
A Method for Including Moisture Safety in the Building Process

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ABSTRACT

Many buildings, both new and old, suffer from moisture-related problems with negative consequences on health, costs for rebuilding, and lost confidence in the building trade. These problems could be avoided if moisture issues are focused on and dealt with throughout the building process. Therefore, a method for including moisture safety in the building process has been developed. The purpose of the method is to help all parties concerned work with moisture safety activities and document these in a structured way. The method includes a number of routines, templates, and checklists for clients to formulate requirements regarding moisture safety early in the project and to follow up and document the actions taken by the different participants. There are also tools for architects and design engineers, such as lists of references, checklists, and design examples to use for dry building design. For contractors, a number of routines for moisture control during construction have been developed. The method has been applied in a number of building projects, both for production of dwellings as well as for commercial buildings. Based on the experiences from these projects, the method and the tools were evaluated and revised. This method is ready to be used by all parties involved in the building process.

Knowledge of how to avoid moisture damage in buildings exists today. However, one of the important tasks of the building sector is to formulate this knowledge so that it can be applied in all stages of, and by everyone involved in, the design, construction, and use processes.

INTRODUCTION

Background

A large number of moisture-related building problems, such as mold growth and chemical emissions from decomposed material subjected to high moisture levels, have occurred during the last few years, with adverse effects on health, building costs, and confidence in the building industry. These problems could be avoided if moisture safety issues, such as design of constructions and choice of material with respect to moisture exposure, weather protection at the building site, drying out of concrete structures, moisture measurements, etc., are taken care of in the building process. Knowledge of how to avoid moisture damage in buildings exists today. However, one of the important tasks of the building sector is to formulate this

knowledge so that it can be applied in all stages of, and by everyone involved in, the design, construction, and operation phases of a building's lifetime.

Questionnaire, Workshop, and Interviews. In an early phase of this project, a questionnaire survey (Arfvidsson and Sikander 2002) was conducted to investigate the level of knowledge of moisture safety and moisture control among participants in the building industry. Out of 635 distributed questionnaires, 216 were returned (34%). The answers were analyzed by a statistician. The results from this survey showed that almost all participants involved asked for a higher level of competence in regards to moisture issues and that almost every building client is willing to pay extra to ensure a moisture-safe building. A majority of those asked would appreciate more assistance in the form of checklists and calculation tools.

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Respondents also suggested that general guidelines for moisture safety management should be developed.

In the beginning of 2003, a workshop was organized (Wihlborg 2003) that approximately 50 people from the Swedish building industry attended. The workshop included representatives from clients, architects, consultants, contractors, suppliers, and property managers. Representatives from each group gave speeches concerning moisture safety issues in their field of work. During the workshop it became clear that participants could not understand why moisture problems still occur. Even though research in the field of moisture has been performed for many years, there is still more to learn to prevent moisture problems from recurring.

The next step of this project was an interview study (Wihlborg 2005), which followed up on the results from the workshop. The aim was to study why problems were still occurring in new buildings even though much is known about moisture in relation to buildings and the potential risks associated with it. Twenty respondents from most participants in the building process were interviewed with open-ended questions that let them open up and speak frankly, with a view to providing comprehensive material to analyze. The survey led to five findings that could increase moisture safety and thereby decrease moisture damage in the future:

- Knowledge about moisture safety must be spread to all participants involved in the building sector.
- Procedures for documenting and communicating moisture safety must be developed and implemented in the work program of the building process.
- Clients must agree on and formulate requirements on moisture safety.
- Time schedules must be realistic from a moisture safety perspective (for example, to permit sufficient drying of concrete).
- Moisture safety issues must be put in focus to bring about an attitude change among the participants to take responsibility for moisture safety in the building industry.

The Client's Role. The client plays a key role in ensuring moisture-safe buildings. By specifying appropriate requirements at the planning and inspection stages and checking that the requirements are fulfilled during the building process, the client obtains verification that essential preventative measures have been completed. However, there is very little to assist the client in doing so during the design and construction stage or during use of the building.

In a project called "The Building Developer's Requirements, Management and Verification to Ensure Dry Buildings by Moisture Control" (Sikander and Grantén 2003) and (Sikander et al. 2004), it was suggested that the developer/client should control and monitor the process by:

- Producing a clear specification in respect to moisture control and performance.
- Clearly defining responsibilities for ensuring moisture

inspection in the building project. In Sweden, the client bears the ultimate responsibility for ensuring that the building is dry and remains dry. However, the responsibility for physically fulfilling the client's requirements lays with the other parties in the contract, such as the designers, contractors, and so on.

- Checking that the other parties are competent or acquire the necessary competence.
- Monitoring compliance with the client's original moisture requirements by checking that the other participants (architects, design engineers, contractors) have carried out the necessary verifications/measurements. The client can also carry out his/her own sample inspections and measurements.

In this project, technical requirements at different risk levels were suggested for microbiological growth, moisture levels in wood, moisture levels in other materials such as gypsum board and insulation, moisture levels in underlying concrete screeds or slabs when applying floor coverings and adhesives sensitive to high moisture levels, airtightness, pressure differences, and moisture input in the indoor air.

Pilot Projects. During the next step of this project, the method for including the building client's requirements, management, and verification of moisture safety in the building process was tested in four pilot projects (Sikander and Mjörnell 2006). These pilot projects were followed up but with slightly different approaches. Pilot projects 1, 2, and 3 have been monitored without interfering. In these projects the client was responsible for follow-up to verify that the original moisture requirements were fulfilled. In pilot project 4 one of the authors of the paper had an active role in helping the client plan and follow up on the moisture safety aspects during construction.

The general conclusions from these first four projects applying the method are that:

- It is necessary to invest time and money to ensure moisture safety.
- It helps if a moisture specialist or a specially trained participant identifies moisture critical designs, methods, and operations and holds discussions with the participants.
- Moisture-critical designs are identified early and deviations are found and dealt with.
- Architects and design engineers need training in the use of routines, templates, and checklists to carry out moisture safety assessments during the design stage.
- More tools are needed for contractors and building managers in their work of ensuring moisture safety in all stages of the building process.

These are the reasons the method needs to be further developed to include routines, templates, and checklists for all parties concerned in the building process.

Objectives of Developing a New Method

The objective was to further develop the method “The Building Developer’s Requirements, Management and Verification to Ensure Dry Buildings by Moisture Control” presented by Sikander and Grantén (2003) and Sikander (2005) to include routines, templates, and checklists for all parties concerned in all stages in the building process. The new method refers to a number of templates, checklists, and good examples produced for the client, architects, design engineers, contractors, and operators to use in their work to produce moisture-safe buildings.

Limitations

Until now the method has only been applied by the authors to Swedish pilot projects, with traditional building techniques and organization.

METHODOLOGY

The results from the workshop, the interview study, and the pilot projects that were presented in the background formed the base of the work presented here. The methodology was to further develop the method and draw up routines, templates, and checklists based on experience from the projects where the method had been used. First of all, an identification of lacking works of reference, such as routines, templates, and checklists, was made. Then, drafts of these works of reference were drawn up. After that, drafts of the new routines, templates, and checklists were tested in new pilot projects, and the usefulness was evaluated by inquiry and

interviews with those who used them. Lastly, the routines, templates, and checklists were revised according to the responses from the users.

RESULT FROM THE DEVELOPMENT OF A NEW METHOD

Schematic Description of the Method

The outline of the new method for including moisture safety in the building process is presented in Figure 1, with the different stages in the building process on the horizontal axis and the different parties on the vertical axis.

The method starts at an early stage of planning when the client decides on the location, type of building, etc. The first step in the method includes the client’s decision on the level of risk that he/she is willing to accept and specification of the requirements concerning moisture levels, etc., in contract documents.

The second stage is the design stage, when the consultants design the building according to the client’s requirements. The consultants apply dry building design and produce documentation of their work.

In the third stage, construction, the contractor appoints a person responsible for moisture inspection at the building site. This person identifies the critical parts of construction and draws up a plan for the handling and storage of materials, use of weather protection, moisture inspection, and moisture measurements. The contractor makes inspection rounds regularly (once a week or more, depending on the intensity of the building site) to check that the plan is followed. At the end of

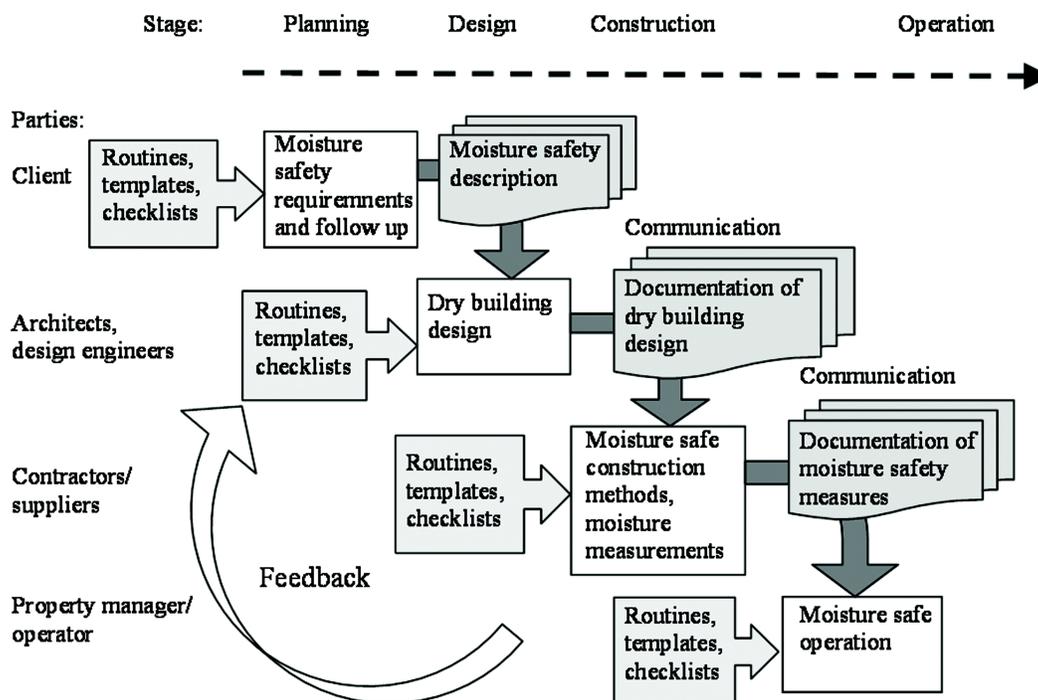


Figure 1 Schematic description of the method.

the construction stage, the moisture safety documentation is put together and presented to the administrator.

In the fourth stage, administration of the building, there are also routines to adopt, such as those for moisture inspection, handling leakage, moisture damage, and complaints of indoor environment problems caused by moisture damage.

The method refers to a number of routines, templates, and checklists to help the participants design and construct moisture-safe buildings. An example of a checklist for moisture inspection rounds at the building site is shown in the Appendix. The complete description of the method and all documents belonging to the method are presented in a forthcoming report (Mjörnell 2007), but they are also accessible at the Fukt-Centrum Web site, www.fuktcentrum.lth.se. At present the material is in Swedish, but it can be translated into English upon request.

Activities, Routines, Templates, and Checklists Included in the “New Method”

The method consists of a number of activities for the different parties in the building process, described briefly in Table 1. Most of the activities, routines, templates, and checklists have been developed to help the parties dealing with moisture safety. The intent was to present a complete set of works of reference including routines, templates, and checklists from which the participants could choose the documents suited for their work.

DISCUSSION AND CONCLUSIONS

The new method, routines, templates, and checklists have been tested in a number of projects at different locations in Sweden to find out if and how they work in regards to moisture safety in the building process. Three of the projects have been followed up to obtain more detail. Among those are one public building, one condominium project, and one apartment building complex. The clients were one public manager, one private housing company, and one municipal housing company, respectively. The different types of contracts were a design and construct contract, a divided contract, and a general contract. In the projects, the developed method was used to different extents. Parts of the works of reference were further developed during the project, so changes and completion of the routines, templates, and checklists were made to meet demands as they arose. Different groups of actors also used different tools. The evaluation of the tools should therefore be used as guidance for future development of the tools. In the interviews after the projects, the experiences from the use of the new method were discussed. The interviews are provided in detail in the report by Mjörnell (2007). Below is a brief summary of the conclusions from the interviews.

- Most of the participants have adopted the method into their own routines in the company.
- The method has been used and is considered to give

increased quality to the building project.

- Meetings in which moisture is discussed have been established.
- Most participants find the requirements are relevant and good. Only a few parties found that the requirements were unreasonably high.
- According to results from the interviews and questionnaires, most participants are quite satisfied with their competence but are positive toward training in the moisture field of knowledge.
- Many participants asked for further development of the routines, templates, and checklists to make them more simple to use and understand but also more distinct.
- There were observations of insufficient follow up and feedback between all participants, so an important remaining task is to increase the interest for follow up and feedback.
- Our experience is that working according to the new method increases the interest to discuss and put more effort toward the work to increase moisture safety; however, the motivation has to be further increased. All participants have not been actively participating in the work.

To sum up, the proposed new method presented in this paper has been used successfully in a number of building projects. The actors involved agreed that working with moisture safety has led to increased quality in their building projects. Many companies have adopted the method and worked in the routines and templates in their work programs. However, there are still a few ways in which the method can be further improved. These are, for example, to:

- Increase the interest for and introduce better methods for follow up and feedback.
- Increase motivation with incentives.
- Offer education and information suitable for the different actors.
- Further develop routines, templates, and checklists to make them simpler and more distinct.

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Table 1. Description of Activities for the Different Parties Concerned and the Routines, Templates, and Checklists Included in the Method

Phase	Activity	Responsible Party	Routines, Templates, Checklists
Planning	Decide on moisture requirements and safety level.	Client	Suggestion of moisture requirements at different safety levels
	Formulate moisture requirements in building program and administrative prescriptions.	Client	Moisture requirements in administrative regulations
	Appoint a person responsible for moisture safety issues or engage a moisture specialist with documented training and experience. (moisture specialist [MS])	Client	Job description for a moisture specialist
	Draw up a moisture safety description for the building project.	Client and MS	Template for moisture safety description
Beginning of Design	Provide information to architects and design engineers about the client's requirements and methods to follow up.	Client and MS	
Design	Hold moisture meetings with architects and design engineers during the design stage.	Client and MS	Meeting agenda
	Work with and document moisture safety design.	Architects and Design Engineers	Checklist and template for documentation of the moisture safety design
End of Design	Carry out self inspection with respect to moisture safety of building documents such as drawings and specification of works.	Responsible Architect and Design Engineer	Checklist for inspection of building documents
	Perform client's final inspection of building documents with respect to moisture safety.	Client and MS	Checklist for final inspection of building documents
	Update and complete the moisture safety description.	Client and MS	
	Provide information to contractors about the results from the dry building design.	Client and MS	
Beginning of Construction	Provide information to contractors about the client's requirements and methods to follow up.	Client and MS	Information meeting
	Pass on requirements and information from design stage to construction stage.	Architects and Design Engineers	Information meeting
	Identify moisture-critical work, operations, and constructions.	Contractors	Checklist for identification of moisture-critical work operations and construction
	Draw up a moisture control plan.	Contractors	Template for moisture control plan
Construction	Hold follow-up meetings with contractors.	Client and MS	Agenda for moisture meetings
	Conduct moisture reviews at the building site.	Contractors	Checklist and template for documentation of moisture review at the building site
	Document moisture safety measures during construction.	Contractors	
End of Construction	Collect all documents dealing with moisture issues, for example, drawings, descriptions, minutes of moisture meetings, results from measurements, and documentation from moisture rounds, etc.	Contractors	Checklist for table of contents of moisture safety documentation
	Put together the moisture safety documentation.	Client and MS	
	Provide information to operator and building manager about moisture safety measures made in the construction stage and moisture critical designs.	Contractors, Client, and MS	Information meeting
Before Operation of the Building	Put together basic data for operation and management instructions concerning building services, surface layer, building materials, and construction with respect to moisture safety.	Client, Contractors, Suppliers	
	Draw up routines for recurrent moisture control/check and measures in case of moisture damage.	Property Manager	
Operation	Carry out regular control/checks of construction sensitive to moisture at maintenance rounds.	Property Manager, Operations Technician	Checklist for recurring check for effects of moisture
In Case of Moisture Damage	Perform remediation measures according to agreed upon routines.	Operations Technician	Routine for handling moisture damage, leakage

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APPENDIX

A Checklist for Moisture Inspection Review at Site

No.	Inspection	Y/N	Comments
1.	Protection of Materials and Designs		
1.1	Are materials and products being inspected on arrival or delivery as planned?		
1.2	Is dry storage space available for materials and products?		
1.3	Are materials and products protected from moisture, dirt, and damage?		
1.4	Is weather protection arranged immediately after fitting sensitive materials?		
1.5	Are conditions in areas where material are stored at the site monitored?		
1.6	Are records available on weather conditions during the past period?		
2.	Leakage, Precipitation		
2.1	Have there been any leaks or abnormal amounts of precipitation? If so, state where and to what extent. Mark the drawings to show.		
2.2	Has water been used when making holes? If so, state where and how much.		
2.3	Is there a contingency plan to deal with leakage, and does it work?		
2.4	Are there means for leading off precipitation from roofs or horizontal surfaces?		
3.	Moisture in Materials		
3.1	Have any wood or wood-based materials (whether fitted or not) become wet? If so, indicate where and to what extent.		
3.2	Has the moisture content in wood or wood-based materials been measured? State the results, describe the method of measurement, and include who made the measurements.		
3.3	Have any gypsum boards become damp? If so, indicate where and to what extent.		
3.4	Have moisture levels in gypsum-based products been measured? State the results, describe the method of measurement, and include who made the measurements.		
3.5	Have other moisture-sensitive materials become damp? If so, indicate which materials, where and to what extent.		
4.	Drying-Out of Concrete		
4.1	Are there pools of water on concrete floors? If so, indicate how much and for how long they were there. Mark the drawings to show where water collects.		
4.2	Has the timeline for pouring, drying-out conditions, or the type of concrete or surface layer been changed relative to the original conditions?		
4.3	Is drying being accelerated? If so, state how and for how long.		
4.4	Is the relative humidity in the concrete being measured as planned? State the method, by whom, and how much.		
4.5	Are measured results available? State any unexpected results, with reasons, and describe what is being done in response.		

A Checklist for Moisture Inspection Review at Site (continued)

No.	Inspection	Y/N	Comments
5. Building Services Systems			
5.1	Are open ducts and terminations covered for protection?		
5.2	Have pressurized pipes been pressure-tested before being built in?		
5.3	Has there been any leakage from such systems? If so, state the type of system and the amount of leakage.		
6. Cleanliness			
6.1	Is there dirt or rubbish on surfaces?		
6.2	Have concrete surfaces been cleaned before being covered with plastic film, air gap creation layers, or other surface layers?		
7. Documentation			
7.1	How have moisture protection measures been documented?		
8. Miscellaneous			
8.1			

Appendices: Plan drawings, marked to show standing water and damp materials; results of measurements; noncompliance reports; photographs.

The above inspections have been carried out:

Date:

Client's moisture representative (initials):

Contractor's representative (initials):