DYNASTEE

NEWSLETTER ISSUE 2017/8

Foreword


Multi apartment building in Beijing, China

The main objective of the DYNASTEE platform is to exchange information and knowledge on building energy performance analysis through dynamic testing and modelling. This newsletter is one of the actions to inform you on the state of projects, workshops, training, etc.

Dynastee is involved in the new IEA project Annex 71. Two contributions tell you more about the aims and the work programme of this project. A workshop on in situ measurement methods is organised in April in collaboration with standardisation working group 13 of CEN TC 89. You will hear about the outcome in the next issue of this newsletter. Moreover, young researchers can improve their skills in dynamic analysis during a new Summer School training session in Spain. The announcement on the dynastee.org website tells you how to register. Two new U-value measurement approaches are also presented. It may inspire you in your own work.

Luk Vandaele, DYNASTEE - INIVE & Hans Bloem, EC JRC

CONTENTS

DYNASTEE

Newsletter Editors

- **Hans Bloem**
- **Luk Vandaele**

Summer School 2017 "Dynamic Methods for whole Building Energy Assessment", 3 – 7 July, Granada, Spain

Hans Bloem, DYNASTEE - INIVE

After 5 very successful editions of the Summer School on "Dynamic methods for whole building energy assessment" this time the focus will be on pragmatic application of these dynamic calculation techniques. For the practical exercises the software tool LORD will be applied on benchmark data.

When and where?

The venue for the Summer School is for the second time at the University of Granada (ETS Arquitectura) and takes place from Monday 3 until Friday 7 July, 2017.

Participants can do a pre-registration by sending a notification by email to Carmen Montesinos at:

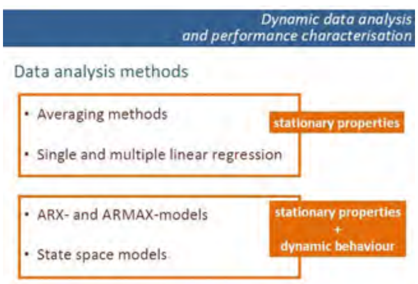
cmontesinos.serviciosexternos@psa.es

Brief introduction

Five well experienced lecturers will give theoretical background information on physical aspects of heat transfer in the built environment. Topics that will be presented encompass data collection and treatment, impact of sensor accuracy and requirements for input. Several analysis methods are presented as well as the choice for the most appropriate model. By means of cross-correlation and residual analysis the decision making process will be discussed. In addition building performance simulation will be presented and attention will be given to the energy policy context. Data that will be made available for exercises range from simulated data to real data carried out from experimental work for the energy performance assessment of buildings for renovation.

Details about the weeklong programme can be found at the Dynastee website by the end of March.

In the document *Software techniques applied to thermal performance characteristics* some further information about methods and tools is given as well as on benchmark data for testing these methods.




View on the Alhambra in Granada, Spain

EBC IEA Annex 71

Building energy performance assessment based on in-situ measurements

An introduction to Annex 71 has been included in the DYNASTEE Newsletter 7. The approach in subtasks 2 & 3 of the project is further explained here.

Subtask 2 of the IEA EBC Annex 71

Dirk Saelens, KU Leuven

Annex 71 Subtask 2 "Building Behaviour Identification" focuses on the development of dynamic data analysis methods suitable for describing the energy dynamics of buildings. The aim is to develop models, based on in-situ monitored data that can be used in model predictive control, fault detection and design, control and optimisation of district energy systems. This Subtask will analyse the data acquisition, development of methodologies and accuracy and reliability of the building behaviour identification models for individual dwellings and residential districts. At the same time Subtask 2 will make the link with BES-models (BES: Building Energy Simulation) by performing a BES-validation and calibration exercise. Subtask 2 consists of three major tasks:

Opportunities in existing neighbourhoods.

Subtask 2.1 looks into finding case studies that can be used for developing reliable procedures for dynamic data analysis and to perform validation and calibration of BES models on real measured data. Currently the participants are proposing cases in which extensive data sets will be collected, making it possible to investigate the impact of reducing the set of input data on the obtained outcome. That way the minimum amount of data needed for a reliable identification can be defined. The obtained data will also be used in Subtask 3 to develop and validate parameter identification procedures and in Subtask 4 to develop a quality assessment.

The aim of **Subtask 2.2** is to identify suitable models for describing the energy dynamics of buildings. A wide range of possible methodologies exist, ranging from white box, through grey box to black box models. Subtask 2.2 will focus on which method to use for dynamic data analysis, taking into account the purpose of the outcome (building behaviour identification), the existence of prior physical knowledge, the available data and the statistical tools. A very important aspect is that the proposed modelling techniques are able to correctly quantify the uncertainties of obtained information correctly. The methodologies will be tested and validated on the data collected in Subtask 2.1. That way quality procedures and guidelines for building behaviour identification can be developed.

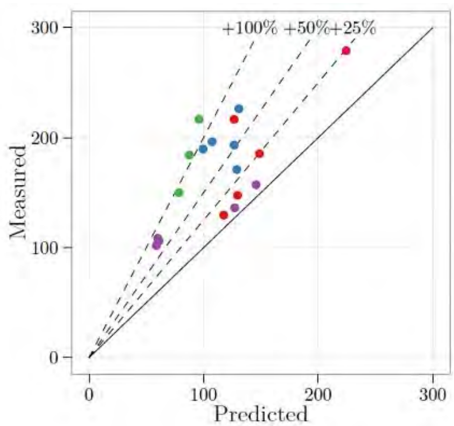
Finally, in Subtask 2.3 a BES validation and calibration exercise is envisaged as a follow up of the Holzkirchen Twin House validation experiment carried out in the IEA EBC Annex 58 project. It will focus. In the validation exercise a blind validation will be performed on one of the collected case studies. The gathered data will be compared with numerical simulations. In contrast to the Annex 58 case, this exercise will deal with a dwelling heated with a real system and occupied by (artificial) users. Apart from the design phase, building energy simulation is often used in renovation or optimization projects of existing buildings. To do so, the BES-models are typically first calibrated based on (limited) measured data to 'tune' the model to the actual performance. To check the reliability of this procedure a blind calibration exercise will be performed within this subtask. The input data will again be based on the collected case studies.

Currently, submissions for choosing case studies are applied for and the participants have been invited to do a first common exercise. Based on experimental data, obtained from a measurement campaign performed during IEA EBC Annex 58 by CIEMAT at PSA in Almeria, Spain, models should be identified that are able to predict the evolution of the indoor temperature during a blind validation period. In addition to the temperature profile, participants are asked to predict the number of overheating hours for the building during this validation period.

Subtask 3 of the IEA EBC Annex 71

Chris Gorse, Leeds Beckett University

Current strategies to reduce the operating energy consumption of the built environment are underpinned by the assumption that a building in-situ exhibits the same performance characteristics as that which were defined in the theoretical design stage. The challenge of this assumption has led to the growth of a body of evidence suggesting that there exists a performance gap between building design and completion. In order to evaluate this performance gap, it is necessary to empirically evaluate the



Energy Performance Gap for several building types physical parameters of the completed building, permitting direct comparison with the theoretical design targets. Typically this is an intrusive and lengthy process, requiring invasive tests to be undertaken whilst the building is unoccupied.

In response to the existing constraints associated with physical parameter identification of in situ buildings, Subtask 3 of the IEA EBC Annex 71 aims to develop analysis methods that may be applied to limited datasets gathered from occupied buildings using unobtrusive equipment such as smart meters. Subtask 3 will build on the knowledge and learning generated during Subtask 2 (building behaviour identification), but rather than attempt to quantify building behaviour for application in other scenarios, Subtask 3 aims to quantify the physical parameters such as the heat transfer coefficient, net energy demand, air tightness and heating/cooling system efficiency. The work will be evaluated against standards and the work will normalise estimated in-use energy use with national standards.

Case studies centred on in-use data from buildings with known physical parameters will form the basis of model development, with multiple approaches ranging from linear regression to grey-box modelling to be explored. Critical to the development of the numerical models will be an appreciation of the uncertainties associated with each method, and as such confidence intervals and quality assessment will be central in Subtask 3. Initial models will utilise all available in-use data, however once sufficiently robust methods for building parameter identification have been generated, stepwise reduction of input data will be undertaken to investigate the minimum data requirement for reliable results.

Subtask 3 will investigate whether in-use data is sufficient to allow the development of robust methods to establish the physical parameters of a building in-situ, and determine the confidence with which these models may be applied. Additionally, the minimum amount of input data required for model development will be explored, and the impact that lower quality data has on model success recognised. The output from Subtask 3 will feed directly into Subtask 4, seeking to apply the findings in a real world context for quality assessment.

The work of this and related subtasks will develop non-intrusive methods of extracting reliable data on building's characteristics and behaviour. As buildings start to incorporate monitoring systems, recording real life data, appropriate disaggregation and analysis techniques are required to underpin and support building automation systems. Understanding the metrics, standards and appropriate use of the data is essential if the industry is to make effective use of smart meters, home automation systems and wireless technologies. The work of Annex 71 will provide a knowledge base and more robust metrics and methods on which the industry can build.

Two methods for U-value measurements

Richard Fitton, The University of Salford

A new unique look at measuring suspended floor U-values

Heat-flow variability of suspended timber ground floors: Implications for in-situ heat-flux measuring:

http://www.sciencedirect.com/science/article/pii/S0378778816313135

Approximately 6.6 million UK dwellings pre-date 1919 and are predominantly of suspended timber ground floor construction, the thermal performance of which has not been extensively investigated. Reducing space heating energy demand supports the UK's legislated carbon emission reduction targets and requires the effective characterisation of the UK's existing housing stock to facilitate retrofitting decision-making.

Researchers at the Sheffield School of Architecture, the University of Salford and UCL examined suspended timber ground floor heat-flow by undertaking and presenting high resolution in-situ heat-flux measurements at 15 point locations on the floor of the Energy House at the University of Salford.

The results highlight significant variability in observed heat-flow: point U-values range from 0.56 ± 0.05 to 1.18 ± 0.11 $Wm^2 K^{-1}$. This highlights that observing only a few measurements is unlikely to be representative of the whole floor heat-flow and the extrapolation from such point values to whole floor U-value estimates could lead to its over- or under- estimation. Floor U-value models appear to underestimate the actual measured floor U-value in this case study. This paper highlights the care with which in-situ heat-flux measuring must be undertaken to enable comparison with models, literature and between studies and the findings support the unique, high-resolution in-situ monitoring methodology used in this study for further research in this area.

The Arcada/University of Salford Project: Rapid U-value Measurement, results now available.

http://www.bre.co.uk/news/BRE-reveals-potential-solution-for-improving-the-measurement-of-heat-losses-from-solid-wall-homes--1126.html

The problem of assessing the measured U-values of solid walls is a major issue for the UK, with over 7 million solid wall properties, representing a major energy efficiency issue. To help establish a lower cost and quicker approaches to establish the performance of solid walls the UK Government held a competition conducted by the UK's Building Research Establishment (BRE) inviting companies and research organisation to submit innovative approaches to measuring U values. The completion was won by a joint submission from the Dr Richard Fitton from University of Salford (UK) and Mikael Paronen, Arcada (Finland), who developed original technology.

We could see the technology developed by Arcada had real potential and we developed the case for the completion with them by running tests in the Salford Energy House ; the results from this showed the system delivered U values in line with expected values in just over an hour, when compared with a minimum of three days using current methodologies.

Supported by funding from the Department for Business, Energy and Industrial Strategy (formerly the DECC), the tool underwent a laboratory and field-based test programme focused on measurement accuracy and speed, ease of use and financial viability. The detailed testing undertaken by BRE indicated that the Rapid U Value Sensor was robust and results were accurate, and more importantly, they indicated that the system was easy to use. This indicates a potential to take the measurement of in situ U-values from a costly and time consuming research method to something that may be available for practitioners as a form of in-line testing.

A bit of modelling history - PASSYS project

Paul Strachan, ESRU, University of Strathclyde

Modelling and simulation formed an important part of the PASSYS project at its commencement in 1986 and continued to do so in subsequent related projects as listed in the previous Dynastee newsletter, through to the current IEA EBC Annex 71 "Building energy performance assessment based on in-situ measurements".

There were two strands to the original research. The first was undertaken by the Model Validation and Development (MVD) subgroup that had the remit of reviewing algorithms in detailed simulation programs and devising validation tests – at first analytical and inter-program comparisons in the PASSYS I project (1986-1989), followed by empirical validation using the operational PASSYS test cells in PASSYS II (1989-1993). This was a substantial research effort – 20 researchers from 10 countries were involved in the MVD subgroup. The developed validation methodology comprised elements of theory review, code checking, analytical validation, inter-program comparisons and empirical validation. Empirical validation itself was broken down into the validation of particular heat transfer processes and whole-model validation which tested the whole program structure. The second research strand was undertaken by the Simplified Design Tools (SDT) subgroup, which developed, as the name suggests, simplified models with correction factors (e.g. utilisation factors for solar and internal gains which became embedded in the EN ISO 13790 standard for building space heating and cooling energy calculations) based on correlation analysis from multiple simulations with a detailed simulation program. The program ESP, developed at the University of Strathclyde in Glasgow, was chosen as the European reference program for the work of both the MVD and SDT subgroups, providing a focal point for comparing, and suggesting new, algorithms that could be tested within the whole building modelling framework.

In subsequent projects (e.g. PASLINK, DAME-BC and PV-Hybrid-PAS), a procedure for calibration, scaling and replication was developed. This involved comparing modelling predictions with detailed experimental data obtained with test components mounted on the test cell, and calibrating the models, if necessary, where there were modelling uncertainties, for example with appropriate convection coefficients. Following this, one or more full-scale buildings were modelled with and without the novel test components (advanced glazings, PV-hybrid modules etc) in order to determine the energy and environmental performance (energy consumption, IAQ, thermal comfort, lighting etc) in realistic operational scenarios. Different climatic boundary conditions could also be applied to assess the performance in different climatic regions. A special issue of the journal Building and Environment (2008, Vol 43(2)) reported on some of the work undertaken, including a summary of case studies.

Recent research undertaken within IEA EBC Annexes has led to a return to empirical validation of detailed building energy simulation programs, notably in IEA EBC Annex 43 in 2003-7 and more recently within IEA EBC Annex 58 in 2011-16 to which many Dynastee participants contributed. As part of Annex 58, detailed experimental specifications and high quality datasets were obtained for validation experiments carried out at Fraunhofer IBP Twin Houses in Holzkirchen, Germany. Over 20 sets of model predictions from 15 organisations using 12 different programs were submitted and compared to the measured data in an iterative process. A paper in the Journal of Building Performance Simulation (2016 Vol 9(4)), “Whole model empirical validation on a full-scale building” summarised the outcomes from the first of these experiments. It is intended that a further validation experiment will be conducted in the recently commenced IEA EBC Annex 71, this time including not only the building envelope but also systems and synthetic occupancy. As detailed simulation programs become more routinely used for design of low energy buildings and regulations compliance, there is a continuing need to ensure that the resulting model predictions are reliable.

Some members of the PASSYS MVD group

ABOUT DYNASTEE

DYNASTEE is an informal grouping of organisations involved in research and application of tools and methodologies for DYNAmic Simulation, Testing and Analysis of Energy and Environmental performances of buildings. DYNASTEE provides a multidisciplinary environment for a cohesive approach to the research work related to the energy performance assessment of buildings in relation to the Energy Performance for Buildings Directive (EPBD). DYNASTEE, being a network of competence in the field of outdoor testing, dynamic analysis and simulation, has over 25 years of experience through a series of EU research projects. DYNASTEE is an open platform for sharing knowledge with industry, decision makers and researchers. DYNASTEE has the expertise needed to support the developments and design of Nearly-Zero Energy Buildings as required by the EPBD. Specific outdoor experimental work needs knowledge of the analysis process in order to optimise the dynamic information in the measurement data. Simulation requires results from analysis in order to be able to scale and replicate the results from analysis and testing to real buildings in different climates. DYNASTEE functions under the auspices of the INIVE EEIG. For more information visit the DYNASTEE web-site at www.dynastee.info