Summary of airtightness track

Around 160 participants attended the joint 36th AIVC – 5th TightVent – 3rd venticool conference held in Madrid, Spain September 23-24, 2015. The programme consisted of 3 parallel sessions with contributions from 27 countries and international organisations.

Over 120 presentations were given covering topics ranging from air infiltration through leaks in the building envelope and ductwork, ventilation in relation to IAQ and health, ventilative cooling and thermal comfort.

It has also been a major discussion place for on-going projects and initiatives such as the TightVent Europe and venticool (http://venticool.eu/) platforms, the Indoor Environmental Quality – Global Alliance (http://ieq-ga.net/), the QUALICHeCK project and platform (www.qualicheck-platform.eu), the IEA EBC annex 62 (http://venticool.eu/annex-62-home/), the IEA EBC annex 68 (http://www.iea-ebc.org/projects/ongoing-projects/ebc-annex-68/) and the Renew School project (http://www.renew-school.eu), based on presentations of results and perspectives as well as fruitful interactions with the audience.

The airtightness track of the conference consisted of 5 sessions with 23 presentations. Specific topical sessions dealing with airtightness included the following topics:

- Building airtightness testing: ground status from various countries
- Airtightness – Airflow measurements
- Solutions and future developments for airtight envelopes and ductwork in new and renovated buildings
- Air infiltration modelling
- Airflow and airtightness measurements

This article summarises the main trends and conclusions addressed during the presentations and discussions in the airtightness track of the conference.

Several presentations reported on **large scale measurement campaigns**. Bailly presented an analysis of the French national airtightness database, currently counting 65,000 airtightness measurement results, gathered over a 6 year period, 2008-2013 (Bailly, Guyot, & Leprince, 2015). They investigated the potential influence of many parameters on the airtightness value, including construction type, age, volume and location as well as the time of measurement during the year. According to the authors, the number of airtightness measurements performed on residential buildings has been growing fast since 2007 (launch of the BBC-Effinergie label later on reinforced by the 2012 EP regulation RT2012- imposing a limit value for airtightness for all new dwellings and the mandatory justification of the building airtightness level) and the buildings are becoming more and more airtight.

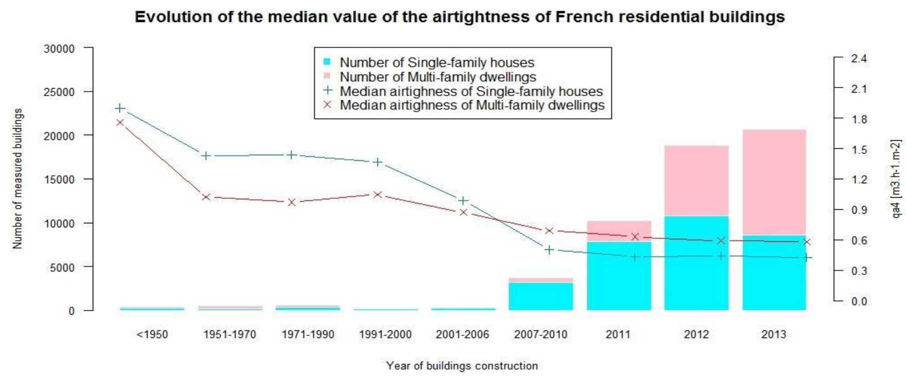

Figure 1: Evolution of the median value of the airtightness of French residential buildings (Bailly, Guyot & Leprince, 2015)

Also in France, Charrier et al., analysed the current process of the French airtightness quality management scheme, its results and the improvements to be scheduled in the next certification process which will be managed by accredited certification bodies (Charrier & Ponthieux, 2015).

Jo presented an analysis of airtightness data and characteristics of 752 units of high-rise reinforced concrete apartment buildings in Korea (Jo, Shin, & Ji, 2015). A key outcome of the study, among others, was an airtightness prediction model derived from a multiple regression analysis performed based on the measured data.

Cope gave an oversight as to how the Air Tightness Testing & Measurement Association (ATTMA) has made lodgement mandatory, the software used and some statistical analyses showing where the UK is at the moment with average Air Permeability (AP_{50}) results (Cope, 2015). Solcher presented the building airtightness status in Germany, where a recent survey revealed that the n50-values are much better than the benchmarks given in EnEV 2014 (German EPBD); one major driving force seems to be the EnEV in combination with funding programmes of the KfW (Kreditanstalt für Wiederaufbau) which gives out subsidies or credits with low interest rates only if an airtightness test is done and the n50-value complies with the benchmarks (Solcher, 2015).

Another study by Agüera et al. analysed data of envelope airtightness in subsidised housing built in Madrid and Seville in 1940-1980, with the aim to characterise airtightness and assess air quality at various levels of airtightness in different seasons of the year (Fernández-Agüera, Sendra, Suárez, Domínguez-Amarillo, & Oteiza, 2015). Their results show that low-energy housing refurbishment must aim both to improve the thermal resistance of the building envelope and its airtightness and ensure that ventilation systems are suitable and efficient.

Gorka et al. discussed the results of airtightness measurements in a 47-appartment building using various methods and confirmed limits of sampling methods to estimate the whole-building air leakage rate (Górka, Górzeński, Szymański, & Bandurski, 2015).

Several presentations also pointed out the benefits of high levels of building (Tomšič, Rakušček, Mirtič, Zupančič, & Šijanec Zavrl, 2015) and ductwork (Salame, Sanz, & Pascual, 2015) airtightness.

The **characterisation of airtightness solutions** was addressed by several authors. A literature review by Roels et al. dealt with the impact of air flow on the thermal performance of pitched roof assemblies (Roels & Langmans, 2015). They showed that it is possible to construct a well-performing and robust pitched roof with high thermal quality and resilient to air flow patterns and the authors put forward guidelines on how to do so.

Belleudy et al. developed a detailed model coupling heat air and moisture (HAM) transfer and used it to analyse moist air flows due to airtightness defects (bad design or poor workmanship, material imperfections, construction tolerances, etc.) (Belleudy, Woloszyn, & Cosnier, 2015). The authors analysed the results in terms of moisture risk and energy impact and carried out a parametric study on boundary conditions. The study showed higher moisture risk in case of air exfiltration through the airtightness defects.

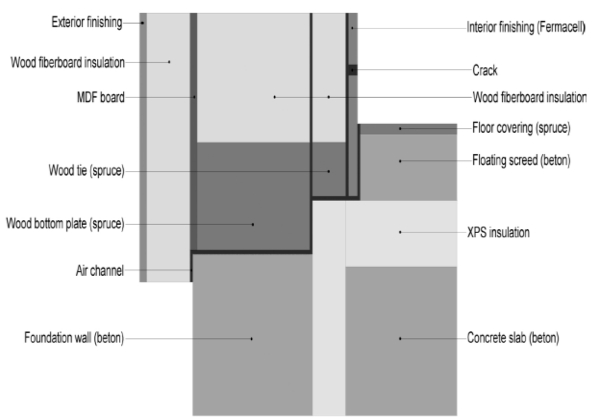

Figure 2: 2D section of the studied airtightness defect (Belleudy, Woloszyn & Cosnier, 2015)

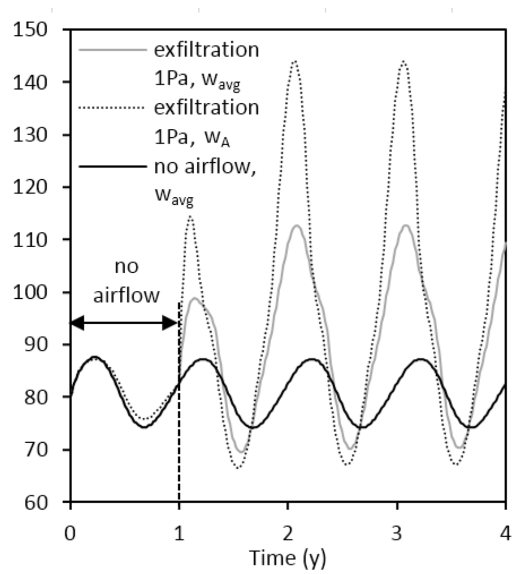

Figure 3: Comparison between averaged moisture content of wood bottom plate and ponctual moisture content evaluated at point A, for exfiltrating scenario (Belleudy, Woloszyn & Cosnier, 2015).

Van Mieghem gave an overview of sealing products and standards that can be used to characterize their performance in terms of air permeability, VOC emissions, movement capacity, etc. (Van Mieghem, 2015).

An investigation of the impact of severe climatic conditions on the airtightness of typical taped joints was conducted by Langmans et al. (Langmans, Desta, Alderweireldt, & Roels, 2015). The authors proposed a methodology to study the durability of taped joints based on air permeability testing and artificial ageing tests. Two different commercially available tapes were exposed to three accelerated ageing protocols and the joint's air permeability was measured before and after being exposed to these conditions. The researcher stressed that the permeability increase was limited for both tapes tested.

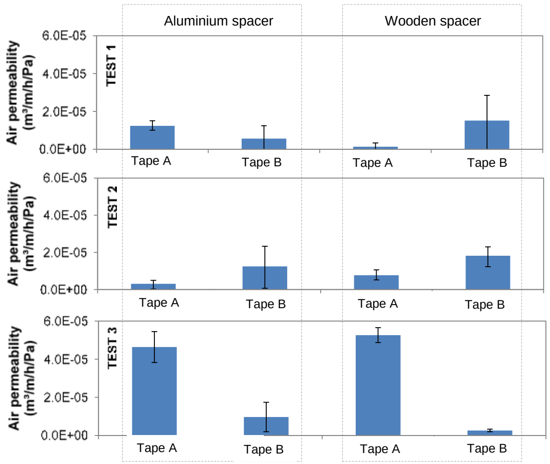

Figure 4: Increase in air permeability of the joints after the artificial ageing of the samples (Langmans, Desta, Alderweireldt & Roels, 2015)

A number of presentations discussed **tools and methods for airflow and airtightness measurements and analyses**. Cooper et al., winners of the conference best paper award, further developed a new low pressure 'quasi-steady' pulse technique (Cooper, Zheng, Gillot, & Riffat, 2014) for determining the airtightness of buildings and compared it with the standard blower-door technique for field-testing a range of typical UK homes (Cooper, et al., 2015). The field trials carried out demonstrated that the pulse test has the potential to be a feasible alternative to the standard blower-door test.

Figure 5: The latest Air Pulse Unit (APU) (Cooper, Zheng, Wood, Gillot, Tetlow, Riffat & De Simon, 2015)

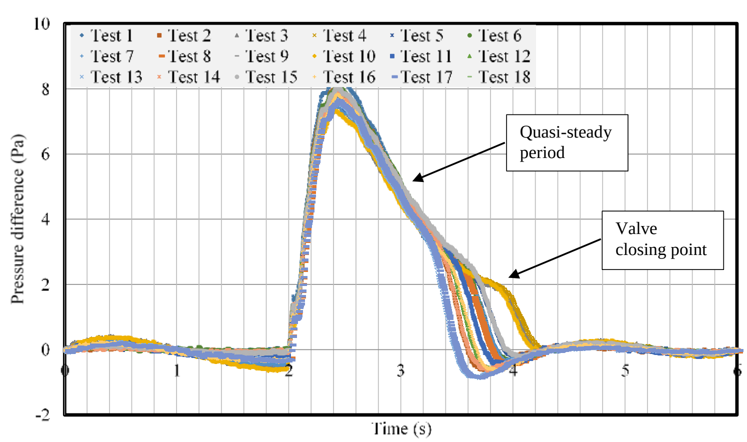

Figure 6: Adjusted internal pressure pulses from 18 repeated test runs (Cooper, Zheng, Wood, Gillot, Tetlow, Riffat & De Simon, 2015)

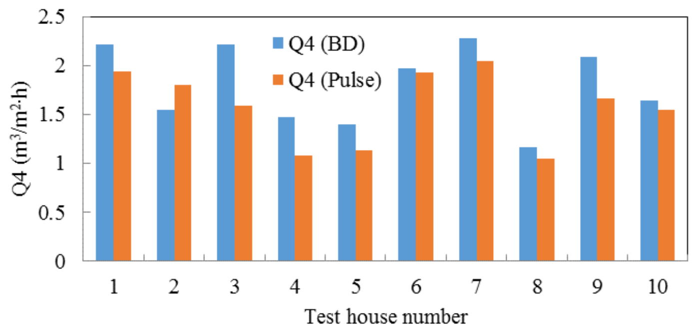

Figure 7: The permeability @4Pa, Q4, predicted by the blower-door (BD) and measured by the APU (Pulse) (Cooper, Zheng, Wood, Gillot, Tetlow, Riffat & De Simon, 2015)

Genge introduced the rCloud app which allows technicians to perform a fully automated blower door or duct test via phone or tablet and store data on a remote server including test location (via GPS), local weather and housing information from local resources (Genge, 2015).

Kraniotis et al., from the Norwegian Institute of Wood Technology, investigated the influence of infiltration on moisture buffer (drying process), studying the simultaneous decay of CO2 and vapours in a relatively tight and insulated cross laminated timber (CLT) test house (Kraniotis, Aurlien, Brückner, & Nore, 2015). Based on the results of the study the moisture content relates to the locations of the leakages, even when the global infiltration rates between two case-studies are very similar. Furthermore, using moisture (water vapours) as 'tracer gas' for estimating the air exchanges in a room, proved complex because, in contrast to the outdoors CO_2 levels, the vapour pressure and concentration outdoors are not constant and thus, a 'vapour injection' from outdoors to indoors takes place even during the decay of indoors moisture.

Richieri et al. assessed the impact of envelope airtightness on airflow patterns for single detached dwellings depending on the ventilation system (Richieri, Moujalled,, Salem, & Carrié, 2015). The authors used a numerical approach based on TRNSYS coupled to a multi-zone air-flow and contaminant transport model COMIS, to analyse the local and global performance of four mechanical ventilation strategies in terms of energy and ventilation efficiencies. The findings revealed a significant impact of air permeability on the ventilation efficiency, with a different impact depending on the mechanical ventilation system. Moreover, when analysing the fresh air origin, results showed that in the case of humidity-sensitive ventilation systems, specific attention should be paid to the air permeability in order to maintain the desired airflow pattern from main rooms to service rooms.

Ng et al. described the design and construction methods used in the Net Zero Energy Residential Test Facility (NZERTF) - built on the campus of the National Institute of Standards and Technology (NIST) - to achieve a very tight building with reliable mechanical ventilation, as well as the results of selected performance measurements in the building (Ng, Persily, & Emmerich, 2015). The authors highlighted some of the measurement and modelling challenges in very tight buildings, including appropriate airtightness limits and the accuracy of measurements at very low airflow rates.

Figures 8 & 9. Construction of NZERTF showing the air barrier (left) and completed structure (right) (Ng, Persily & Emmerich, 2015).

Lim presented an estimation of the uncertainty in the calculated ventilation airflow rate associated with changes in the wind velocity profile (Lim, Ooka, & Kikumoto, 2015). The results of the study showed that the ventilation airflow rate obtained from a constant value for the exponent index for an isolated building with two openings is underestimated by up to 8% in the daytime.

Fulop et al. introduced a simple but refined method to specify the average air change rate (ACH) for a heating season based on field tests (Fülöp & Polics, 2015). The method calculates the natural ACH based on BlowerDoor tests by taking into account the temperature difference and the wind speed. Results showed that the ACH derived from the proposed method increases the reliability of the energy balance calculations, yet further tests are required to achieve more reliable values.

Bink discussed the zero pressure compensation method for air flow rate measurement (Bink, Lok , & Struik, 2015). The result of the study showed that although in theory it seems straightforward to compensate the pressure caused by an intrusive device, in practice it is not. To this end, an 'extended' zero pressure method is being developed allowing a more accurate determination of the pressure to be compensated both for supply and return flows.

Simons explained what calibration should mean and looked into the hierarchy of and the differences between the calibration labs of national standards, accredited labs and manufacturer's calibration labs. His presentation also covered the measuring range and the accuracy of pressure gauges and measuring fans, as well as their calibration process (Simons, Rolfsmeier, & Pujiula, 2015).

References

Tomšič, M., Rakušček, A., Mirtič, M., Zupančič, L., & Šijanec Zavrl, M. (2015). Thermal envelope quality versus nZEB parameters and long-term economics: the eco-silver house case in Ljubljana. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 261-271). Madrid: AIVC.

Bailly, A., Guyot, G., & Leprince, V. (2015). 6 years of envelope airtightness measurements performed by French certified operators: analyses of about 65,000 tests. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 22-32). Madrid: AIVC.

Belleudy, C., Woloszyn, M., & Cosnier, M. (2015). Detailed numerical modelling of moist air flow through a complex airtightness defect. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 601-611). Madrid: AIVC.

Bink, N., Lok , P., & Struik, W. (2015). The zero-pressure paradox. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 272-279). Madrid: AIVC.

Charrier, S., & Ponthieux, J. (2015). Airtightness Quality Management Approaches in France: end and birth of a scheme. Previous and new schemes overview and analysis. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 250-260). Madrid: AIVC.

Cooper, E., Zheng, X., Gillot, M., & Riffat, S. (2014). A nozzle pulse pressurisation technique for measurement of building leakage at low pressure. Proceedings of the 35th AIVC - 4th TightVent - 2nd venticool Conference , 24-25 September, Poznan 2014 (pp. 236-244). AIVC.

Cooper, E., Zheng, X., Wood, C., Gillot, M., Tetlow, D., Riffat, S., & De Simon, L. (2015). Field trialling of a new airtightness tester in a range of UK homes. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 759-767). Madrid: AIVC.

Cope, B. (2015). Analysis of results from ATTMA lodgement –what are the realistic air permeability characteristics of UK housing. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 19-20). Madrid: AIVC.

Fernández-Agüera, J., Sendra, J., Suárez, R., Domínguez-Amarillo, S., & Oteiza, I. (2015). Airtightness and indoor air quality in subsidised housing in Spain. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 43-52). Madrid: AIVC.

Fülöp, L., & Polics, G. (2015). Estimating the average air change rate for the heating season. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 300-308). Madrid: AIVC.

Genge, C. (2015). rCloud -capturing the moment, a new era in automated testing. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 239-240). Madrid: 2015.

Górka, A., Górzeński, R., Szymański, M., & Bandurski, K. (2015). Multivariant measurements of airtightness of multi-family building. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 778-788). Madrid: AIVC.

Jo, J., Shin, H., & Ji, K. (2015). Airtightness Data and Characteristics of 752 Residential Units of Reinforced Concrete Buildings in Korea. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 33-42). Madrid: AIVC.

Kraniotis, D., Aurlien, T., Brückner, C., & Nore, K. (2015). Impact of air infiltration rates on moisture buffering effect of wooden surfaces. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 727-737). Madrid: AIVC.

Langmans, J., Desta, T., Alderweireldt, L., & Roels, S. (2015). Laboratory investigation on the durability of taped joints in exterior air barrier applications. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 615-623). Madrid: AIVC.

Lim, J., Ooka, R., & Kikumoto, H. (2015). Uncertainty in airflow rate estimation of daytime ventilation associated with atmospheric stability. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 241-249). Madrid: AIVC.

Ng, L., Persily, A., & Emmerich, S. (2015). Infiltration and ventilation in a very tight, high performance home. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 719-726). Madrid: AIVC.

Richieri, F., Moujalled,, B., Salem, T., & Carrié, F. (2015). Numerical evaluation of the airtightness impact on airflow pattern in mechanically ventilated dwellings in France. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 738-749). Madrid: AIVC.

Roels, S., & Langmans, J. (2015). How to construct a domestic pitched roof with high thermal quality. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 593-600). Madrid: AIVC.

Salame, T., Sanz, R., & Pascual, S. (2015). Airtight duct systems [a simple way of improving a building's energy efficiency without increased investment]. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 293-299). Madrid: AIVC.

Simons, P., Rolfsmeier, S., & Pujiula, F. (2015). Calibrating measurement gauges –expense and findings. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 768-777). Madrid: AIVC.

Solcher, O. (2015). Building airtightness in Germany -what are the driving forces. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (p. 21). Madrid: AIVC.

Van Mieghem, F. (2015). Characterization of sealants and expanding foams. Proceedings of the 36th AIVC-5th TightVent-3rd venticool Conference, 23-24 September (pp. 612-614). Madrid: AIVC.