



Water Infiltration and Mold Prevention

Strategies for Contractors



Background

Mold (fungi) is present everywhere – indoors and outdoors. There are more than 100,000 species of mold. A relative few are alleged to present health concerns. Exposure can occur if people inhale the mold spores, directly handle moldy materials or accidentally ingest it. Mold can sometimes produce chemicals called mycotoxins. Mycotoxins may cause illness in people who are sensitive to them or if they are exposed to large amounts in the air. Individuals with respiratory ailments or illness causing immunosuppression may be more susceptible than the general population. Most types of molds, routinely encountered are not hazardous to individuals.

Since mold is everywhere, preventing mold growth should be part of a mold control strategy. Mold is most likely to grow where there is water or dampness – such as in bathrooms and basements. Some of the concern raised recently has been the result of mold infestations caused by roof leaks, plumbing leaks or other types of maintenance or construction problems resulting in chronic moisture. In addition, natural disasters such as tornadoes, thunderstorms, flooding, etc. can contribute to the formation of mold infestation through water leaks and water damage to structures.

Following are some general considerations to help you reduce mold in construction and remodeling projects.

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Pre-construction considerations

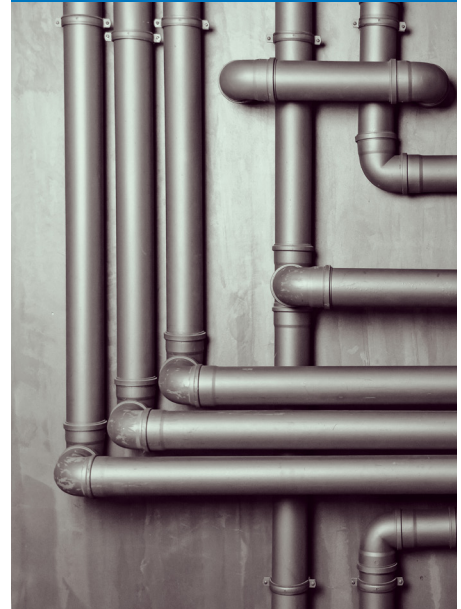
Explicit consideration and awareness of various design parameters, including construction materials, methods and workmanship that affect risk factors contributing to the growth of mold, are an important part of a mold prevention strategy in the pre-construction phase. The key risk factors for mold growth are moisture and humidity levels, temperature, air circulation and availability of nutrients.

Many construction materials, such as wood, plywood, drywall and others, contain cellulose and other organic sources of nutrients for mold. Drywall and gypsum boards have paper backing and glue that may be a source of nutrients for mold growth. Porous construction materials retain more moisture than hard surfaces and can contribute to mold growth. Consider protection of construction materials containing an inherent source of nutrients with special paints and coatings. When possible, select materials appropriately. For example, use carpet padding made of man-made material in the basement and other areas where there is a potential for water damage. Because of its lack of ability to breathe, vinyl wallpaper can trap moisture and can contribute to mold growth on the wall. A contractor that employs qualified, experienced subcontractors and has a good quality control plan and procedures can increase the likelihood the specified materials will be utilized and installed correctly.

In addition to the selection of construction materials, protection of materials from water damage, both onsite and in storage, is a key step. Use plastic covering and other measures to protect partial construction and storage areas from rain and other weather damage. Moisture meters can be used for inspection and testing of water content in construction materials prior to use and in drying of the materials.

In the planning stage, it may be appropriate to consider employing an engineer specializing in hydrology (a hydrologist) to evaluate the history of flooding and local water table fluctuations to prevent the construction of a structure that may have inherent water infiltration problems. Consideration may be given to directing overland flow due to rain and subsurface flow away from the structure. The installation of systems such as French drains around the perimeter of a structure to focus water away from the building is one common method for preventing subsurface water infiltration. Subsurface flow infiltration is typically only a concern for structures constructed below grade. The installation of gutters and downspouts to direct rainfall away from a structure are often required by code and should be considered a key component to the overall drainage system.

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Proper grading of the land and other water runoff measures reduce the sources of water infiltration in the building. The design of the structure should consider the potential impact of grading or changing the flow of water across the property. The design should consider the placement of external sprinkler systems so water is not directed toward the building.

There are several other measures, such as the design of the HVAC system, natural airflow and temperature fluctuations, that may help keep the moisture condensation and humidity levels under control in the building. The migration of humid air from outside can also contribute to a chronic moisture problem. A faulty heating and ventilation system

can lead to poor humidity and temperature control in the building and can contribute to the mold growth. In evaluating the HVAC, consideration should be given to installing dehumidifiers, especially in smaller structures and where the HVAC system may be underutilized or shut down periodically. Smaller structures may also be susceptible to condensation from maximum use of showers, tubs, washing machines and dishwashers. The HVAC or dehumidifying system should be designed to accommodate such usage.

Ventilation of areas not serviced by the HVAC systems may also need to be addressed in the design process, including unfinished basements

and crawlspaces. Contracts with various subcontractors and trades should specifically address the responsibility for repairs. Contracts with subcontractors should contain enforceable language providing for the defense and indemnity of claims arising out of their work. Typically, a contractor or subcontractor will be asked to complete the prequalification questionnaire and data sheet as part of the contractor selection process. The responses to these forms provide information to help determine the ability of the subcontractor to execute and complete work.



Pre-construction planning tasks

Prior to the start of construction, responsibility for planning effective means and methods to prevent water intrusion and damage should be delegated to a member or members of the project management team. They should know peak periods of rainfall for the project location and schedule accordingly. That team should also identify water sources at the start of the project and develop plans or practices to control each source including groundwater, floodwater, seepage, storm water, new and existing wet utilities, sewers, snow/ice melt, condensation and runoff or discharge from adjacent properties. The following should be completed prior to the start of construction:

1. Train project management and workers on the importance and methods of preventing water intrusion.
2. Plan the delivery and storage of interior materials so they are kept dry. Avoid the storage of porous materials (drywall, lab furniture, millwork, carpet, insulation, etc.) in the basement or lower levels as these areas could be subject to flooding or accumulation of water from rainstorms, system leaks, groundwater intrusion, backup of sewers, etc.
3. Establish procedures for the inspection of materials so wet materials are not installed.
4. Establish a report procedure for any water damage, leaks or intrusion.
5. Identify and specify procedures to either reject or dry out any water-damaged material.
6. Build in strict adherence to designs and specifications.



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8. Question concept-only, inadequate architectural design or outright improper building plans.
9. During the design phase, carefully review the details with specific attention to ensuring an impermeable envelope.
10. On geometrically complex buildings, consider employing an envelope specialty engineer for a third-party opinion on the water tightness of the envelope.
11. On a renovation or addition, carefully survey the existing building before construction begins. Look for discoloration in finished surfaces or a musty smell. It is possible a pre-existing water problem can become the contractor's problem once construction begins.
12. Develop the project schedule with envelope construction completion as a predecessor to installation of finishes. This may be impossible on some projects; if so, have a detailed weather plan for all areas of exposure and establish a sufficient budget to implement the plan. Also, schedule the completion of site drainage, paving and landscaping as early as possible. If humidity is a problem, schedule porous material installation after interior climate is stabilized and controlled.
13. Establish a partnering program with the owner and promote a peer review for the mechanical system and building envelope designs.
14. Carefully document any recommended changes to the architect and/or owner on standard owner-architect-contractor project delivery methods; the architect's approval must be obtained. In the event the recommendation is rejected, reiterate the recommendation in writing; copy the owner.
15. Prequalify potential subcontractors and ensure the subs have adequate experience in the specific work being bid.
16. Consult manufacturers of moisture critical products to confirm the product's application and recommend standard details; also utilize preferred installers.
17. Construct mock-ups for systems involving multiple materials, complex construction methods or sequences particularly critical to the project's end use (clean rooms, data rooms, medical equipment rooms, museums, etc.)
18. Effectively schedule delivery of porous interior materials (e.g., drywall, paneling, ceiling tiles, wood items) so materials will arrive after envelope is complete whenever possible.
 - Provide for dry storage of materials off ground away from moisture sources
 - Minimize storage time
 - Provide plastic sheeting or tarps used to cover materials, secured loosely to allow air circulation.
19. Prearrange the availability of drying equipment (dehumidifiers, wet-dry vacuums, super-sucker trucks, etc.)

During-construction considerations



Inspect and hydrostatically test all water services (including fire sprinklers) and waste lines before charging and closing up walls and before installing ceilings and floors.

Pre-construction measures rely heavily on the contractor's awareness of key risk factors that may contribute to mold growth. Addressing these factors may reduce the availability of nutrient sources and moisture from construction materials. During the construction phase, the workmanship and choice of construction methods should be part of a mold control strategy. Use of plastic sheets and other measures should be considered for the protection of construction materials prone to water and weather damage. Faulty installation of windows and faulty construction of exterior walls can lead to many water intrusion problems that can go undetected for a long time. Although many aspects of construction methods and workmanship issues are likely to be unique to a specific project, the following are some examples of workmanship failures that may contribute to a mold problem after completion and occupancy of the building.

1. Improper "drying in" during construction
2. Inadequate waterproofing, including flashing and moisture barriers, causing water leaks from exterior walls
3. Improper vapor barriers causing ceiling insulation damage from condensation
4. Leaking roof resulting in water infiltration
5. Faulty plumbing resulting in hidden water damage and mold growth in concealed spaces
6. Inadequate drainage on flat roofs resulting in water puddles on the roof
7. Improper installation, flashing and caulking of windows, doors, and skylights, resulting in water leaks
8. Failure to allow drainage of exterior walls
9. Improper mixing of concrete, allowing insufficient bonding and wicking of water through slabs
10. Failure to prepare soil and under-slab drainage and moisture barriers

During-construction planning tasks

The project should be regularly inspected during construction for any water intrusion issues. Preventive measures should also be inspected to assure desired results.

1. Inspect materials upon delivery for pre-existing water damage or impregnation.
2. Install materials in dry condition per manufacturer's specifications.
3. Inspect and hydrostatically test all water services (including fire sprinklers) and waste lines before charging and closing up walls and before installing ceilings and floors. Check for:
 - Proper installation
 - Connections properly made and for leakage, multiple inspections of sprinklers
 - Water lines (particularly chilled water) properly insulated
4. Make certain temporary water lines, hoses and accessories are adequate for the service at hand and capable of containing the water pressure without fault.
5. Determine if high-value, long lead time equipment such as electrical gear, medical equipment, process equipment, etc. will have to be installed before the water systems (domestic and fire) are hydro-tested. If so, temporary protection in the form of plastic sheeting, shrink-wrap or drip shields may be necessary as additional protection during and after testing.
6. Ensure all temporary water sources (spigots, etc.) are properly shut off when not in use. Never rely on a hose for the containment of water pressure during periods when the water is not being used.
7. Inspect all temporary site drainage, roof drains, flat roofs, pits, and other areas where standing water may accumulate after a rain or snow event.
8. Properly install all building penetrations and check for leakage. If needed, provide temporary coverings at:
 - Doors and windows
 - Balconies and decks
 - Roof membranes - lapping at corners and joints
 - Ventilation/exhaust ducts and piping
 - Roof penetrations
9. Make certain all tears, openings or punctures in vapor barriers have been repaired as soon as possible.
10. Ensure all flashings and caulking are checked for proper lapping and application and verify the compatibility of sealants when used on joints of dissimilar materials.
11. Make certain all roof drains are installed as early as possible and maintained. Ensure temporary and permanent roof drains and downspouts are directed away from the structure, particularly basement windows, doors and mechanical chases or HVAC intake wells.
12. Properly support and brace roof drains for large-volume storms.
13. Vent all moisture-generating equipment outdoors.
14. Slope all grades away from foundation.

15. Carefully backfill below-grade waterproofing as early as possible after completion and inspection.
16. Properly ventilate attics, crawlspaces, or other tightly enclosed areas.
17. Follow manufacturer's specifications for installation of HVAC systems:
 - Correct filters properly installed
 - Drip pan and drains for cooling coils and chillers properly installed prior to start-up
 - Ducts sealed and insulation protected from moisture
 - Systems are cleaned and tested prior to start-up
18. Document critical installations and prepare change orders with photographs.
19. Use moisture-resistant drywall for priority walls such as shaft liners, electrical rooms, HVAC chases, etc. that must be installed before structure is enclosed.
20. Conduct walks at the end of each day, on weekends and holidays; especially on residential-use projects, hotels, hospitals, etc. because the fixture count is typically higher in these buildings. Room checks can identify water, fire, theft, and quality control issues on a routine basis.
21. Inform the security services of higher risk locations throughout the building, utilize after-hours security services for additional surveillance of high-risk areas, wet areas, etc.

Ensure all flashings and caulking are checked for proper lapping and application and verify the compatibility of sealants when used on joints of dissimilar materials.



Post-construction consideration

In the first few months after construction is completed and the building is occupied, construction defects and workmanship problems may begin to manifest themselves. A punch list of specific items that need to be repaired should be completed prior to transfer of a project. A third-party inspection of the project prior to job transfer may provide an opportunity to correct any defects and documentation for the project file. A systematic approach for addressing the reported problems and customer complaints during the warranty period can help you control small problems and prevent them

from becoming big ones. Prompt attention to water leaks may minimize costly structural damage and mold growth. Mold can start to grow when water damage is not cleaned up in the first 48- 72 hours. Depending on the extent of the water damage, possible structural damage may have to be assessed and fixed. Construction materials and furniture with water damage may need to be removed or dried thoroughly. Sources of water infiltration and moisture must be addressed. Extensive mold contamination may necessitate consultation with professionals.



Post-construction planning tasks

The following are suggestions that might prevent water intrusion after completion of the project. The contractor should consider providing instructions on proper maintenance and operation of the property, including the following:

- Have manufacturers inspect installations for warranty purposes.
 - Repair leaky plumbing and leaks in the building envelope as soon as possible.
 - Watch for condensation and wet spots.
- Prevent moisture due to condensation by increasing surface temperature or reducing the moisture level in the air (humidity).
- To increase surface temperature, insulate or increase air circulation.
- To reduce the moisture level in the air, repair leaks, increase ventilation (if outside air is cold and dry) or dehumidify (if outdoor air is warm and humid).
- Keep HVAC drip pans clean and draining properly.
- Vent moisture-generating appliances, such as dryers, to the outside.
- Maintain low indoor humidity.
- Perform regular building/HVAC inspections and maintenance as scheduled.
- Install and maintain proper air filters.
- Clean and dry wet or damp spots or remove water-damaged material within 48 hours.
- Do not let foundations stay wet. Provide drainage and slope the ground away from the foundation.
- Ensure envelope penetrations are properly sealed.
 - Landscape irrigation system does not spray building foundation

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Self-assessment for helping you reduce the chance of water infiltration and mold*

Pre-construction (design phase issues)	Yes	No
Are there procedures for reviewing plans and specifications with explicit consideration of water infiltration and potential mold-related exposure from construction materials, methods, and HVAC system requirements?		
Are there written procedures for using Request for Information (RFI) to notify the A&E or owner’s representative regarding findings of weakness in the prevention of water infiltration?		
Are there written procedures for documenting these communications and change orders?		
Are there written contracts with all subcontractors and trades explicitly addressing the responsibility for repair and remediation of water damage and mold growth, as well as defense and indemnity of construction-related claims?		
Are subcontractors prequalified based on a systematic evaluation?		
Is there a materials control program to review and approve construction materials?		
Are there site-planning procedures with consideration for proper drainage of water?		
Are there allowances for reserves in the project budget for punch list and warranty-related repairs?		
Are there plans for use of tarp and plastic covering for the protection of work-in-progress and susceptible construction materials from rain and other weather elements?		

Assessment and action items:

See pre-construction planning tasks for ideas

*These suggestions may not be appropriate and/or practicable for all construction projects.

Self-assessment (continued)

During construction	Yes	No
Is there a detailed work package program to communicate the specific details of the work methods and material specifications to assure the integrity of all critical tasks such as waterproofing, vapor barriers?		
Are there photographs of the actual completed waterproofing work and other work-in-progress prior to covering up the work?		
Is there use of a moisture meter to assure drying of construction materials?		
Is there a quality control plan in place?		
Is a quality control plan required for all the subcontractor trades?		
Is there a plan to inspect the work completed by the subcontractor trades prior to covering up the work?		
Are the procedures for covering susceptible materials and work-in-progress consistently followed?		
Is there a Water Damage Prevention Plan for the project that identifies water damage sources, mitigation controls and assigns responsibilities?		
Are routine and pre/post storm building envelope inspections conducted?		
Does the construction schedule identify critical building “dry-in” dates or temporary “dry-in” measures before installing moisture sensitive materials?		
Is a detailed water intrusion / water leak response plan (and tools) in place?		
Are wet work permits or other authorization procedures in place prior to filling, testing and energizing water carrying utilities and systems?		

Assessment and action items:

See pre-construction planning tasks for ideas

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Self-assessment (continued)

Post-construction	Yes	No
Are there job transfer punch list procedures?		
Is there a dedicated punch list team?		
Are there adequate reserves in the project budget for punch list-related repairs?		
Does the contractor have a dedicated team which focuses simply on water infiltration problems?		
Are there procedures for documentation of satisfactory completion of punch list items?		
Is there a third-party inspection of completed projects prior to job transfer?		
Is there a systematic program for addressing and handling customer complaints and warranty issues?		
Does the contractor have a dedicated team that can respond quickly to warranty issues?		
Are there procedures for prompt response to customer complaints associated with water infiltration and/or mold problems?		
Are the reserves adequate for warranty items?		
Are there procedures of documentation for satisfactory completion of warranty work?		
Are there procedures for assessing the potential mold problem and structural integrity?		

Assessment and action items:

See pre-construction planning tasks for ideas

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Internet Resources

<https://www.epa.gov/mold>

This is a very useful site with comprehensive information on mold assessment and mitigation maintained by the Environmental Protection Agency. It also provides information on controlling mold exposure in homes, schools and large buildings.

<https://www.nyc.gov/assets/doh/downloads/pdf/epi/epi-mold-guidelines.pdf>

This New York City website contains one of the most widely cited guidelines on assessment and cleanup of mold.

<https://www.cdc.gov/mold/faqs.htm#:~:text=Mold%20will%20grow%20in%20places,carpet%2C%20fabric%2C%20and%20upholstery.>

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