CHAPTER 9
MOLD

INTRODUCTION

The presence of mold in buildings and the resulting health issues of building users have been in the news almost constantly lately, and this, in turn, has placed an added emphasis on mold prevention and restoration. It is important to note that by following the waterproofing concepts presented throughout this book, all types of mold can be prevented because mold cannot form without the presence of moisture, which typically results from water infiltration through the building envelope.

For mold to form and grow, it requires: moisture, a food source, and warmth. The food source is readily found in all types of structures—organic building materials. The most common type is drywall, where all types of molds can grow. Warm temperature-controlled interiors of work and living spaces likewise present ideal conditions for mold growth.

Since building materials and controlled interior environments cannot be eliminated to prevent mold, it is the third component, moisture, that must be controlled and considered the cause of all mold problems in construction.

An exception to mold caused by water infiltration though the building envelope is typically mold related to plumbing or heating, ventilation, and air-conditioning (HVAC) systems. For instance, a leaking water pipe behind a wall can provide the moisture necessary for mold growth. Likewise, a faulty air-conditioning system can raise the humidity levels above 60 percent (the level necessary for mold support) when such things as clogged drain pans are present.

However, by far the vast majority of serious mold growth is caused by infiltration of moisture through the building envelope (often referred to as the "sick building syndrome"). Most people have seen news related to entire buildings being evacuated and shuttered owing to mold issues. Yet, in very basic summary, there is no more to mold prevention than following the basic principles of this book to ensure that any structure does not permit the intrusion of water in any form to provide the growth of any type of mold or mildew.

Basic mold remediation may eliminate the presence of existing mold, but any mold remediation procedures are useless without the most important process of eliminating the causes of water penetration, which permitted the growth of mold in the first place. *In fact, mold remediation without proper waterproofing restoration will permit mold to return.*

MOLD

Prior to the publicity about mold growth in structures, mold was commonly referred to as *mildew* and was considered more for its confirmation of leakage than its relationship to

health issues. Mold is actually fungi, which are organisms that obtain food by absorbing nutrients from external sources rather than through an internal digestive system. Fungi release digestive enzymes that break down the food source, which then can be absorbed back into the fungi as they grow.

Molds reproduce by releasing tiny spores into the air that land on surfaces that can provide a food source (e.g., organic building materials such as drywall) and a moist environment. Almost all molds can be detrimental to people with respiratory and asthma problems, including the common black mold, *Stachybotrys chartarum.* This type mold is often found in bathrooms, typically around shower walls, growing on the organic grout materials in the warm and moist environment.

Most molds are generally nontoxic, and we encounter them everyday outdoors as part of nature's way of degrading and disposing of materials such as tree leaves. Some molds actually are beneficial, the most well-known being penicillin. This mold produces a waste product known as an *antibiotic.*

More serious are molds that produce hazardous waste products called *mycotoxins.* Mycotoxins are poisons produced by certain fungi or molds. The common black mold described earlier also can produce mycotoxins, as evidenced by the amount of press coverage given to the subject recently. Molds and mildew that produce mycotoxins can create a large variety of health problems from asthma to even life-threatening conditions. It is this concern that mandates that all mold and mildew growth should be prevented in all building structures regardless of whether it is the type that produces mycotoxins or not.

There are in fact so many different types of molds and fungi (estimates as high as over 500,000) that actual identification of the type of mold and whether it is toxic or not should not be a priority. Rather, the immediate emphasis should be on mold remediation and remedial waterproofing to prevent the water source that provided the opportunity for the mold to grow in the first place.

TESTING FOR MOLD

Usually mold is identified easily by visual examination; it is often located near or at the source of water infiltration. For example, mold growing on drywall around widow frames is very common in residential construction when the widows have not been installed using the recommended techniques for transitioning from the building cladding to the window frame and sealant along the window frame has been applied improperly.

Mold also often is identified by a musty smell, and then procedures must be undertaken to identify the location, which might involve removing architectural finishes such as carpet, wallpaper, tile, etc. to expose the mold contamination. In many cases, certain architectural finishes must be removed to expose the areas of mold, such as pulling back wallpaper to uncover the drywall that is infested with mold growth. Removal of sufficient finishes to determine the complete extent of the mold infestation is required to prepare the area for actual mold remediation.

In extreme situations, where the mold source cannot be readily identified and located, air testing may be required. Air testing for the presence of mold must be done by experienced professionals and can be extremely expensive. Air testing is often required in office

buildings or other work areas where employees are experiencing systems of mold-related disorders. However, as described earlier, mold is present everywhere outdoors, and air testing therefore may register a false reading because it may be detecting mold from outside sources being brought in by open windows or doors.

Generally, most mold is recognized by strong odors inside or actual visual detection, and more elaborate and expensive detection methods are not required. However, once mold is detected, no matter what type of mold it is, it must be remediated, and the source of water and/or moisture allowing the mold to grow must be stopped.

MOLD REMEDIATION

It is not the intent of this book to present a detailed description of the procedures for mold remediation. Such work would require a text of its own, and besides, mold remediation should not be undertaken by amateurs unless the mold has been identified as nontoxic. This section merely provides an introduction into the actions necessary for mold remediation with the understanding that the point of this chapter is to prevent the formation of mold formation in buildings by preventing water infiltration using the 90%/1% and 99% principles, as well as, if necessary, remedial waterproofing techniques if mold is indeed encountered in a structure.

While most homeowners are comfortable with removing mold that grows in their showers or baths, remediation of mold growth found growing on other organic building components such as drywall should be undertaken with caution. Mold growth on building complements, as described earlier, can be extremely toxic, and therefore, professional advice is usually called for prior to remediation.

Remediation of mold in residential homes by the homeowner can be successful if guidelines such as those published by the California Department of Health Services are followed. These and other guidelines outline basic steps a homeowner can take to remediate basic mold infestation, including the basic protective clothing and measures to treat and kill the mold.

When remediating mold, it is necessary to understand that most porous building materials such as drywall, ceiling tile, and carpet, must be removed and discarded because the mold growth may not be fully remediated and the mold may return even if the presence of water is eliminated. Therefore, it is critical that drywall be inspected for the complete extent of mold formation and that infested areas are removed completely rather simply treating such porous building materials. This is seen commonly when flooding of a home has occurred and the drywall beneath the high-water line is removed completely rather being treated with a chlorine spray.

Mold remediation never should be undertaken before the source of moisture/water has been found and remediated. Removing mold before the source of moisture is stopped likely will lead to the mold reforming, and even if the water source is remediate afterwards, certain mold/mildew types can continue to grow by creating their own moisture. Therefore, is critical that the source(s) of water or moisture are fully corrected *prior* to mold remediation; otherwise, additional mold remediation and associated costs may be necessary.

Simple mold remediation consists of killing the mold. Typically, this is done with a 10–30 percent hydrogen peroxide solution. This method generally is noted to be more effective

than application of chlorine (bleach). If bleach is used, a diluted application if more effective than spraying bleach directly from the bottle. Usually, the bleach is diluted with two parts water.

Spray applications of hydrogen peroxide or bleach are only effective on nonporous building materials, but they may be used on areas such as concrete, concrete block, and other masonry that cannot be readily removed for remediation. Nonporous material such as furniture is best treated by cleaning with a detergent cleaner rather than these spray applications because the mold is not able to penetrate the surfaces and removal is usually complete with a thorough cleaning of the surfaces.

Again, it is critical not to attempt to remediate badly infested porous building materials such as ceiling tiles and drywall. These should be removed and disposed of properly and the finishes replaced with new ones to ensure that the mold does not reappear, even if the source of water is repaired. Prior to replacing such finishes, it is important to give the area sufficient time to dry thoroughly. This will eliminate the possibility of mold returning unnecessarily.

It is also important to inspect beyond the initial layer of mold for deeper or wider infestation prior to remediation. For example, carpet may have molded down through to the padding and even through the padding to the plywood substrate. In this case, the carpet, padding, and possibly the infested plywood all must be removed for proper remediation and to prevent mold from returning even if the water source has been eliminated. During this process, it is imperative to carefully wrap and protect the materials to be removed before moving them through other areas of the structure because any mold spores present in the materials can easily become airborne and result in contamination in other areas of the structure.

Prior to attempting any mold remediation, a complete program plan should be written out and each step carefully reviewed before work is begun. Adequate information resources are available at libraries, on the Internet, and through your local or state health departments.

CAUSES OTHER THAN THE BUILDING ENVELOPE

While direct leakage through the building envelope is the main concentration of this chapter, it is helpful to review other causes of mold infestation, particularly in residential construction, that a homeowner can address immediately without waterproofing repairs. Among the most severe causes of mold infestation is flooding, whether it occurs from river overflows or hurricanes. Flooding so severely damages building finishes, especially such organic components as drywall and carpet, that nothing short of complete removal will remove the mold and prevent it from returning after building repairs are completed.

In residential and single-family construction, there are numerous causes for the presence of water, moisture, or humidity to support the growth of mold. In fact, mildew/mold growth in bathrooms and particularly in showers is so common that there are numerous household products sold in grocery stores for “remediation” of these areas. Other situations that occur frequently in residential homes that lead to mold and mildew growth include

- Inadequate ventilation in laundry rooms or bathrooms
- Drying clothes inside or inadequate outside ventilation of a clothes dryer
- An excessive number of houseplants and overwatering of houseplants
- Indoor hot tubs, whirlpool bathtubs, and pools

- Humidifier overuse
- Leaking plumbing or appliances such as washing machines
- Poor insulation around ducts that results in condensation and high humidity in living areas

Each of these or any combination can provide sufficient conditions for mold growth. While some mold formation is readily visible, such as the mold on the tile grout of shower walls, mold may grow in other areas that are not readily accessible and may require thorough inspection. For example, mold may grow behind a finished wall as a result of leakage from a water pipe that the homeowner inadvertently damaged when hanging a picture. Such instances usually are readily identifiable as non-water-leakage building envelope problems and are reparable without addressing building envelope components.

BUILDING ENVELOPE CAUSES

Any leakage through a building envelope into heated spaces that have organic building finishes such as drywall, grout, carpet, or other finishes eventually can lead to the formation of mold, mildew, and fungi. Besides the serious health issues that mold can create, as addressed earlier, mold also can destroy the usefulness of the finishes themselves. Furthermore, while the water leakage itself may not spread to cause more damage, the resulting mold growth can expand until the entire building is designated as uninhabitable with sick building syndrome. Repair costs in such cases far exceed the cost of building envelope repairs and literally may require the entire building to be torn down to its structural components and rebuilt to effectively remove all traces of mold and spores.

Prevention of mold is another important reason for adequately designing, specifying, constructing, and maintaining a watertight building envelope following the principles discussed throughout this book.

Below grade

An edible form of mold/fungi—mushrooms—actually is grown commercially in basement-like settings, suggesting that most below-grade structures are likely areas to support the formation and growth of mold and mildew. The high humidity levels often found in basements owing to poor ventilation of below-grade areas and the presence of water leakage through the building envelope merely require the addition of organic building finishes such as carpeting to foster the growth of mold, mildew, and fungi.

In many basements or similar below-grade areas you will find the strong musky odor of mold readily apparent. Often, particularly in residential structures, you are likely to find dehumidifiers running constantly to remove the constantly present moisture. This moisture is likely caused by poorly designed and constructed below-grade structures in combination with poor surface drainage and groundwater control.

In residential structures, a structurally sound basement may be susceptible to mold formation owing to the addition of windows—added for light—that are actually below grade. Such windows are protected by the addition of a galvanized metal barrel–type surround that permits light to enter the window, but it also permits standing water to collect near the window if surface water and groundwater are not drained adequately and sloped away from the structure.

The standing water increases humidity levels in the warm interior areas or actually penetrates the envelope through joints adjacent to the window or between the windowpanes themselves.

A recurring situation in residential basement construction is installation of a laundry room in the basement without proper detailing to provide adequate ventilation for the dryer to prevent moisture and humidity from reaching levels that can create conditions for mold growth. Dryer vents are often installed through venting that rises above the basement level and out through outside walls above grade. This is necessary because venting is not possible through outside walls that are backfilled with soil against them. If the venting is not deigned properly, the moisture-laden air from the dyer may not be removed and may create high humidity in the basement. This also occurs in bathroom areas below grade that do not have sufficient mechanical ventilation to move the moist air out, leading to mildew and mold growth in the bathroom and possibly surrounding areas.

Many residential basements may not have been designed as a finished area, but later the homeowner applies organic building materials such as drywall, and soon mold contamination affects the entire structure. In older basements, particularly those with sump pumps, standing water often collected from groundwater drainage stands in the sump pump area to be pumped outside when the water reaches a certain level. The sump pump area provides constant moisture that easily could lead to mold growth if organic finishes are present in the basement. Usually these areas were never intended to be finished but rather were designed to remain with nonorganic, nonpermeable surfaces such as concrete. For such areas to be fitted out for typical building interior finishes, the sump pump area would have to be removed or isolated prior to finishing of the basement area.

It is also common in older residential construction that the basement areas were constructed using damproofing protection only, not waterproofing materials, and again, they were meant only for storage or for use as a laundry area. Application of organic finishes in such basements without prior application of remedial waterproofing systems often leads to mold and mildew problems.

In all types of older structures, mold often is found during interior renovations when organics finishes such as drywall or paneling are removed from exterior walls. It is therefore recommended that in any below-grade area that is being renovated for interior building finishes as a living or working space, the entire below-grade structure should be examined for water infiltration and that both surface water and groundwater controls should be reviewed or installed as necessary prior to the start of renovations.

Below-grade structures should follow the guidelines presented in Chap. 2 anytime there is an intention to use organic interior finishes in those areas to prevent the formation of mold and mildew. Particular attention should be paid to ensuring that the envelope is continuous around the foundation forms a watertight and moisture-tight barrier between the vertical and horizontal areas. Often in residential construction the foundation is constructed with no attention to proper waterproofing details for the transition between the horizontal and vertical areas of the basement. For example, rarely will you find a residential builder using the water stop required in a common basement construction detail.

All too often residential contractors will merely apply a vapor barrier to the horizontal slab portions and neglect to add a proper waterproofing membrane below the slab (refer to the section on vapor barriers in Chap. 2). When organic carpet and padding are installed on the

basement slab, use of a vapor barrier, when a waterproofing membrane actually is necessary, will permit sufficient moisture to permeate through the slab to foster mold and mildew growth.

Residential contractors also rarely provide proper detailing attention to the transition between vertical and horizontal construction. Residential basements often show moisture penetration occurring at the base of the exterior walls along the basement perimeter, and carpets and other floor finishes often will show signs of mildew and mold formation along the perimeter caused by this moisture penetration.

When existing basement or below-grade areas are remediated for use as living spaces, negative-type waterproofing systems are often employed. These systems are discussed in detail in Chap. 2 under "Positive and Negative Systems." These systems can provided adequate protection from leakage and mold formation. However, it is important to note that when using such negative or remedial waterproofing systems, they must not be punctured when applying the interior finishes such as drywall or paneling. Too often a carpenter unfamiliar with the building envelope will fasten the drywall studs or paneling to the exterior walls by driving nails directly through the negative membrane application and creating a void so that moisture and water can enter and support the creation of mold on the organic finishes.

Above grade

Above-grade mold and mildew formation is just as common as mold and mildew formation in basement and below-grade areas. Most common, in both residential and commercial construction, is mold and mildew growth around window perimeters. Other areas include the floor–wall juncture at grade line, especially if carpet is present to support mold growth.

As is the case in below-grade mold formation, the cause of water infiltration and mold contamination in above-grade areas typically is lack of attention to the 90%/10% and 99% principles presented in Chap. 1. Perfect examples are window frame installations. Both residential and commercial contractors rarely provide the transitions detailing necessary for the proper application of sealant along the exterior perimeters of window frames and create further problems by incorrectly installing or omitting the installation of flashing around window perimeters.

The entry of water, warmth provided by sunlight through the glass, and such typical organic finishes around windows as drywall, paint, and/or wall covering provide a perfect breeding location for mold and mildew. Next time you spend a night in a hotel, take time to inspect the widow sills and jambs, especially those where a wall or window air conditioner is installed. More often than not you will find mold or mildew or evidence of past mold remediation.

Health issues are well documented related to sick building syndrome. Often this is simply the case of mold formation around window or curtain-wall detailing, and in 99 percent of construction, these exterior windows do not operate so as not to unbalance the air conditioning. Unfortunately, the amount of fresh air brought into the structure is very limited to provide the most economical cooling and heating costs, but the price for this is a constant circulation of mold spores around these sealed windows and the resulting poor health conditions. This is a very common cause of sick building syndrome in commercial construction.

This makes the 90%/1% principle a health issue as well. Clearly, it is necessary that the transitional detailing between windows or a curtain wall and adjacent construction (that 1 percent of a building's envelope that causes 90 percent of all leakage) is installed properly to prevent

water infiltration. If the 90%/1% principle is not adhered to in these specific areas, especially given that few commercial buildings allow for widows to be opened by occupants, the failing becomes a health issue when mold grows owing to water infiltration in this 1 percent of the building's area.

Both commercial and residential air-conditioning units can be a cause of mold contamination and can contribute to the spread of spores though the duct work. All HVAC systems have some means of draining off the condensate that forms when the air is cooled, and if the drip pan piping that drains the condensate becomes clogged, an area can be created that encourages mold growth, and the spores can be spread throughout the building as air circulates around the clogged drip pans.

While commercial air-conditioning units are inspected regularly by maintenance personnel, residential owners rarely inspect their air-conditioning units. This is why most local residential building codes require that condensate overflow piping exit somewhere outside the residence where it is readily visible by the occupants so that they realize that the drip pan has become clogged so as to prevent damage from condensate overflowing the pan, as well as preventing the formation of mold in the attic and other areas where the units themselves are located. The reason for such code provisions is that homeowners rarely inspect their air-conditioning units unless a problem develops, so this condensate overflow is necessary to alert the homeowner of an unsafe condition.

Commercial or residential structures with flat roofs that use scuppers or roof drains for drainage also should be inspected regularly. Clogged roof drains or scuppers can become areas of mold growth, particularly if leaves are clogging the drains because they provide a perfect food source for mold. This mold then can enter the structure in numerous ways, from mold spores being pulled in though air-conditioning or heating inlets to spores that enter with water through leakage areas at widows when the rain water overflows and washes down the side of the building instead of through the gutter.

SUMMARY

Mold is often the first sign that a structure is experiencing water infiltration because evidence of mildew or mold growth may come when leakage starts and has not noticeably saturated an interior area. Other than interior bathrooms and utility rooms, where humidity levels present opportunities for growth, mold and mildew typically are a sign of water infiltration.

Anytime mold or mildew is located, testing for the cause of water infiltration should be undertaken, but protection from contamination from the mold also should be provided. However, again, it is critical to always cure the source of water infiltration prior to undertaking mold remediation.

Chapter 11 presents detailed information about leak investigation and detection for any areas where mold is discovered. Chapter 7 then can be used as a resource for selecting a remedial waterproofing system to correct the leakage found that is creating the moisture source for mold growth.