Is the air in your apartment stale?
Are your windows foggy?
Do you suffer from draft?
Do you suspect moisture or mould damages in the building?
How to get enough fresh air?
In Finland there are approximately one million apartments with natural ventilation having serious deficiencies in them. This instruction card gives advice on how to use and improve natural ventilation. Natural ventilation was commonly used until the 1980’s. The latest instructions included in the National Building Code are from 1978 and they state, for instance, that natural ventilation is allowed in living, office and meeting spaces only if there also exists a possibility to air the spaces. The regulations of 1987 no longer included any instructions concerning natural ventilation due to which only mechanical (forced) ventilation has been used after this date. More recently the possibility to plan natural ventilation has been introduced in the regulations again. However, this instruction card cannot be used to design ventilation according to the new regulations. Thus, this instruction card is applicable to apartments which have been built before the regulations of 1987. The instructions given on this card are also limited to individual and terraced houses only.

Pollutants and moisture are continuously created in the indoor air, for instance, by cooking, showering, drying the laundry, people, pets and furniture. The quality of the air we breathe has great impact on our wellbeing, so the air must be pure and there has to be sufficient ventilation. Poor ventilation and high humidity of the indoor air can even cause mould and health problems.

The basic principle of ventilation is to carry a sufficient amount of fresh air through the living spaces. Outdoor air is led into the bedrooms and living rooms after which it is removed through the kitchen, toilet and the wet rooms. The aim is to remove air impurities such as odours and excess moisture from where they are generated so that they would not spread in the whole apartment.

After changing from oil heating into geothermal heating, installing additional insulation and ensuring sealing one must also take care of good ventilation.
Natural ventilation

Natural ventilation was most commonly used in houses which were built before the 1980’s. The function of natural ventilation is based on the pressure differences between the indoor and outdoor temperatures and those caused by the wind and therefore it depends on the weather conditions. Warm air tends to rise upwards and because of this the air can be led out through ducts which have been placed near the interior ceiling. Exchange air can be obtained by using many different methods and its recovery is not problematic if the ventilation system has been designed correctly.

The function of natural ventilation changes according to the seasons. In winter the air may change sufficiently but in summer the ventilation can be almost non-existent. If the pressure difference between the indoor air of the building and the outdoor air is small, the air flow may even change its direction and, if this happens, the exhaust duct is used to recover intake air. This might also allow pollutants and impurities to enter the living spaces. Enhancing the ventilation during the warm season may be based on utilising the wind or using electric fans or using the combination of the two above-mentioned methods.

The generator of natural ventilation has often been oil heating which has also warmed the exhaust ducts positioned in the same chimney. However, masonry ducts are often weathered/crumbly and they have damages which may weaken the air flow. Based on the condition inspection of the ducts, it is decided if the ducts can be repaired and how it can be done. The options available are tubing and lining. The air flow is also weakened by changes in the heating method if the temperature of the duct drops.

Intake air i.e. fresh air vents are usually positioned either in connection with the window or on the surface of the exterior wall near the window. Unfortunately, in some apartments, there are no intake air vents at all. During the cold season, excessive air flows may prove to be a challenge as they cause the feeling of draft. The discomfort caused by the draft can be reduced by positioning the intake air vent behind the radiator or immediately above it or by using a heat recovery ventilation.

Every room and space should have an air vent

- Supply air vents in the bedrooms and living rooms
- Exhaust air vent in the kitchen, washroom and toilet
- Basements, entrance halls, cold-storage rooms, porches, storage facilities etc. should also have ventilation whenever possible.
Four seasons of natural ventilation

In spring, the daily temperature changes are big. The daytime temperature can reach, for instance, +10°C and the night temperature can sink to –10°C. At night natural ventilation functions reasonably well but during the day the air exchange is fairly low. During working days or schooldays lower air exchange rate does not cause much harm. However, the effects of humidity caused by air-drying the laundry indoors must be taken into account.

In summer the temperature and pressure difference between the indoor and outdoor air is almost non-existent most of the time. When the weather is calm, it is not helpful to ventilate or air the living space through the windows. In this case, ventilation must be enhanced mechanically in order to achieve high-quality indoor air.

The autumn example describes a situation where the outdoor air temperature is around 0°C. In Finland, there are about one hundred days a year when the outdoor temperature is around 0°C. During these days the air exchange rate is fairly low.

During the severe winter frosts, the temperature difference between the indoor and outdoor air can even exceed 50°C. In such situations, the air exchange rate can become uncomfortably high. However, a conventional number of vents only nearly reaches the requirements set for current ventilation.

The adjacent figures illustrate the thermal pressure difference of the duct. The actual pressure difference is also affected by wind, duct size as well as the type and number of the intake air ducts.

Natural ventilation is mostly based on the thermal pressure difference i.e. warm and light air tends to rise upward and, at the same time, in the lower parts of the building, cold outdoor air tends to enter the premises.
Challenges of natural ventilation

Common challenges for natural ventilation are:
- intermittent or continuous insufficient ventilation
- uneven distribution of fresh air
- the air does not change at all in some parts of the house
- too small pressure differences in the ducts and vents
- reverse flow from the exhaust ducts
- insufficient amount of exchange air
- missing or blocked exchange air vents
- exchange air flowing in through joints and cracks in the structures
- spreading of odours
- feeling of draft.

Challenges listed by G.E. Asp in 1902: “Although natural ventilation is usually a useful phenomenon, it can occasionally prove to be quite disastrous if it allows either filthy air or other poisonous gases to flow into the living quarters through it. This case can easily occur when air leaks in the room from inside the earth through the basement and the foundation. For it is most often so that the air inside the earth is contaminated by decomposing substances and for this reason it can, when entering the room, cause diseases in the habitants of the room.”

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Figure. Warm air tends to rise upward thus creating overpressure in the upper parts of the building and depression in the lower parts of the building. The greater the temperature difference between the indoor and outdoor air, the greater the pressure differences created over the envelope. The ventilation ducts on the roof function as exhaust air vents. The intake/fresh air vents on the walls should be situated as low as possible because of the maximal depression at that point. The intake air vent above the window functions in buildings which have mechanical exhaust ventilation, but it does not function in natural ventilation.
Assessing and examining ventilation efficiency

The function of the ventilation is to bring in fresh air and to carry out the air pollutants, carbon dioxide and excess moisture in the indoor air. Ventilation is used for producing sanitary and comfortable indoor air. In addition to poor quality indoor air, poor ventilation can cause wetting and damage of structures and odour problems.

In normal circumstances the indoor air of an individual house must change at least once every two hours. When necessary, the rate of ventilation is increased as in the case of using the sauna or cooking.

ASSESSING THE EFFICIENCY OF VENTILATION

Examining the ventilation can be divided into two stages; a rough condition assessment and a more profound condition inspection.

Condition assessment includes, among other things, an assessment of the
- functioning capacity and remaining lifespan of the system
- quality of the indoor air and the symptoms experienced by the residents (stuffiness etc.)
- level of comfort, draft and noise in the apartment
- removal of odours and moisture
- cleanliness of filters and ventilation shafts

Condition inspection includes
- measuring the air currents and pressure ratios
- examining the condition of the shafts, vents and equipment
- assessing the odours, dust, noise and visible moisture damages
- assessing the need for cleaning the shafts and adjusting the airflow
- monitoring and measuring the indoor air temperature and moisture
- determining the need for additional air exhaust and exchange ducts.

Monitor the indoor air humidity level at your home. During the winter frosts, the humidity must not rise above 40...45 % RH. The relative air humidity of the basements should also be kept sufficiently low in summer. This can be achieved by keeping the temperature of the basement above +20°C.
Improving natural ventilation

Poorly functioning natural ventilation can be improved in different ways. Utilising, for instance, wind power or the thermal radiation of the sun in order to heat the upper parts of the ducts does not require purchased energy.

Recently the market has come up with inexpensive control solutions for small electric fans. These are based, for instance, on humidity measurements, timer controls or motion detectors. When installing the electric fans in the ducts one should make sure that the ducts are sufficiently sealed. In wall installations it is easy to renew the already existing duct penetration system when necessary.

Small fans do not use much electricity, but they improve the functioning of natural ventilation. The kitchen hood is one of the most common ways of improving the ventilation during cooking and at other times as well.

The instalment of extractor fans will improve the ventilation, but it will also change the name of the system into mechanical extract ventilation. Changing the system into mechanical extract ventilation also includes the risk that an increasing amount of pollutants from the structures will enter the indoor air.

Changing into mechanical ventilation requires specialised planning and an operation permission issued by the Construction Supervision. It is advisable to contact the Construction Supervision already at the planning stage in order to ensure a smooth planning and authorization process.

Duct fans. The power of the fan on the left is 14 W and the power of the one on the right is 67 W. It can be presumed that the fan on the left makes natural ventilation more efficient. Installing the fan on the right, on the other hand, can transform the system into mechanical extract ventilation.
Planning for more efficient ventilation

Renovations such as adding extra thermal insulation to the facades, replacing windows and repairing plinths are all subject to authorization. During the authorization process of these repairs the Construction Supervision requires a clarification concerning the proper functioning of the ventilation and the securing of the exchange air supply. The list below summarises the basic options for ventilation during renovations:

1. The minimum solution is to examine and clean the ventilation and to secure a sufficient supply of exchange air. Specific technical building plans are not necessarily needed.

2. Sealing structures, renovating windows and basic adjusting of the heating system as well as increasing the number of exchange air vents and chimney cowls. Special attention must be paid to the air-tightness of the ducts and the ducts in poor repair must be either fitted with tubes internally or sealed by coating. These measures require a good knowledge of building technology.

3. Installing control automated extractor fans or replacing old vents with them. Technical building plans are needed and the need for building permission has to be verified.

4. Building mechanical intake-exhaust ventilation which will significantly improve the quality of the air. In this case it will also be possible to design a heat recovery system. Simultaneously the air-tightness of the building envelope and risk inducing structures must also be assessed. This change requires specialised planning and an authorization from the Construction Supervision.

It is not recommendable to install mechanical extract ventilation into old buildings because in order to function properly it requires circa 10 pascal vacuum and thus also creates new risks for the indoor air.

Fireplaces are efficient pieces of “exhaust air equipment” because burning consumes a lot of air and the warm flue acts as a good channel for exhaust air.

The exchange air entering an apartment must come in a controlled manner from the fresh outdoor air, not through the structures. When there are enough routes for the air, too much draft will not be created through one particular route.
Options for securing exchange air intake in natural ventilation

EXCHANGE AIR VENT IN THE VENTILATION OPENING
Usually the easiest and cheapest solution is to install an exchange air vent in the ventilation hatch. A hole is drilled in the ventilation hatch and a plastic tube and a vent is installed in it. A well-covering filter cut out of roll goods can also be installed on the inner side of the ventilation shutter. The filter reduces the flow of street dust and pollen into the indoor air. For natural ventilation the recommended position for the exchange air vent is in the lower part of the hatch.

EXCHANGE AIR WINDOWS
In the ground-level of a two-storey building the intake of exchange air can be improved by using exchange air windows of which there are several different models available. The exchange air window pre-heats the incoming air and is therefore a more comfortable solution than the window frame vent. It also filters the incoming air more efficiently. However, the functioning of exchange air windows in natural ventilation is uncertain. In mechanical extract ventilation it is possible to operate this solution as planned.

WALL VENT
The exchange air vent is installed in such a location where the warm air rising from the radiator mixes with the colder outdoor air flowing in from the vent. Wall vents should be installed as low as possible so that a sufficiently efficient pressure difference is achieved for the operation of the vents. The filtration level of the wall vents varies from a small coarse filter into a larger pollen filter.

THERMOSTATIC VENT
The thermostatic vent regulates the opening of the vent according to the incoming air temperature. In cold weather the pressure difference between the indoor and outdoor air is bigger, so the opening can be smaller in order to receive a sufficient amount of exchange air.

HEATING EXCHANGE AIR SOLUTIONS
In the market there are exchange air vents which are installed behind the radiator. Using them not causes usually unpleasant air movement but their installation always requires basic re-adjustment of the heating system and possibly new radiators. The exchange air can also be heated electrically or by mixing it in the indoor air with a fan. The position of these vents can be chosen more freely than that of the basic vents.

ROOM-SPECIFIC AIR VENT WITH HEAT RECOVERY
The vent can be installed in a horizontal opening penetrating the wall and measuring 110 mm. The vent includes heat recovery piping and a small fan, which blows the indoor air outward and recovers exchange air with the aid of vacuum. NB! This vent cannot be used in temperatures colder than -5° C due to risk of freezing.

PARTIAL REMOVAL OF WINDOW SEALANTS
As an emergency solution some sealant from the bottom part of the bedroom and living room inner and outer window frame can be removed in order to acquire exchange air. Usually the removal of sealants is not a permanent solution for the exchange air problem.

Air must change all the time and everywhere.

Figure. A fresh air vent equipped with thermostat balances the flow of the outdoor air. In cold weather the pressure difference between the indoor and outdoor air increases but partial shutting of the vent reduces the air flowing through it.
Significance of air-tightness

The air-tightness of the building has a substantial impact on the hygrothermal performance and the ventilation of the building. It is easier to control the ventilation in an air-tight building. On the other hand, poorly functioning ventilation causes more problems in an air-tight building. Installing extra insulation in the exterior walls, renovating the plinth or replacing the windows may improve the air-tightness of the building envelope which, again, requires that the functioning of ventilation has to be ensured. Similarly, the use of a fireplace, kitchen hood and central vacuum cleaning system significantly increase the need of exchange air.

When the exterior walls and windows of a building are renovated it is always important to ensure sufficient ventilation. The air-tightness has an impact on the correct performance of the structures in relation to their constructional physics and hygrothermal properties. Warm indoor air which includes more moisture than the outdoor air can condense in the structures if the structures have not been sealed with a water vapour barrier. At its worst, condensed moisture can cause microbial damage. Air can also be transported through the structure from the outside to the inside and the pollutants in the structures may then be passed in the room air.

There are different methods of improving the recovery of sufficient exchange air. The number of exchange air vents in the exterior walls and windows of the living rooms and bedrooms can be increased. In the design of the exchange air vents the requirements set for their levels of draft, sound insulation and air filtration must always be taken into account. Exchange air vents should always be positioned as far as possible from the potential sources of pollutants such as waste bins, carports and smoking places.

In old buildings the comfort for living is particularly weakened by leakage in the attic floor joints. Warm air can escape through leaking joints and the cool exchange air flowing in from the cracks around windows and doors pours on the floor causing it to feel cold even though the floor might be well insulated. Leaks can often be found, for instance, in the sealed joints of the chimneys and ventilation ducts. There is no feeling of unpleasant air movement in an air-tight, well-insulated house which has a properly functioning ventilation.

Replacement of windows and exterior doors

If the building does not have separate exchange air vents, significant amount of the exchange air usually comes in through the joints between the walls and the window frames or the joints between the window frames and the sashes. This has to be taken into consideration when windows are replaced or their sealant is renewed. In addition to sealing windows, it is therefore necessary to ensure sufficient fresh air intake.

Insufficient exchange air routes can cause indoor air problems as the air then seeks the most harmful route into the building. Uncontrollable exchange air may then flow in, for instance, from a crack between the window and the wall bringing simultaneously potential pollutants from the structures in the indoor air. The condition of the exterior door sealants has a great impact on the air-tightness of the entire building envelope.

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**Air-tight structures do not weaken the indoor air quality, but the potential cause of problems is insufficient ventilation of premises.**

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**Installing additional heat insulation, replacing windows, giving up oil-heating and renovating the plinth also require planning for ventilation.**
Energy efficiency

Ventilation accounts for a significant share of energy consumption in all buildings. The air in the building must be heated so that people can stay in the premises and feel comfortable. The energy efficiency of natural ventilation is improved by the fact that no electric fans are needed but on the other hand, heat recovery from the exhaust air is difficult or impossible to implement.

Therefore, in energy saving, the attention must be directed to suitable amount of air currents. In natural ventilation the air volumes remain so low that the amount of energy it consumes does not significantly differ from mechanical ventilation with heat recovery.

Good indoor air is, however, at least as important a factor as energy efficiency. Therefore, mechanical enhancement of ventilation is needed at least periodically. For instance, using clock-timing extractor fans in the building or extractor fans with humidity sensors in washrooms will save energy.

Experiments have also been made about pre-heating the intake air in the ground or in the fresh air intake windows. When the temperature of the intake air rises a little, the feeling of unpleasant air movement is reduced and the feeling of thermal comfort is improved. Sometimes, the increase in thermal comfort makes it is possible to lower the indoor temperature slightly. Lowering the temperature by one degree causes about 4-5% savings in heating.

Air filtration

Natural ventilation does not suit well in places where the outdoor air quality is so poor that the intake air has to be filtered. The filter causes a significant pressure loss in the air flow and therefore weakens the recovery of intake air. When the filter gets dirty the pressure loss caused by it increases even further.

If the air has to be filtered, the filter should be as well-covering as possible. Ventilation hatches and windows can be installed with filter cloth which is sold in roll goods in order to reduce the amount of pollutants coming in from the outdoor air. A filter mounted outside the ventilation hatch provides a wide filter surface. The filters should be changed frequently enough to prevent pressure loss caused by dirt.

Sound techniques

The intake air for natural ventilation is usually supplied through the shortest possible duct directly from outside. The intake air routes should be wide enough to secure sufficient air flow. The acoustic insulation properties of short and wide ventilation ducts are practically non-existent and the sounds carried in from the outside may feel disturbing. Acoustic insulation solutions are available especially for ventilation hatches and ducts penetrating the wall. When choosing an air intake silencer, the pressure loss caused by it should be taken into consideration so that the installation of the silencer would not significantly weaken the recovery of exchange air.

20-40% of the consumption of heating energy is exhausted through ventilation!

Tips for saving energy by improving ventilation

- humidity controlled extractor fans in washrooms
- motion detectors and time control for extract fans
- fresh air vents with thermostats
- manual adjustment of vents according to changing seasons (weather conditions)
From oil heating to geothermal or district heating

Giving up oil heating noticeably weakens the operation of natural ventilation. Firstly, the oil boiler is usually positioned in the basement and the heat leaking from the boiler keeps the basement at least partially warm and therefore also dry. The other benefit of the oil boiler is that flue gases generated by the boiler keep the chimney and the air flues in it warm. A warm chimney creates a better air flow in the flues as well.

In summer the basement walls and floor are cool unless the basement is heated. When the outdoor air is very humid, the relative humidity of the basement premises rises, and water vapour may condense in the structures or on their surfaces. For this reason, the thermal insulation in the basement has often failed and microbes have started to grow in the insulation.

The conditions of the basement cannot be maintained in summer by using ventilation alone, because the humidity level of the outdoor air is high. Keeping the temperature of the basement above +20°C is usually sufficient. Mould-sensitive materials should not be stored on the floors and beside the walls either. Cardboard boxes, for instance, should be stored off the floor on the shelves and the shelves should be positioned slightly away from the walls so that warm air can also flow behind the boxes and heat the wall.

Figure. Draft inducer. In summer the difference between the indoor and outdoor temperature is small and therefore the pressure difference is also small. The draft in the chimney can be improved by using a draft inducer which utilises wind power. Improving the draft may also be based on the warming effect of solar radiation in the upper part of the chimney.

Considerations for planning

**INTAKE AIR**
- positions for vents?
- type of vents?
- removal of window sealing?
- ventilation windows or hatches?

**EXHAUST AIR**
- humidity of washrooms
- exhausts for toilets
- kitchen fumes
- pets, sandboxes
- air flows upstairs and downstairs

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**Adjusting and controlling intake air**
- thermostat
- pressure difference
- manual adjustment

**Adjusting and controlling exhaust air**
- humidity
- time control
Adjusting natural ventilation

Poorly adjusted ventilation system can cause the feeling of unpleasant air movement which, again, weakens the comfort of living. The adjustment of natural ventilation is challenging, because the weather conditions significantly affect its operation.

The measurement of air volumes in natural ventilation can be based on senses. There should be no significant odours when one comes in the indoor premises from outside. The nose adapts to odours in 30 seconds, so a short visit outside followed by sniffing of the indoor air says a lot about the indoor air quality. The airflow from the intake air vents may cause a feeling of draft when the back of the hand is placed in the immediate vicinity of the vent but further away from the vents the air current should not be sensed on the skin.

There are very few adjustment possibilities for natural ventilation without electric fans for different situations of use. The air volume is adjusted by limiting the amount of intake air when needed. The volume of intake air can be limited either by manual adjustment or by thermostatic vents. Normally the vents are kept fully open but in freezing temperatures the air intake of the vents can be adjusted to a lower level. As the weather gets warmer, one must remember to adjust the intake of the vents to a higher level again.

The volume of the exhaust air can be improved with electric extractor fans such as kitchen hoods or electric fans which can be installed to replace old vents. In the design of new natural ventilation, the use of ventilation windows is not accepted as a means of adjustment. In previously built dwellings they can, of course, be used to improve the intake of fresh air particularly in the summertime.

Fresh air is needed the most during the night, because people stay in one place at that time and the need for fresh air is the greatest locally. In the evening we can spend time in different rooms with the partition doors remaining open, so the need and recovery of exchange air is more even. The air quality in the bedrooms can be improved by keeping the doors open also during sleeping. During the working day the ventilation can be kept in a much lower level.

- How to remove humidity from the washrooms and drying rooms for laundry?
- How to ensure the humidity safety of structures?
Cleaning vents and ducts

The maintenance of natural ventilation includes the cleaning and replacement of filters, cleaning of vents and the inspection and cleaning of ducts. Ventilation which has not been maintained properly does not operate as planned and it can cause problems to the users of the building and the building itself.

Regular inspection and cleaning of the ventilation ducts every 5-10 years is necessary in order ensure their operation and hygiene. The dirt accumulating in the system from outside as well as inside weakens the operation of the system in the course of time. At worst, high humidity levels can cause microbes on the surfaces to grow and thus create health problems inside the apartment.

The exchange air vents should be cleaned and the filters replaced/cleaned regularly, usually 1-2 times per year. The residential air purity and the proximity of traffic affect the maintenance interval. The vents are removed with their collars for cleaning. The vents can be cleaned, for instance, in the dishwasher.

The grease filter of the kitchen hood must also be cleaned regularly. Depending on the amount of cooking, the cleaning interval can vary from a couple of weeks up to a couple of months. The easiest way to clean the filter is to use the dishwasher when the filter has not yet collected a thick layer of grease and dust. A congealed layer of old grease can be removed, for instance, by pouring boiling water and a cup of baking soda on the oven pan and immersing the filter in the liquid for a few minutes. After this a glass of vinegar is evenly poured over the filter.

In violation of fire regulations, the exhaust duct of the kitchen hood is often made of flexible hose i.e. spiral hose. Cleaning them mechanically is almost impossible without breaking the wall of the duct. Replacing of the old spiral hose with a new fire-rated duct made of sheet metal is a fairly inexpensive and high-quality method of cleaning the duct. During the replacement process it is necessary to ensure the air-tightness of the vapour barrier of the roof and the fire-proofing of the exhaust ducts in the attic.

The air vents must be cleaned every year and the ducts must be cleaned around every ten years. The vents are removed by rotating the frame. They are washed under running water or in the dishwasher. The position of the plate in the vent must not be changed if the apartment has mechanical ventilation.
**Forget the Old Rules of Thumb**

When the mechanical air exhaust solutions started to become more common in the 1970s, a lot of errors were made in their planning. The solutions are often hybrids or panaceas between natural ventilation and mechanical ventilation. In the course of various renovations, the operation of old, fairly well-functioning ventilation systems has also often been weakened. In addition to this, users have often closed or blocked exchange air vents due to feeling of draft. This phenomenon was partly caused by the rigorous pursuit for energy savings that began in the 1970's.

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<td><strong>3</strong> Fresh air vents should be installed above windows</td>
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More Information

www.ouka.fi/oulu/rakennusvalvonta/korjausrakentaminen
The Internet site of the City of Oulu offers a comprehensive information package for building repairers.

www.energiakorjaus.info
The aim of the Energiakorjaus (Energy Repair Site) is to provide objective information on the planning, progress and individual remedies concerning the repairs and, in particular, how the repairs encompass the energy efficiency of the building.

www.pksrava.fi
Uniform practises for Construction Supervisions are being developed in the so-called TOPTEN -groups. Originally, the name came from the ten largest cities in Finland that started developing uniform practises. Currently, many more cities have committed in the use of these practises. Practises -cards are published on the joint site of the Construction Supervisions in the metropolitan area (pksrava.fi) under the search term “topten”. The practises are mainly intended for the construction of new buildings, but they can also be applied, for instance, in the building of attics.

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