Performing intermediate checks and early-stage testing of airtightness

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Good building airtightness is now commonly regarded as an important prerequisite for both good energy performances, user comfort and service life of most modern buildings. Builders want to avoid the surprise of a poor airtightness measurement result in the finished phase of a new building. Repairing documented air leaks can then be a very costly experience and a complicated process.

This paper gives effective methods to overcome this problem, by sharing some good experiences from the process of avoiding pitfalls and achieving good airtightness of buildings.

Early-stage testing

Performing intermediate checks and early-stage testing of airtightness of the building envelope is becoming part of common practice in Norway. Locating and repairing leaks is at this stage is usually a very cost-effective task.

There are several approaches to early-stage testing:

TESTING REPRESENTATIVE SMALL PARTS OF THE ENVELOPE: In large building projects one may test representative parts of the envelope details that have been completed early compared to the rest of the project. The purpose of this is to gather experience that can be used further on other the parts of the project. This test is also useful as an extra quality assurance of as-built design, details and description of workmanship issues. This is especially helpful when the builder is confronted with building products or details that are new to the firm or to the industry.

One method of doing this testing is by defining and pressurizing a temporarily isolated representative zone, as shown in the **Figure 1**.

In this case, one measures the leakages from the test zone, including leakages from the temporary "tent". Designers

Figure 1. Temporary "tent" made from plastic foil, with a (red) blower door mounted. The amount of air that is sucked out of the tent by the fan in the blower door equals the leaking air that pass through the details of the façade being tested. A person inside the tent may easily detect air-leakages in the facade by just feeling with his hand along joints and details in question, if the air pressure inside the tent is kept at a lower level than the outside (around 50 Pa). This picture is from a new large building with passive-house ambition (n_{50}<0.6 h^{-1}).

and contractors may draw conclusions of good detailing, if one reaches good levels of airtightness. In the opposite case, one may not draw too strict quantitative conclusions, as some of the leaking airflow may come from the tent.

TESTING ZONES: Another approach is to pressurize a zone. These zones are often volumes of the building that are supposed to be airtight from other zones for other reasons too, like fire zones of a large building. In early stages of this kind of a building project, extra preparations are often required to insure airtightness from the other zones. Just achieving a pressure difference by use of a fan (not needing to read the measured leakages), and using a thermography camera, the technician may detect problems that need to be fixed for the rest of the project. **Figure 2** shows one example of a practical issue that had not been thought about in the design phase of the project: temporary anchoring of the

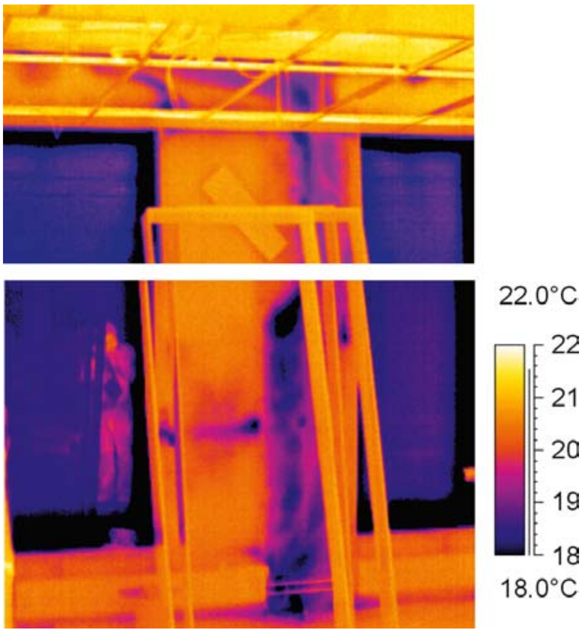

Figure 2a. Thermography from inside of construction shown in next photo.

Figure 2b. Leaky wind barrier detail, from anchoring of the outside scaffolding (Photos: Tormod Aurlien).

outside scaffolding. In this case, the design was immediately changed for the rest of the building project, and the already built part has been repaired.

WIND-TIGHT-LAYER TESTING: What seems like a Norwegian speciality is our relatively new emphasis on testing detached and semi-detached houses in early wind-tight-stage, often by using low-cost simplified equipment. A very large part of our population lives in these houses, and small firms usually build them.

Common experience from numerous airtightness measurements that have ended up with high air permeability levels, shows that trying to repair leaks on the inside often is nearly fruitless. A report often has thermograms pinpointing the leaks, but the technician only detects where the leakage airflow enters the inside of the building, not its source. The source may be somewhere in the outer wind-tight layer. Once the air has leaked in from the outside, it is easily distributed through cavity constructions that are filled with highly permeable insulation. As constructions have become thicker, often with the vapour-barrier being placed at a defined distance from the surface materials, it has become increasingly more challenging to detect the flow paths using infrared cameras or other detection techniques.

A natural response to this has been to perform airtight-measurements in the stage where the outer layer is complete, doors and windows are in place etc, but before insulation is placed from the inside and covered. Leakages are readily detected in this stage, by just feeling with the hand, having an inside under-pressure through use of the measuring fan. Furthermore the repair of these leakages is very cheap and easy.

We know of three measurements in this early wind-tight-stage being performed in the 80's in Norway. A later similar measurement that took place in 1998 caught great interest.

An initiative from The Norwegian Homebuilder Association soon led to simplified equipment being designed and spread to the market of their members in the building industry (**Figure 3**).

The initial philosophy was to just create a pressure difference between the building and the outside (exceeding around 30 Pa and possible to feel by hand on foils

www.Flexit.no
300 – 1 500 m³/h @ 50 Pa

www.villavent.no (Systemair)
Small < 500 m³/h
Medium 500 – 1 500 m³/h
Large 1 500 – 3 000 m³/h
@ 50 Pa

Figure 3. Simplified Norwegian equipment for airtightness measurement of smaller buildings.

etc. being tight). If the craftsman using the fan failed to achieve any pressure difference across the wall, then his job was to find the leaks and repair them, until a pressure could be detected. This simple approach was very good! The project caught on, and it soon evolved into having some quantified results coming out of the process too.

Response from craftsmen

Doing airtightness testing on a more regular basis has been met with a bit of scepticism by some building firms. On the other hand, a very common reaction by skilled craftsmen, is that they very much appreciate being valued for the effort that they put into good craftsmanship and reaching technical goals, like airtightness; not only being valued for their effort towards the aesthetic finish. It is nice being told in forehand in the project that measurements are planned, though. Being given the tools to perform these checks by oneself is even nicer. This last point has been an important reason for development of the simplified-method testing: the possibility for the builders to perform testing themselves.

An important additional argument for performing these simplified-method tests is that airtightness testing requires being on site on exactly the right time in the building process, when the level of completeness is just appropriate. Craftsmen dislike being stopped in progression, having to wait for someone with the right equipment to come when they have the capacity to do it themselves. As an illustration, one might note that the early-stage measurement on the building shown in **Figure 4** was performed a little bit too early; one balcony door was not mounted yet, the result of challenges in timing.

The importance of final-state measurement

Quite recently the airtightness of the whole building from which **Figure 1** is shown was measured. In this case governmental funding for passive house activity, requiring airtightness measuring, was released based on the preliminary measurements from the tents. It could have been awkward, though, if the required airtightness goals were not met in the final measurement of the whole building. Fortunately, the final-state measurements met the ambitious goals. Both builder and customer were happy.

Experience from several measurements in both early stage and in finished stage on the same building shows that one might end up with a poorer airtightness at the final stage compared with the early-stage-measurements. In fact, many things happening during the late part of the building process may cause extra air-leakages to the buildings. Examples include ventilation ducts being installed in a late phase, with little attention to making penetrations airtight, or balconies being mounted delayed in the building process, the improvised anchoring causing leaks.

Figure 4. Norwegian wooden building being in early-wind-tight-stage. Wind-break layers are of nonwoven HDPE fabric. Some parts of the wall have gypsum boards in addition, to reach fire resistance goals.

The conclusion is that early wind-tight-stage measuring should be followed up by a finished-state measurement. The early wind-tight-stage measurement should be recognized as a good insurance for the builder against blunders or incidents causing trouble with the customer in a later stage. It also serves as a powerful tool in the process of gathering experience to achieve the intended level of airtightness, especially with unfamiliar processes, details and materials, and thereby becoming everyday practice in a rapidly changing industry.

The level of measurement accuracy for the fans and other equipment used is not extremely important, when used in early stage measurements. The purpose of these initial depressurisations is not data with high accuracy. We must assume that the following final measurements are carried out with sufficiently precise equipment. It is equally important that competent users of the equipment, who understand and perform this according to international standards, do these measurements.

CHANGE OF NORWEGIAN REGULATIONS: 3rd party independent inspection of design and workmanship for airtightness level is becoming mandatory at the start of 2013 for most of the Norwegian new buildings. It is going to be exiting to follow how this turns out and develops.

Measuring is being recognised as being needed to prove this important quality: *Detailed design is necessary, but not sufficient to reach targeted level of airtightness needed for low-energy buildings.*