric, trend and cluster analysis on a sample of 167 articles. The research has been carried out on one of the most acknowledged databases as Scopus and allowed to identify main trends and dynamics of the scientific literature.

See full paper



Energy Renovation of Social Housing: Finding a Balance Between Increasing Insulation and Improving Heating System Efficiency

E Van De Moortel¹, K Allacker¹, F De Troyer¹, L Stijnen² and E Schoofs³

¹ KU Leuven, Leuven, Belgium

² Zonnige Kempen, Westerlo, Belgium

³ Molse Bouwmaatschappij, Mol, Belgium

els.vandemoortel@kuleuven.be

As the budget of social housing companies is limited, reducing the energy use of their housing stock to be compliant with current standards and actions plans is an important challenge. Currently social housing companies in Flanders often prefer replacing the heating system to insulating the building envelope due to the lower investment cost and easy implementation. However, the investment in better heating systems has to be repeated several times during the service life of the building. This paper provides insights in the investment cost and life cycle cost of both renovation strategies. Moreover an environmental life cycle assessment provides insights in the environmental impact of the renovation strategies. The analysis reveals that it is recommended to replace heating boilers not earlier than at the end of their technical service life, both from an environmental and economic perspective. Sensitivity analyses show that changes in the estimated remaining building service life and increasing discount rate lead to changes in the life cycle costs but have no influence on the ranking of the renovation scenarios. Changes in the energy price, insulation level and original building type lead to changes in the costs and ranking of the renovation scenarios.

See full paper



The District Energy-Efficient Retrofitting of Torrelago (Laguna de Duero – Spain)

**A Vasallo¹, E Vallejo¹, G Massa¹, A Macía¹, L Pablos¹, C Criado²,
E Arrizabalaga³, J Iturralde³, A Gordaliza⁴, I De Castro⁵ and F Larrinaga⁶**

¹ Fundación CARTIF

² ACCIONA Ingeniería

³ TECNALIA Research and Innovation

⁴ VEOLIA

⁵ 3IA Ingeniería

⁶ MONDRAGON Corporation

alivas@cartif.es

The urban growth is estimated to reach up the 66 % by 2050 and consequently the need of resources within the cities will increase significantly. This, combined with the 40 % of energy consumption and 36 % of CO₂ emissions of the building sector, makes necessary to accelerate the transition towards more sustainable cities. The CITYFiED project contributes to this transition, aiming to develop an innovative and holistic methodological approach for energy-efficient district renovation and deliver three large scale demonstration cases in the cities of Lund (Sweden), Laguna de Duero (Spain) and Soma (Turkey). CITYFiED methodology consists of several phases that ease the decision-making tasks towards the district renovation, considering the energy efficiency as the main pillar and local authorities as clients. For the case of Torrelago district (Spain) the intervention consists of a set of energy conservative measures including the façade retrofitting of 143.025 m² of living space in 31 twelve-storey buildings; the renovation of the district heating network with a new biomass thermal plant; the integration of renewable energy sources, including a micro-cogeneration system, and the installation of individual smart meters. After the renovation action, one-year monitoring campaign is ongoing. The CITYFiED monitoring platform will collect information from the energy systems and deliver environmental, technical, economic and social key performance indicators by March 2019. At the end of the project the achievement of the predefined goals will be verified: up to 36 % of energy saving and 3,429 tons-CO₂/yr emissions saving covering the 59,4 % of the energy consumption with renewable sources.

See full paper



Energy Sustainable Living – Deep Renovation of Residential Building – PAVE

J Včelák and E Novák

Czech Technical university in Prague, University centre for energy efficient buildings
Trinecká 1024, Buštěhrad, 273 43, Czech Republic

jan.vcelak@cvut.cz

There are not many energy plus building projects in Czech Republic. Project described in this paper aims even higher because the goal is to renovate older building to energy plus standard and not build it from the scratch. This article describes concept of energy active building which will be renovated in Litoměřice. Older military building from 1980 will be renovated into energy active standard with a high share of renewables. The purpose of the building is to provide low area – starting flats for young families. The concept is unique in terms of complexity since it counts with direct use of the energy from PV, battery energy storage as well as electromobility charging stations. The results of simulations and estimations are shown in this publication as well as comparison of various simulated options.

See full paper



Incremental Integrated Holistic Rehabilitation: A New Concept to Boost a Deep Renovation of the Existing Building Stock

J Zanni¹, S Labò¹, C Passoni¹, E Casprini¹, A Marini¹, A Belleri¹ and C Menna²

¹ Department of Engineering and Applied Science, University of Bergamo, via Marconi 5, 24044, Dalmine (BG), Italy

² Department of Structures for Engineering and Architecture, University of Naples Federico II, via Claudio 21, 80125, Napoli (NA), Italy

jacopo.zanni@unibg.it

The renovation of the post-World-War-II reinforced concrete building has become an urgent action in order to meet energy-saving and to foster safety among the European communities. In this context, in order to overcome the major barriers to the renovation and to increase the feasibility of a deep, sustainable renovation action, a new incremental holistic rehabilitation (IHR) approach is introduced. This new approach has the major aim of fostering a safe, resilient and more sustainable society by addressing the life cycle thinking principles and by implementing incremental levels of safety. In this paper, an IHR strategy is defined and applied to a reference scholastic building. Fundamental criteria for the selection of the proper renovation strategy guaranteeing the minimum environmental impact and the applicability to Reinforce Concrete existing infilled frames are derived. The results show that a holistic incremental rehabilitation strategy can represent a good answer to the urgent need of sustainable renovation of Italian and European building stock.

See full paper



Indoor Environmental Quality

Influence of Airflow on Thermal Comfort in an Energy-Saving House

D Adamovský and M Kny

University centre for energy efficient buildings CTU in Prague, Třinecká 1024, Buštěhrad
daniel.adamovsky@fsv.cvut.cz

The current thermal properties of building external structures including openings are supposed to suppress effects of draft to thermal comfort. But is it true expectation? The subject of the paper is the analysis of airflow around the window in three types of heating systems with predominant radiant as heat transfer. The analysis is based on experiments in the climatic cabin representing the room of a low-energy family house. To obtain the relevant data, a series of particle image laser velocimetry measurements were performed to visualize and quantify the airflow in the investigated area. The paper present results of the thermal comfort of the inhabitants of the room, which prove that with the influence of draft it is necessary to count on modern energy-saving buildings. They prove that old well-known rules about the position of the heating surface apply to the most cooled constructions and bring interesting conclusions about underfloor heating.

See full paper



Performance Analysis and Energy Saving Potential of Room Integrated PCM Wallboards for Passive Cooling Application

B Chhugani, M Yasin, F Klinker, H Weinlaeder, S Weismann and M Reim

Bavarian Center for Applied Energy Research (ZAE Bayern), Division Energy Efficiency, Magdalene-Schoch-Straße 3, Würzburg 97074, Germany,

felix.klinker@zae-bayern.de

Phase Change Materials (PCMs) can enhance thermal mass and energy efficiency in lightweight buildings. In this work, the thermal behaviour of plasterboards with incorporated microencapsulated PCM is investigated. These PCM wallboards are mounted in office rooms of the Energy Efficiency Center (EEC) in Würzburg (Germany). The experimental results show that the PCM wallboards can provide a passive cooling power of up to 8.4 W/m^2 . However, the regeneration behaviour of PCM during the night critically influences their thermal performance for the next day. In the period from April to September of the years 2015 and 2016, the average regenerated (solid) fraction of the PCM in the wallboards at the beginning of each day was only 20 %, even though the regeneration is supported by the nightly operation of cooling ceilings. In order to improve the thermal performance of the wallboards this problem has to be addressed. Therefore, a case study is performed with the thermal building simulation software TRNSYS 17. In this simulation, a night ventilation is used to enhance PCM regeneration, whereas active cooling by means of the cooling ceiling only takes place during the day. The simulations were carried out for two PCMs differing in the melting range. The simulation results reveal that the regeneration of the PCM wallboards could be increased by a factor of 2, which directly increases the latent heat storage capacity in rooms and reduces the temperature rise during daytimes. Compared to a reference room without PCM wallboards, the electrical energy demand for active room cooling is reduced by 30 %.

See full paper



Acoustic Evaluation of the Air-Conditioning Unit in the Room

J Králíček^{1,2} and M Kučera^{1,3}

¹ Czech Technical University in Prague, Faculty of Mechanical Engineering, Department of Environmental, CZ

² AKUSTPROJEKT s.r.o., Prague, CZ

³ University Centre for Energy Efficient Buildings of Technical University in Prague, Prague, CZ

jan.kralicek@fs.cvut.cz

This paper deals with an acoustic simulation, evaluation and measurement of an indoor air-conditioning unit commonly used in hotel rooms. The unit is situated in the plaster board ceiling of a hotel room above the entrance of the hotel room. The first step was to create a model of the real indoor air-conditioning unit from the catalogue data of a manufacturer, then built the model for the simulation of the internal sound propagation in the hotel room. The second step was to mock-up the real hotel room. The goal of the paper is to compare the calculated data from the simulations with the measured data in-situ.

See full paper



Assessment of the Indoor Environment for Education

M Kraus and P Nováková

Institute of Technology and Business in České Budějovice, Department of Civil Engineering, Okružní 517/10, 370 01 České Budějovice, Czech Republic
info@krausmichal.cz

Indoor environment quality (IEQ) and its effect on well-being, productivity and performance are phenomena. Achieving suitable and comfortable indoor environment is a key factor in the creation and operation of the buildings in terms of basic principles of the sustainable development. The poor indoor environment is associated with the Sick Building Syndrome (SBS). The occurrence of pollutants in the indoor environment brings health problems to occupants as well as affects their productivity and performance. The main aim of the contribution is the study of indoor environment for educational purposes. The ordinary university classrooms located on the outskirts of the city České Budějovice (Czechia) are analysed. The classrooms are places, where the students reading, calculating, writing, and solving the assigned tasks. Achieving and satisfying the comfort in the indoor environment for education purposes is necessary for these student's activities. For example, insufficient air exchange and the CO₂ concentration above of 1000 ppm, cause fatigue and decreased concentration. The assessment of physical-chemical parameters includes analysis of indoor air temperature [°C], relative humidity [%], Carbon Dioxide (CO₂) concentration [ppm], and illumination intensity [lx] in the university classrooms. The high-quality sensor for measuring air flow, temperature, humidity, pressure, heat radiation, CO₂ concentration and illumination intensity Testo 480 with globe probe, IAQ probe, light probe and comfort level probe is used for measurement. The work is supported by the grant Specific University Research SVV 201802 Address identification and analysis of the determinants of the Indoor Environment Quality (IEQ).

See full paper



Daylighting Design Process for Visual Comfort and Energy Efficiency for a Signature Building

N Kutlar and M P Mengüç

Ozyegin University, Center for Energy, Environment and Economy (CEEE), Istanbul, 36794, Turkey

nil.kutlar@ozyegin.edu.tr, pinar.menguc@ozyegin.edu.tr

Human comfort is the most important priority in designing living environments. Achieving thermal comfort, visual comfort, effective operation of a building along with innovative energy efficiency measures require extensive involvement of engineers and architectures in tandem for the future high-performance buildings. In this paper, we focus on design of the daylighting aspects of a complicated building and present a methodology. The concept here is based on the interactions of several stakeholders including the project owner, the project architect, structural engineers, façade engineers, mechanical engineers, lighting designers and electric engineers, who are involved in extensive discussions towards the design and construction of a complicated building in a university campus. Simulations are carried out using different architectural and computational techniques including DesignBuilder and Revit. The project constraints set by the stakeholder preferences are resolved with other engineering methodologies. This interactive process allowed a very favourable design of daylighting in the building. In this paper, the steps are discussed and the methodology is outlined.

See full paper



Effect of the Personalized Ventilation to a Human Thermal Comfort

V Mazanec^{1,2} and K Kabele^{1,2}

¹ Department of Indoor Environmental and Building Services Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6 – Dejvice, Czech Republic

² University Centre for Energy Efficient Buildings of Technical University in Prague, Trinecká 1024, 273 43 Buštěhrad, Czech Republic

vojtech.mazanec@fsv.cvut.cz

The paper deals with effect of the personalized ventilation on thermal comfort of the human body. Especially the influence of different temperatures and velocities of the supply air provided by the personalized ventilation on sitting user during standard light office work. The goal is to figure out possible and comfortable range for the personalized ventilation system and to determine the maximum power of the device. For measurement we were using a prototype of the personalized ventilation system which is able to adjust temperature of the supply air using thermoelectric elements. A thermal manikin was used to simulate the human body and to measure the effect of the ventilation system to the human thermal comfort and the PIV (Particle Image Velocimetry) was used to measure vector field around the human body.

See full paper



Virtual Air Temperature Function for Room Thermostats

O Nehasil, J Horváthová, A Kohoutková and M Kny

CTU in Prague, University Centre for Energy Efficient Buildings, Trinecká 1024,
273 43 Buštěhrad, Czech Republic

ondrej.nehasil@fsv.cvut.cz

Room thermostats and indoor controllers are currently based on the air temperature set, which is a regulated quantity. The aim of the control is to keep the air temperature on its setpoint. The purpose is, however, to achieve and maintain thermal comfort in the indoor environment. Even so, thermal comfort is dependent on more parameters than simply air temperature. The thermal comfort function has been known since the 1970s, and has since been verified many times. This paper introduces a novel virtual air temperature function that can be used in indoor thermostats, that takes into account all important inputs for thermal comfort assessment, such as average radiant temperature and air velocity, as well as clothing, activity and user expectations. The method for obtaining listed input parameters is described and does not require more complex technical equipment than a conventional thermostat. In addition, the paper describes the actual function of the virtual air temperature that determines the comfort setpoint for the room thermostat. This function is verified in several operating states by both quantification and calculation. The results are compared against normal recommendations for determining the setpoint, and the difference in thermal comfort is discussed. Finally, the applicability of the equation to normal room thermostats is verified.

See full paper



A Commercial Building Lighting Demand-Side Management through Passive Solar Design

O K Overen¹, E L Meyer¹ and G Makaka²

¹ Fort Hare Institute of technology, University of Fort Hare, Alice, Eastern Cape, South Africa

² Physics Department, University of Fort Hare, Alice, Eastern Cape South Africa

ooveren@ufh.ac.za

The commercial sector that comprises of schools, libraries, public and private offices is the third largest energy-consuming sector in South Africa. Lighting is a significant contributor to the overall energy consumption in this sector. The aim of this study is to analyse the indoor daylight illuminance of a passive solar office building and the potential demand-side management. A passive solar building in SolarWatt Park, Alice South Africa was used as a case study. The indoor illuminance that includes electric and day lightings were monitored by two sets of Li-210R photometric sensors. Four cool white fluorescent fittings with each containing two 58W lamps served as the electric lights of the office inner space. The average illuminance of the office space with all electric lights on and without daylight was found to be 460 lux. The indoor average daylighting illuminance was 910 and 170 lux on a typical clear sky and overcast days, respectively. A daily cumulative energy savings of 11.14 kWh on a clear sky day and 0.47 kWh on an overcast day was achieved, assuming the office inner space illuminance was maintained at 300 lux. The monetary savings due to the energy saved was estimated at 1285.36 USD per annum. Based on the findings of the study, daylighting through passive solar design reduces energy consumption without compromising the visual comfort of the occupants. Integration of passive solar design for daylighting with indoor daylight switch controller is recommended for optimum energy savings.

See full paper



Measuring Airtightness in a Tall Multi-Family Passive House when Exposed to Wind and Thermal Lift (Stack Effect)

S Rolfsmeier and P Simons

BlowerDoor GmbH, Zum Energie- und Umweltzentrum 1, 31832 Springe, Germany
rolfsmeier@blowerdoor.de; simons@blowerdoor.de

The effects of wind and thermal lift (Stack effect) present particular challenges when measuring the air permeability of large and tall buildings. In high-rise buildings, even small temperature differences between the indoor and outdoor air can lead to undesirably high natural pressure differences on the building envelope. Extreme fluctuations in natural pressure difference can also be caused by wind. This paper presents and compares sets of measurements taken on a 60 m high multi-family Passive House. The building was measured on two separate days in different weather conditions. This paper outlines the extended measurement setup and the measuring process adapted to this setup, as well as the results and findings.

See full paper



Potted Plants as Active and Passive Biofilters Improving Indoor Air Quality

J Sowa¹, J Hendiger¹, M Maziejuk², T Sikora², Ł Osuchowski² and H Kamińska³

¹ Warsaw University of Technology, Faculty of Building Services, Hydro and Environmental Engineering, 20 Nowowiejska Street, 00-653 Warsaw, Poland

² Military Institute of Chemistry and Radiometry, Avenue Gen. Antoniego Chruściela „Montera” 105, 00-910 Warsaw, Poland

³ Florabo Sp z o.o., ul. Rydygiera 8, wieża 6B, 01-793 Warsaw, Poland

jerzy.sowa@pw.edu.pl

Plants are the planet's source of oxygen and the sink that removes carbon dioxide produced by burning, respiration and decay of organisms. The studies performed in small chambers indicated that plants also reduce volatile organic compounds (VOC's). All these phenomena result in a fact that potted plants have a potential to improve IAQ and to some extent to support ventilation. Trends to “go green” increase the growing interest in the introduction of a large number of plants to offices. One should remember that work in modern offices is often associated with a high level of stress. Ornamental plants give highly significant reductions in negative mood states – reductions in anger, anxiety, depression, confusion, fatigue and stress. Leaves provide also additional sound attenuation and cooling effect due to evaporation. The paper summarises the R&D project devoted to the development of the efficient, safe and competitive systems of biofiltration based on the properties of potted plants. The paper presents examples of laboratory tests and describes first experiences from applications in two pilot office buildings.

See full paper



Sound Insulation of a Wall in a Panel House with Demountable Joints

J Vychytil¹ and M Vychytil²

¹ CTU in Prague, Faculty of Civil Engineering, Department of Building Structures, Thákurova 7/2077, 166 29 Prague 6 – Dejvice

² CTU in Prague, CTU Rector's Office, Jugoslávských partyzánů 1580/3, 160 00 Prague 6 – Dejvice

jaroslav.vychytil@fsv.cvut.cz, vychyma1@cvut.cz

Classical technologies used in civil engineering are characterized by limited adaptability. Easy disassembling and relocation to another location are practically eliminated. Flexible building systems, that make this possible, are not only favourable in terms of sustainable buildings. These structures are an alternative to traditional prefabricated or monolithic systems implemented in previous years. This solution is more sophisticated in term of sustainability than solutions with rigid non-demountable joints. Problems associated with it arise with regard to guaranteeing the desired properties of such a structure. Many requirements are placed on partition wall structures. The paper deals with the verification of the sound insulation of a partition wall made of reinforced concrete panels with dismountable joints. The principle of the solution of the demountable joints in the vertical heading joint between the panels is described. The heading joint is designed in two variations, which are described in detail. The aim of the structural solution is to ensure meeting sound insulation for use between flats. Furthermore, the fire resistance of the whole structure is necessary to ensure, too. The sound reduction index of the wall depending on the frequency is first calculated using three different methods of computation. Parameters of the used material, namely bulk density, longitudinal wave speed density and loss factor, were measured to ensure reliability of calculations. The results from measurement of the sound reduction index of the two variants of the solutions of demountable joints in acoustic chamber are presented at the end of the paper.

See full paper



Heritage Regeneration and Sustainability

Technical Cultural Heritage on the Elbe-Vltava Waterway

P Fošumpaur, T Kašpar and M Zukal

Department of Hydraulic Structure, Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic

zukal@fsv.cvut.cz

The article presents the principal objectives and current results of the project “Documentation and Presentation of Technical Cultural Heritage on the Elbe-Vltava Waterway”, which is part of the National and Cultural Identity programme administered by the Ministry of Culture of the Czech Republic. The historical development of the modifications of navigable sections of the Elbe and the Vltava Rivers documents that its beginnings coincide with the beginnings of the settlement of the river valleys in the Middle Ages. These modifications were related to the human need to use rivers for navigation and hydropower generation and went through an interesting development throughout the Medieval Times. The lock structures situated on the Elbe-Vltava Waterway represent extensive and unique technical heritage which still serves its original purpose. The locks are typically composed of a weir structure, a lock and a hydroelectric power plant. The project’s objective is to document the existing technical heritage at the level of individual locks and their construction and technological elements. Furthermore, attention will be focused on the identification of endangered structures on the Elbe-Vltava waterway which no longer meet the present-day functional or capacity requirements and which will probably need to undergo sensitive modernisations in the future in the context of their cultural and historical value. The project intends to present and introduce these technical monuments to the general public. The presentation of the structures includes the historical development of their design, the description of the original technological elements and their present-day role in water transport, and the exploitation of their potential for recreation and tourism.

See full paper



Sirius: Retrofitting Brutalism in Sydney

V Gandh¹ and ML North²

¹ Srishti Institute of Art, Design and Technology, Bangalore, Karnataka – 560046, India

² Extent Heritage, Sydney, New South Wales – 2009, Australia

vidhugandhi@gmail.com

The Sirius building in Sydney, Australia has and continues to be at the centre of contestations pertaining to its proposed sale, possible demolition, and redevelopment of the site. The ostensibly Brutalist building erected between 1975 and 1980 was built to accommodate public housing tenants, as were a number of other such buildings in different parts of the world built during post-World War II, as Brutalism was seen to represent an ethical architecture through its expression and aesthetic. With 79 apartments of 1-4 bedrooms, and of in-situ and precast concrete construction, Sirius is being upheld as an excellent example of Brutalism, and opposition to the proposed sale and redevelopment of the site has been mounted on the basis that the building should be heritage listed for its historic, social, technical and aesthetic significance. The argument of saving the building on the basis that it houses public housing tenants has also been rigorously employed. At the same time the sale of the building has been justified on the basis that its retention would cause undue economic hardship to the owners by limiting funds for reinvestment in social housing elsewhere. This paper while acknowledging both sides of this debate, will seek to explore whether the retention of Sirius can be undertaken through refurbishment and retrofitting. Other such examples of Brutalist public housing in countries like the United Kingdom which have been retrofitted will form the basis of comparison to examine whether retrofitting of the Sirius will uphold its ethical dimension, or whether its retention will serve a market of consumers with an interest in mid-century architecture and design.

See full paper



Potential and Impact of Incorporating Roof Photovoltaic to Enhance Environmental Sustainability of Historic English Churches in the United Kingdom

S Khatri¹, K Ip², M Picco² and A Hashemi²

¹ Crowther Associates Architects LLP, Brighton, UK

² University of Brighton, School of Environment and Technology, Brighton, UK

smita.khatri@outlook.com, k.ip@brighton.ac.uk, p.marco@brighton.ac.uk,
a.hashemi@brighton.ac.uk

The Church of England (CofE) is responding to climate change by taking measures to reduce their CO₂ footprint under its flagship programme ‘Shrinking the Footprint’, to facilitate the CO₂ emission reduction target of 80 % by 2050. Meeting this target will require both energy efficiency measures and zero carbon energy generation of which solar PV technology is a frontrunner as it has a substantially lower CO₂ footprint than grid’s electricity, with no moving parts, low maintenance and a long service life. Conventional church roofs built along the East-West axis offer the ideal pitches and orientation for collecting solar energy. However, within the CofE’s vast estate of over 15,000 church buildings, 78 % of these buildings are listed and hence care must be taken to protect the building fabric. With this context in mind, this study identifies the benefits and concerns associated with the application of rooftop solar PV on historic English Churches and evaluates viable technologies currently available. The specific design and procedural requirements have been investigated and the process map of the implementation methodology established and illustrated through a case study of an existing church. Results showed that rooftop solar PV system has the potential to reduce the GHG emissions substantially, ranging between 75 %–84 % for electricity and between 20 %–27 % for gas based on the current demand and the choice of technology option. Findings on the issues, design options and life cycle environmental impacts are analysed with discussion and recommendation of future adaptation at a national level.

See full paper



Cost Optimization for Renovation and Maintenance of Cultural Heritage Objects

**D Macek, R Schneiderová Heralová, E Hromada, I Střelcová, I Brožová,
S Vitásek, J Pojar and R Bouška**

Department of Construction Management and Economics. Faculty of Civil Engineering,
Czech Technical University in Prague, Thákurova 7, 166 29 Prague, Czech Republic

daniel.macek@fsv.cvut.cz

The paper deals with the issue of maintenance and renovation of cultural heritage objects. This is a very specialised area of cost optimization, for which there can still be used procedures and methods applied to more normal contemporary objects, but where there are many peculiarities and differences that need to be taken into consideration. In the initial phase, it is necessary to gather all relevant data about such objects. From data there can be obtained information that can be used to build the structure and correlations of the recovery and maintenance model. In the Heritage Catalogue there can be found basic information about cultural heritage objects. It provides basic description of the objects, but technical data which could be used for creating the recovery and maintenance model are missing. Only if based on a sufficiently large and properly structured database, is it possible to deduce the correlations and dependencies needed to create a system for the types of planning and optimization involved in recovery and maintenance. In order to establish the recovery and maintenance costs, it is necessary to complement the database for individual construction elements costs and the length of recovery and maintenance cycles.

See full paper



Historical Water Management Constructions, their Value, Function and Significance

K Nedvedova¹, M Dzurakova¹, A Vyskocil², Z Svitak², R Kleparnikova¹ and D Honek¹

¹ VUV TGM, Czech Republic

² HIU AV CR, Czech Republic

nedvedova@gmail.com

The contribution would like to present a new research project focused on expansion of the knowledge, systematic documentation and definition of objective criteria for the evaluation of a specific group of technical monuments – historical water management constructions. The main goal is to develop a methodology of unambiguous identification, categorization and evaluation of historical water management objects in terms of historic preservation and renewal, based on an interdisciplinary approach.

Attainment of the project's goals through:

- documentation and analysis of the water management objects' evolution in chosen study areas, using historical topographical maps of five different periods, as well as archive sources,
- comparative analysis of the historical water management objects' development in study areas, taking into consideration different conditions both natural and socio-economic

The project's outcomes will be:

- a set of maps,
- the methodology of identification, categorization and evaluation of historical water management objects. The methodology will be a significant contribution to further research activities involving documentation, evaluation, preservation and renewal of this specific cultural heritage fund.

See full paper



Building Integrated Photovoltaics (BIPV) in Line with Historic Buildings and Their Heritage Protection

E Novak and J Vcelak

University Centre for Energy Efficient Buildings, Czech Technical University in Prague,
Trinecka 1024, 273 43 Bustehrad, Czech Republic

erik.novak@cvut.cz

Historic buildings are often classified as highly energy-intensive buildings with low energy efficiency. Thanks to their overall percentage share in the European real estate market, it is important to focus on these dwellings with an innovative approach and functional, sensitive aesthetic solutions, thus significantly reducing their energy intensity, increasing their energy efficiency and improving the indoor living conditions. At the same time, it will greatly increase the chance to meet the new energy and emission targets currently proposed by the European Commission.

See full paper



Awareness-Raising Campaigns and Tools

Adoption of Sustainable Construction for Small Contractors: Major Barriers and Best Solutions

B G Hwang¹, W Q Liu², M Shan^{2,4} and J M Lye³

¹ Department of Building, National University of Singapore, 4 Architecture Drive, Singapore, 117566

² School of Civil Engineering, Central South University, 22 South Shaoshan Road, Changsha, China, 410075

³ Frasers Centrepoint Limited, Singapore

ming.shan@csu.edu.cn

There have been numerous studies on the adoption of sustainable construction; however, few have attempted to analyze the sustainable construction adoption from the perspective of small contractors. The objectives of this study are to investigate the major barriers that prevent small contractors from adopting sustainable construction and to propose a group of best solutions that can overcome these barriers. To achieve these goals, a comprehensive literature review was conducted first. Then, data from 30 Singapore-based small contractors were collected through a questionnaire for analysis. Results reported that “extra investment required”, “slow recovery of investment”, “lack of incentives”, “limited knowledge on sustainable construction”, “tendency to maintain current practices”, and “lack of demands from clients” were the top six barriers that hinder small contractors from adopting sustainable construction. Results also revealed that three barrier categories, namely “financial barriers”, “management barriers”, and “knowledge barriers”. Lastly, five best solutions that could help small contractors overcome the identified barriers were suggested. This study contributes to the body of knowledge. Meanwhile, the findings from this study can help the industry practitioners enhance their understandings of the barriers and can also assist policy makers to come up with more effective policies to tackle these barriers.

Rethinking Public Buildings' Functions: The Case for Participatory Design Methodology

V Kandusová and T Vácha

Czech Technical University in Prague, University Centre for Energy Efficient Buildings,
Trinecká 1024, Buštěhrad, Czech Republic

veronika.kandusova@cvut.cz

Municipalities often struggle with reconstructions and refurbishing of buildings in public ownership. This is not only because of limited expert capacities that municipalities struggle with (municipal architect position or urban planner position is vacant, or non-existent etc.) or lack of finances. There is an increasing need and demand from municipalities for redefining buildings' original purpose and finding new, sustainable and innovate functions. They have to decide not only how to reconstruct, but how to rethink its original purpose. The case study from a city of Slaný shows how participatory design can serve the goal of finding new functions of a public building and effectively contribute to the planning phase of reconstruction projects. Sustainable urban development should react to people's needs, new technologies and environmental challenges. Reconstruction projects should reflect innovations in both technologies and approaches and respond to newly emerged functions. The methodology demonstrated in the case study can serve as a tool for assessing preferences of citizens, needs of the municipality and bridge the gap between politicians, experts and citizens by supporting efficient communication and evidence-based decision making. Moreover, this case shows how to ensure social sustainability and project effectiveness by involving multidisciplinary teams, in this case architects, urban planners, sociologists, communications experts and environmental and engineering psychologists.

See full paper



Green Construction Capability Model (GCCM) for Contracting Companies

H Setiawan¹, W I Ervianto¹ and A L Han²

¹ Universitas Atma Jaya Yogyakarta, Indonesia

² Universitas Diponegoro, Indonesia

haris@mail.uajy.ac.id

Construction project has been considered as one of the contributors to the environmental destruction, therefore green construction becomes the important issue in many countries including Indonesia. However, the success of green construction implementation depends on the capability of contractors, therefore model to assess the capability of contractors to build the projects based on green construction approach becomes important need to be developed. This study is aimed to develop a model to assess capability level of contractor to implement green construction. The model has adopted the concept of Capability Maturity Model (CMM). The model assesses the capability level of contractors based on 16 factors that are categorized into seven aspects of green construction. Those aspects are energy conservation, water conservation, safety and health, environment management, appropriate land use, air quality, sources and cycle of materials. While the capability of contractors to implement green construction is classified into five levels: initial, repeatable, defined, managed and optimizing. Finally, the assessment model named Green Construction Capability Model (GCCM) is proposed as a tool to assess the capability level of contractors to implement green construction.

See full paper



Young Leaders of the City of the Future

D Śmiechowski

Academy of Fine Arts in Warsaw, Interior Design Faculty, ul. Mysłowiecka 8, 00-459
Warszawa, Poland

dariusz.smiechowski@asp.waw.pl

Sustainable built environment aimed at community's well-being is possible to be striven for – with substantial involvement of citizens. Cultural vitality and freedom, social equity, environmental renewability, economic prosperity and solidarity are high global goals, although everyday reality depends to the largest extent on the way our closest surroundings are treated – according to common will and visions, individual attitudes, skills. Wider interrelationships concerning the inhabited space and its values, are evident to those who are emphatic, open to constant learning, imagining, experimenting, cooperation. This should concern, in larger and larger extent, the younger generation. An important point of departure for a new paradigm is the conjunction of environmental care and active participation, to foster self-agency within citizenship. Engaging young leaders in planning processes and governance, gives a chance to facilitate the implementation of invaluable potential, as well as puts education into practice – within the important lessons of everyday democracy. Examples of educational projects as well activities of school groups and youth councils may prove the value of this potential. The set of Sustainable Development Goals as well as the postulated Polish Architectural Policy contain the message ready to be translated both in educational and design practice.

See full paper



Using Public Opinion to Estimate Improvements in Economic and Social Dimensions of Sustainability

M Šůra

CTU in Prague, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague, Czech Republic
sura@fsv.cvut.cz

The responsible body preparing a building project often gets into the situation when they have to carry out a project influencing the public. Sustainable building objectives form an important issue for public awareness when a project is to be implemented, while other objectives and concerns presented by community, individuals or economic operators also may change the original project in some way. The projects in question were not viewed and accepted equally by each party as different effects on the stakeholders were expected and the project did not naturally resonate with everyone's views.

In the article we inform about a course of action of municipality when involving the public and other stakeholders to a building project that was required to be a sustainable one. The purpose was to lessen threats to sustainability paradigms from them, threats such as disagreements with the building project, consequential delays and future costs, caused by lack of information, by other parties' interference, or omission of unrecognized public and stakeholders' interests. Some figures are provided that document time change of public attitude, and an indicator that might provide a rough estimate on projects' sustainability aspects improvements or changes, prior to construction.

See full paper



Policy Making Processes

Assessment of Different Methodologies for Mapping Urban Heat Vulnerability for Milan, Italy

S Bhattacharjee¹, E Gerasimova³, C Imbert¹, J Tencar² and F Rotondo⁴

¹ ECOTEN Urban Comfort s.r.o. Prague, Czech Republic

² UCEEB CTU in Prague Bustehrad, Czech Republic

³ Peter the Great St.Petersburg Polytechnic University, St. Petersburg, Russian Federation

⁴ Politecnico di Milano, Milan, Italy

jiri.tencar@cvut.cz

Aims: To compare methodologies for calculating vulnerability index of Milan city and find correlation between the main components influencing vulnerability.

Methodology: At-satellite brightness temperatures were used to study exposure of city districts to Urban Heat Island. The distribution of vulnerable population (people younger than 14 and older than 65) was also taken into account by producing a map, which showed sensitivity indices for each city district. Adaptive capacity was represented as a complex set of sub-indicators such as health care accessibility, level of living conditions and vegetation cover. Exposure, sensitivity and adaptive capacity – main indicators of vulnerability – were used to obtain five different maps, which could identify districts more vulnerable to the Urban Heat Island. Collected data showed correlations between factors influencing vulnerability.

Results: All formulas except one show similar vulnerability index distributions. Correlation graphs showed direct proportionality with exposure, very low correlation with sensitivity and indirect proportionality with adaptive capacity (except one formula which is discussed in paper).

See full paper



Greening Actions and the Related Potential Impacts on Outdoor Comfort in a Dense Built Environment

J Gaspari and K Fabbri

University of Bologna, Department of Architecture, via dell'Università 50, Cesena
jacopo.gaspari@unibo.it; kristian.fabbri@unibo.it

The increasing attention paid to the effects of climate change on the dense urban fabric of contemporary cities had led Public Authorities to develop local adaptation plans in order to suggest some effective measures to mitigate and reduce the impacts of urban heat island [UHI] and heat waves as well as to improve water management capacity. Among the suggested actions, the greening of in-between spaces of the built environment and the introduction of new green surfaces (roof and/or facades) in the framework of wider regeneration plans offers interesting perspectives and impacts. The paper reports the outcomes of a research activity run by the Department of Architecture and the Municipality of Bologna to investigate how to define/optimize the most effective arrangement of greening solutions with the aim to improve outdoor comfort conditions. The study takes into account several aspects including paved/green surfaces extension, the use of material, the geometry of the site, etc. and simulate the potential effects of changes using simulation software ENVIMET. Once the main features of each site are modelled the different deriving scenarios can be compared evaluating the different architectural, economical and practical constraints. The results are then compared with other factors, related to the social aspects, the use of the spaces, the perception of the sites, etc. A district of the city of Bologna is used as test bed in order to test the proposed methodology and the related potential impacts.

See full paper



Energy Saving and Climate Adaptation of Buildings: A Paradox?

S Golz¹, J Nikolowski² and T Naumann¹

¹ University of Applied Sciences, Friedrich-List-Platz 1, D-01069 Dresden

² GB1-Engineers, Friedrich-Hegel-Strasse 29, 01187 Dresden

sebastian.golz@htw-dresden.de

The European climate policy goals include (a) reducing energy consumption and avoiding the emission of climate-affecting gases as well as (b) adapting to existing and expected climate change. The synergetic implementation of both goals forms a central challenge particularly for the building stock. There is evidence that damage to buildings due to extreme weather events (e.g. heavy rain, fluvial flooding, hail, summer heat) steadily increase. Therefore, several national strategies and action plans in European member states formulate requirements for climate-adapted modernisation and retrofitting of existing residential buildings.

The paper explores the conflicts between the two named goals at the building level, since building energy saving measures are unfortunately not in any case consistent with the goal of increased climate adaptation, as they undesirably increase the vulnerability of buildings. For this purpose, the paper first deals with the structural design of selected building types, which have been refurbished in order to optimize their energy efficiency. Second, it analyses and evaluates the physical vulnerability of existing buildings against extreme weather events. Then, the paper proposes some practical options on how to achieve the two goals effectively. Finally, some implications for future research and practice are discussed.

See full paper



ENERGIS: Decision-Support Tool for the Implementation of Energy Policies at Urban and Regional Level

**G Hernández Moral, V I Serna González, G Massa and
C Valmaseda Tranque**

CARTIF Technology Centre, Energy Division, Valladolid, Spain

gemher@cartif.es, vicser@cartif.es, giumas@cartif.es, cesval@cartif.es

The implementation of energy policies to reduce CO₂ emissions poses specific challenges, especially to public authorities, who should define specific objectives, and evaluate the adequacy and impact of energy actions proposed. Nevertheless, an appropriate analysis is highly time-consuming due to the lack of tools. In this process, the first step is to establish the baseline energy status of the area of study. Only with this knowledge, in particular of the residential sector (main CO₂ emissions contributor in cities), is it possible to plan for a low carbon economy. In this context, the ENERGIS tool will support energy planners by mapping energy demand of the residential sector at different scales, as a first step towards CO₂ emissions calculation. To do so, a nationally validated Energy Performance Certification (EPC) tool has been automated, its results at building level mapped and aggregated at different scales. By basing the proposed platform on EPC calculation methodologies supported by the Energy Performance Directive of Buildings (EPBD 2010/31/EU), the ENERGIS platform achieves two main goals: it aids in the implementation of energy directives and energy actions by offering an easy to use tool to identify areas in need and, secondly, it promotes the EPBD, by making use of one of its main instruments to measure energy performance: the EPCs.

See full paper



Statistics and Governance. Current Issues of Affordable Housing: The Case of Prague

T Hudecek¹, P Hlavacek², J Hainc³ and M Cervinka¹

¹ Czech Technical University Prague, Masaryk Institute of Advanced Studies, Kolejní 2637/2a, 160 00 Praha 6, Czech Republic (CZ)

² Architekti Headhand s. r. o., U Obecního dvora 799/7, 110 00 Praha 1, CZ

³ Prague Institute of Planning and Development, Vysehradská 2077/57, 128 00 Praha 2, CZ

hainc@ipr.praha.eu

Housing has become an issue around the world, both in emerging and developed countries. The affordability of housing is decreasing globally; however, the governance system can be harnessed as a tool to help to turn the situation around, the benefit being that it is in the hands of the local or national administration. The analysis of state of the art data, together with qualitative research based on the knowledge and experiences of experts, have been used to examine the case of Prague. The aim is to prove a direct link between the approvals processes for buildings and the governance system, including the decisions made by different levels of public administration in last two decades. The hypothesis, based on early outcomes, shows a strong relationship between governance systems (including administrative divisions) and the length and complexity of the building approvals process. The results of these analyses are the main outcomes of the article, while designing changes will be the subject of subsequent research. The article should help with the debate and open up the topic, which is, in our globalized and increasingly complex world, an issue for a growing number of societies. The question of balanced, inclusive and sustainable growth will be part of the research agenda.

See full paper



Author Index

- Abualdenien, J 73
 Adamovský, D 111, 140, 185
 Alao, P F 47
 Al-Hashlamun, R 101
 Ali, H H 101
 Allacker, K 107, 178
 Álvarez, S 169
 Ameri, S 33
 Andenæs, E 102
 Apró, D 150
 Arrizabalaga, E 179
 Asprone, D 50
 Astudillo, D 157
 Bantová, S 120
 Barozzi, B 128
 Barros, N N 74
 Bartoli, G 38
 Bašta, J 112
 Bellazzi, A 71, 128
 Belleri, A 38, 175, 181
 Belussi, L 128
 Ben-Alon, L 34
 Bhattacharjee, S 215
 Bianco, N 50
 Bielek, B 103
 Bimesmeier, T 42
 Birgisdottir, H 69
 Blum, A 149
 Boehme, L 35
 Bogdanovics, R 171
 Bohne, R A 102
 Borodinecs, A 123, 141, 171
 Borrmann, A 73
 Bouška, R 202
 Braune, A 49, 70
 Brauner, M 36
 Broukalová, I 44, 78
 Brožová, I 202
 Bucking, S 164
 Buday, P 103
 Bukovszki, V 150
 Burroughs, S 37, 104
 Casanovas Rubio, M d M 84
 Casprini, E 38, 181
 Cekon, M 105
 Celler, J 39
 Cervinka, M 219
 Chambers, J 143
 Chan, C 135
 Chan, H Y S 80
 Chen, H-H 159
 Chhugani, B 186
 Chmúrny, I 109
 Cobo, D 156
 Corallo, A 73
 Criado, C 179
 Croce, S 151
 Curpek, J 105
 Čeněk, M 77, 152
 Červín, R 127
 Daksa, G 171
 Danza, L 71, 128
 da Silva, M G 117
 De Castro, I 179
 de la Fuente, A 108
 de la Fuente Antequera, A 84
 de Oliveira, C C 142
 de Oliveira, F 129
 De Tommasi, L 169
 De Troyer, F 107, 178
 Dědič, M 88
 Deilmann, C 42
 Dejaco, M C 92, 177
 Delem, L 72
 Depalma, M 128
 Depoortere, A 35

- Devitofrancesco, A 71, 128
 Di Biccari, C 73
 Dietrich, U 159
 Diviš, J 57
 Diviš, M 45
 Dixit, M K 40
 Dolejš, J 39
 Durica, P 106, 132
 Dvořáková, K 144
 Dzurakova, M 203
 Ecorchard, P 61
 Egusquiza, A 160
 Eisazadeh, N 107
 Ekanayake, B J 93
 El Ridouane, H 169
 Eliáš, M 56
 Engebø, A 102
 Ervianto, W I 209
 Essig, N 150
 Fabbri, K 170, 216
 Fládr, J 78
 Fortova, K 41
 Fošumpaur, P 199
 Frick, J 142
 Fung, S M 130
 Gabrielli, L 170
 Gandh, V 200
 García-Fuentes, M A 169
 Garrecht, H 142
 Gaspari, J 170, 216
 Geikins, A 171
 Geiselman, D 49, 70
 Gerasimova, E 215
 Ghaffarianhoseini, A 36
 Ghellere, M 128
 Ghosh Saxena, D 153
 Giaimo, C 154
 Giannakis, G 169
 Gilani, G 108
 Gołębiewski, M 55
 Gołębiowska, J 97
 Golz, S 217
 Gomes da Silva, V 74, 75, 117
 Gordaliza, A 179
 Gruhler, K 42, 59
 Gruis, V H 63
 Guazzi, G 71, 128
 Guimarães, G D 75
 Gunatilake, S 85
 Gutting, R 149
 Habert, G 87
 Hafner, A 76
 Hainc, J 219
 Haist, M 26
 Hájek, K 48
 Hájek, P 43, 48, 66, 79, 176
 Hameen, E C 34
 Han, A L 43, 209
 Hanzlikova, J 119
 Hao, T 155
 Harries, K A 34
 Hashemi, A 201
 Heckova, P 119
 Hejazi, S B M 142
 Hejtmánek, P 172
 Hendiger, J 194
 Hensen, J L M 121
 Hermida, M A 156, 157
 Hernández, G 169
 Hernández Moral, G 218
 Hlaváček, D 77, 152
 Hlaváček, P 219
 Holický, M 173
 Hollmuller, P 129, 143
 Honek, D 203
 Horáková, A 44, 78
 Horváthová, J 191
 Hořická, J 158
 Hosseini, S M A 84
 Hrabová, K 79, 131
 Hraska, J 105
 Hrdlička, T 131
 Hromada, E 202
 Hudecek, T 219

- Hu, L 146
 Hwang, B G 207
 Iannaccone, G 87
 Imbert, C 215
 Ip, K 201
 Iringová, A 45
 Iturralde, J 179
 Izkara, J L 160
 Jandacka, J 132
 Jára, R 39
 Jejčič, N 94
 Jelinkova, V 119
 Jörchel, S 46
 Juras, P 106, 132
 Just, A 47
 Kabatova, V 106
 Kabele, K 190
 Kabrhel, M 145
 Kaestner, A 119
 Kaiser, J 88
 Kallakas, H 47
 Kalousek, M 133
 Kamińska, H 194
 Kandusová, V 208
 Kapler, P 134
 Kašpar, T 199
 Katsigarakis, K 169
 Kers, J 47
 Kerz, N 89
 Khatri, S 201
 Khoja, A 150
 Khosravi, S N 110
 Kichou, S 122, 134
 Kleparnikova, R 203
 Klinker, F 186
 Knappe, F 59
 Kny, M 111, 185, 191
 Kočí, V 54
 Kohoutková, A 44, 191
 Kong, K W 135
 Kopecký, P 136
 Korjamins, A 141
 Kostelecká, M 58
 Krajčík, M 103
 Králíček, J 187
 Kraus, M 188
 Kregl, F 56
 Kučera, M 187
 Kujawski, W 161
 Kuklík, P 61
 Kutlar, N 189
 Kvande, T 102
 Kwiatkowski, J 174
 Kyndt, L 60
 Labò, S 181
 Laiblova, L 48
 Lain, M 121
 Lam, K W 135
 Larrinaga, F 179
 Lee, C K 80
 Lee, H H Y 162
 Legner, T 112
 Lehmann, I 59
 Lemaitre, C 49
 León, F 157
 Liblik, J 47
 Li, J 60, 64
 Lilis, G N 169
 Lisowski, P 52, 55
 Liu, W Q 207
 Loftness, V 34
 Lohne, J 102
 Lorch, R 25
 Lowitzsch, J 81
 Lupíšek, A 53, 116, 137, 172
 Lützkendorf, T 28, 59, 82
 Lye, J M 207
 Mabe, L 169
 Macák, M 103
 Macek, D 202
 Macía, A 179
 Maffè, C 128
 Mahdavi, A 110
 Mahinkanda, M M M P 83

- Makaka, G 192
 Maleki, B 84
 Malík, Z 144
 Mančík, Š 116
 Manjarres, D 169
 Marini, A 38, 175, 181
 Martín, S 169
 Massa, G 179, 218
 Matschi, C 138
 Matuska, T 113, 114, 115, 127
 Mauro, G M 50
 Mazanec, V 111, 190
 Maziejuk, M 194
 Meeten, N 139
 Meitã, V 65
 Mengüç, M P 189
 Menna, C 50, 175, 181
 Meroni, I 128
 Meyer, E L 192
 Mocová, K A 51
 Moffatt, J S 26
 Moretti, N 92, 177
 Mörmann, K 59
 Muchow, N 59
 Müller, H S 26
 Naismith, N 36
 Naumann, T 217
 Nazeer, S F 85, 93
 Nedvedova, K 203
 Nehasil, O 140, 191
 Neira, C 156
 Nemeth, I 138
 Nikolowski, J 217
 North, M L 200
 Novák, E 180, 204
 Novák, M 133
 Nováková, P 62, 188
 Novotny, J 115
 Nowotna, A 52
 Nývlt, M 176
 Odineca, T 141
 Oehler, S 70
 Oregi, X 169
 Orova, M 86
 Österreicher, D 27
 Ostrý, M 120
 Osuchowski, Ł 194
 Overen, O K 192
 Pablos, L 179
 Paparella, R 151
 Passoni, C 38, 175, 181
 Patel, M 143
 Pavlů, T 41, 53, 54
 Pazderka, J 176
 Pešta, J 53, 54
 Petcu, C 65
 Picco, M 201
 Pietruszka, B 52, 55
 Pittau, F 87
 Pojar, J 202
 Pokorný, M 56
 Pokorný, N 114
 Poltimăe, T 47
 Pons, O 108
 Pont, U 110
 Poon, C Y C 80
 Pope, S 164
 Pošta, J 39
 Prota, A 50
 Prušková, K 88
 Qu, M 146
 Ramachandra, T 85
 Rashid Kbah, A A 163
 Rasmussen, F N 69
 Re Cecconi, F 92, 177
 Reim, M 186
 Reith, A 86, 150
 Renkerová, P 51
 Repka, J 48
 Rietz, A 89
 Riva, P 38
 Rolfsmeier, S 193
 Rotondo, F 215
 Ruiz Durán, C 49, 70

- Ruschel, R C 74
 R  ther, N 33
 R  zi  ka, J 37, 57
 Rybarik, J 106
 Ryklov  , P 116
 Ryparov  , P 58
 Saade, M 75
 Saade, M R M 117
 Sackey, L N A 51
 Sacha, J 119
 Sakiyama, N R M 142
 Salamone, F 128
 Salata, S 154
 Sandanayake, Y G 83
 Sat, P 135
 Scamoni, F 128
 Scrosati, C 128
 Serna Gonz  lez, V I 218
 Serna, V 169
 Setiawan, H 43, 209
 Shan, M 207
 Shemelin, V 114
 Shi, W 146
 Schiller, G 59
 Schneiderova Heralova, R 90, 202
 Schneider, S 129, 143
 Schoofs, E 178
 Schreiberov  , H 78
 Schuler, M 144
 Sierens, Z 60, 64
 Sikora, T 194
 Silva, M 75
 Simons, P 193
 Skandalos, N 118
 Skopek, J 164
 Slanina, P 113
 Smallwood, J 165
   miechowski, D 210
 Snehota, M 119
 Sojkova, K 136, 172
 Sowa, J 174, 194
 Spurny, J 145
 Stanek, K 118
 Stijnen, L 178
 Storck, M 76
 Struhala, K 120
 St  relcov  , I 202
 S  ra, M 91, 211
 Svitak, Z 203
 Svora, P 61
 Svorov   Pawelkowicz, S 61
 Swanepoel, F 165
 Szab  , D 109
     l, J 62
   ikula, O 110
   imek, J 121
   r  mov   Slu  sn  , M 61
 Tagliabue, L C 92
 Tencar, J 215
 Tennakoon, G A 93
 Tepl  , B 79
 Tla  sek, M 131
 Tom      , M 94
 Tookey, J 36
 Treberspurg, M 27
 Tytens, G 60
   tywoniak, J 58, 118
 V  cha, T 208
 Vallejo, E 179
 Valmaseda Tranque, C 218
 Van De Moortel, E 178
 van Stijn, A 63
 Vandevyvere, B 60, 64
 Vandewalle, L 64
 Vandli  kov  , D 45
 Vanek, A 48
 Vasallo, A 179
 Vasile, V 65
 V       , J 111, 180, 204
 Verstrynge, E 64
 Vettorato, D 151
 Villanueva, A 160
 Vitasek, S 95, 202
 Vitiello, U 50

- Vlach, T 48
Vogel, M 26
Vogt, G 138
Volf, M 53, 172
Vychytil, J 195
Vychytil, M 195
Vyskocil, A 203
Výtlačil, D 96, 166
Waidyasekara, A S 93
Wang, J 155
Wang, Q 146
Wastiels, L 72
Weinlaeder, H 186
Weismann, S 186
Welsch, M 89
Wiszniewski, A 174
Wolf, P 122, 134
Yasin, M 186
Yip, K M G 80
Yuen, P H F 80
Yuen, T 130
Zaharia, M C 65
Zajecs, D 141, 171
Zak, J 95
Zanni, J 181
Zavrl, M Š 94
Zavřel, V 113
Želazna, A 97
Zemitis, J 123
Zhang, S 146
Zmrhal, V 113
Zucarato, L 75
Zukal, M 199
Žáková, H 176
Ženíšek, M 66

The CESB19 conference is an international event dedicated to key issues of sustainable built environment in the Central Europe. Our mission is to discuss possible approaches to these issues by confronting the local approach with solutions provided by experts from all around the world. CESB 19 topics are:

Buildings and climate change

Design strategies for energy efficient and climate-friendly buildings, design optimization tools, integrated design approach, best practice case studies

Innovative use of materials and products in sustainable buildings

High-tech advanced and natural-based materials, sustainable production, and use of building materials

Systems for energy efficient and energy positive buildings

Integration of advanced and alternative technologies improving sustainability of buildings

Sustainable urban development

Urban regeneration strategies and spatial planning practices responding to climate change, new technologies and local communities

Sustainable retrofitting of existing buildings

Examples of sustainable modernizations and refurbishments of existing buildings and districts, innovative retrofitting solutions, prefabrication in retrofitting of existing buildings

Decision-support tools and assessment methods for sustainable built environment

Building sustainability assessment methods, benchmarking and regional aspects, social, economic and environmental indicators of built environment, life cycle costing

Industrial heritage regeneration

Economically and environmentally effective adaptive reuse strategies, industrial heritage in context of urban regeneration, temporary reuse and regeneration initializing activities

CESB 19 Book of Abstracts:

http://cesb.cz/cesb19/cesb19_boa.pdf



CESB 19 Full papers:

<https://iopscience.iop.org/issue/1755-1315/290/1>

