Moisture...
The Silent Home Wrecker

Peter Kuelker

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Foreword

Moisture management in residential homes is becoming increasingly more important as we are building homes that are more and more airtight. We do all this in an effort to conserve energy.

In these airtight and highly insulated homes new problems are emerging when it comes to moisture management. In comparison older homes could dry out much more readily due to the fact that moisture as well as energy was lost through the walls.

We are going to make an attempt in this booklet to point out in simple terms how to control the moisture in these new dwellings.

I would like to extent a special thanks to Brent Applegate for his contribution. Brent has been involved in the building industry for many years as a building inspector and he has given numerous seminars on roofing and building envelope technology.

It is interesting to note that on an average building lot in an average year a total of 20 dump-truck loads of water are deposited either by rain or by snow. This water must somehow be managed.

I personally have been involved in the building industry for over 30 years and in the last few year I have develop the revolutionary new product “Stonetile” which has received a CCMC evaluation number. It is the only manufactured stone system in Canada that has received this evaluation.

I am pleased to present this booklet to you. I hope that these pages will result in a better understanding of how to manage moisture and add decades of problem free life and comfort to our homes.

Peter Kuelker
President of Stonetile (Canada) Ltd.

INTRODUCTION

This report is intended to give the reader awareness of what problems may arise if moisture in building envelopes is left uncontrolled. We will discuss how moisture can get into the envelope and what actions can be taken to control this process.

You will learn why in new homes there seam to be more moisture problems then in old houses (60 to 110 years old).

Rain is the main source of the moisture that can potentially end up in the wall cavities from the outside.

To keep this water out of the house we do the common sense stuff:

- We make sure the roof does not leak,
- We make sure there is a maximum roof overhang,
- We select a wall system that will manage water entry
- We make sure that windows and doors are flashed correctly,
- We make sure that windows do not leak
- We make sure that the ground around the house has a positive slope away from the house
- We make sure that the downspouts have extensions on them.
- We make sure rain water does not enter through capillary action (this means water could be siphoned upwards behind siding or it could be channelled vertically or horizontally into the building trough unsealed concrete)

The second source of moisture comes from air bourn water (humidity.) this humidity can migrate to the wall cavities from the inside.

To minimise this problem we can do the following:

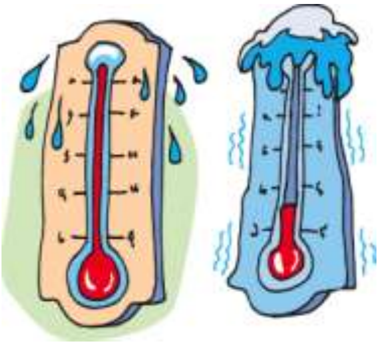
- We make sure humidifiers are off or at a low setting (30%)
- We make sure steam such as cooking, showering is at a minimum through the use of bath and kitchen fans
- We make sure that the drier is properly vented and cleaned
- We make sure that proper ventilation exists in the home
- We make sure that the wall features a vapour barrier and
- We make sure that no interior air is allowed to enter the wall cavity through open holes. Relatively small holes such as electrical or plumbing penetrations can result into significant issues. (The water in this air will then condense in the wall cavity)

Unmanaged moisture in a wall will promote mould growth. Trapped moisture over time will cause wood to rot and metal to rust. Repairs could become very costly. Insurance companies typically exclude mould damage.

After reading this material and completing the exam you will have an understanding of the following:

- *Heating degree days / cooling degree days*
- *Liquid moisture and air born moisture sources*
- *How water damages wood and other building materials*
- *Why older buildings have less moisture problems*
- *How water gets into the wall cavity from the outside and the inside*
- *What is a building envelope*
- *How heating the house affects the wall envelope*
- *How you can test to see if a window is leaking*
- *The line of defences against moisture problems*
- *The 4 cladding systems*
- *How to construct moisture smart walls*
- *How to ensure proper lot drainage*
- *How teamwork of the different sub-trades can result in a moisture smart house*
- *How failures happen and what they can look like*

HEATING DEGREE DAYS / COOLING DEGREE DAYS



18 degree Celsius is considered to be a comfortable outside temperature. It is the benchmark temperature for human comfort. If temperatures are below that point in colder climates our furnace kicks in. If the temperature is above that point the air conditioner kicks in (if there is one).

In cold climates such as Alberta our heating degree days are approximately between 4500 to 7000 per year. This means that if you count all the degrees every day for the year that are below 18 degrees you will end up with between 4500 to 7000.

Here is an example: Start adding! On a day where the average day and night temperature comes to zero (daytime high is +9 night time low is -9 this equals 0 for that day) The next day it is +20 and during the night it is +10, this is a 15 degree average. Now there is a day that has + 22 day and night.

Start adding and subtracting.

Day 1 18 – 0 = 18   start adding + 18
Day 2 18 – 15 = 3   + 3
Day 3 22 – 18 = 4   - 4
The 3 day total = 17 x 365 days = 6205 heating degree days.

In Las Vegas for example there are approximately 1000 cooling degree days. As you can see, the furnaces are running more in Alberta in comparison to air conditioners in Las Vegas. The significance of the difference between room temperature and outside temperature in regards to moisture control will become evident later in this booklet.

WATER AND AIR IS EVERYWHERE

Water rains, water snows, water freezes solid, water vaporises and water condenses. The average Alberta house is bombarded with water year round.

Water vapour is constantly present in the air that we breathe. The amount of vapour air can hold in suspension is dependent on the air temperature.

Relative humidity (Rh), what does it mean?
Relative humidity is a moving target.

Cold air can hold less water vapour then warm air.
A m3 of air at + 10 degrees will have reached 100 % Rh. if there are 9 g of water in it.
A m3 of air at + 20 degrees will have reached 100 % Rh. if there are 17 g of water in it.
A m3 of air at + 30 degrees will have reached 100 % Rh. if there are 30 g of water in it.

A m3 of air at + 40 degrees will have reached 100 % Rh. if there are 55 g of water in it.

An example: If you have air that is 40 degrees warm and had a water content of 27.5 g you would have air that has a relative humidity of 50%. If you cool this air you will soon come to the point of saturation or 100% humidity. (This would happen at around + 25 degrees.)

The dew point is the temperature at which condensation forms. Air temperature can drop to the dew point and the water in the air will fog up and fall to the bottom. Surfaces temperature can drop below the dew point. When this happens water will condensate on these surfaces. This fact becomes very significant in home exterior walls.

WATER CAN ROT WOOD AND RUIN OTHER BUILDING MATERIALS

Wood absorbs and releases water and consequently expands and shrinks. Wood is considered to be dry when it is down to 19% water content. Wood is considered wet and saturated when its moisture content is 28%. If you add warm temperature to this wood and don't allow it to dry out it will start to rot. The speed of rotting is dependant on temperature and moisture. Wood needs fungus for it to rot. Fungus spores (seeds) are in good supply everywhere. There are many different fungi but the ones we are most concerned about are the ones that cause wood to degenerate (rot).

Some other building materials that don't do very well when subjected to water for a long period of time, are drywall, some metals and carpet.

WOOD AND WATER

Water is readily absorbed by wood. Wood fibre is an elongated fibre and it likes to soak up water. Under a microscope picture wood fibres look like long spaghetti. These strands do not get longer when they have been soaked in water. They will only get fatter. Therefore when you have a wall stud it will not change its length but it will expand about 2% in width. Shrinkage is most significant when it comes to floor joists, rim joists and trusses. Shrinkage becomes important here especially when other materials are used in these areas and where these materials shrink at vastly different rates. Cracks could develop in drywall and you could develop truss uplift. This could result in unwanted air leaks. Wood is soaking wet when a tree is felled. It will dry out over time (at least a season). Wood can also be dried in huge kilns (kiln dried wood) where the moisture content is taken down to below 19%.

Mould

As mentioned before mould spores are everywhere. If the conditions are correct mould will grow on organic and on some non-organic surfaces.

Insurance companies no longer cover mould damage. The problem becomes the builder's problem. Although no firm link has been established between mould and illness and no personal injury lawsuits have been won in the BC leaky condo disaster, the burden of keeping housing units moisture and mould free becomes the builder's and the homeowners problem. Building homes with a face-seal or drain-screen exterior in areas of higher precipitation is not advisable.

It takes 48 hour for mould to grow.

Mould grows between 4c and 38c.the optimum temperatures are between 24c to 35c. The Rh adjacent must be above 70%. Oxygen, warmth and moisture are needed for its growth.

When it comes to wood-decay-fungi, it starts to germinate when the wood has a moisture content of 25% to 28%. Rapid growth happens when wood is soaked 35% to 50%. Of course for mould to flourish you must have to right temperature conditions.

Concrete has no food source for mould to grow.

There are moisture / mould detection strips available that can be installed in walls and the situation can be monitored and thus provide early detection of upcoming problems.

THEY DON'T BUILD HOUSES LIKE THEY USED TO!

We have all heard this expression. I am here to tell you that, this is mostly a blessing and not a curse. The big difference would be that old houses were much more prone to air leaks. That means that entrapped moisture in the walls was much less likely to happen. On the other hand foundations were usually of poor quality in old homes due to the fact that cement and aggregate ratios were not usually at their maximum. The gradation of the sand was not looked at as a science in those days either. Often round fieldstones were mixed in with the concrete and the end result was not the best. Footings were not of proper dimensions and capillary brakes were not even considered. Weeping tiles are usually non existent on a 100 year old house. On a lot of the old houses that I have seen, the beams, joists and trusses were completely undersized, resulting in sagging floors and walls. When it comes to heating bills, ouch -- we all wished that we had a newer house. The 3 inches of wood shavings in the attic did little to save energy. So, when we look at all these shortcomings (and I could list a lot more) only one fact remains as a positive: A 70 or a 100 year old house was not subject to as much moisture entrapment as a modern house.

The good news is: We can fix these problems by properly planning the construction of a new house.

HOW DOES WATER GET IN THE WALL CAVITY FROM THE OUTSIDE?

The number one cause is leaking during rainstorms. We usually have better things to do during a rainstorm than stand in the rain and watch how the wall is drenched from top to bottom with water. This water will find a way to get inside the wall trough the smallest cracks and smallest openings. It will also enter the wall trough capillary action. One building envelope expert told me about a case where the water came into a room of an apartment building from a leak that started 10 feet below the actual leak appearance. For water to creep up a couple of inches behind the siding or flashing is a cakewalk. Once inside the wall it does not disappear as fast as the water that was on the outside of the wall. When the sun comes out the wall dries quickly on the outside. On the inside it is a different story. You could have several weeks following the rainstorm where humidity is high and where nothing dries in the wall. Evaporating water inside the wall cavity does not always exit trough the same opening. It will vaporise and may get trapped and condensate in a different part of the wall. The old "out of site out of mind" attitude towards this problem is not necessarily the right one. All this could come back to haunt us.

Water can get into the wall through vapour. In heating climates (such as Alberta) the vapour is more likely to get into the wall from the interior and condensate in the wall where the coldest spot is. That would be the sheathing, the tarpaper, or the backside of the siding. It is recommended that the vapour diffusion retarder gets installed on the warm side on the part of the wall that is closest to the inside, perhaps just behind the drywall. (Remember warm air carries more moisture than cold air. The vapour pressure is higher with warmer air. Higher vapour pressure wants to equalise toward lower pressure.) In a cooling climate such as the city of Miami, the vapours would likely enter from the exterior. In that city the vapour diffusion retarder should be installed closest to the outside of the wall, perhaps just behind the siding as this will usually be the warm side.

HOW DOES WATER GET INTO THE WALL FROM THE INSIDE?

Warmer air can carry more humidity than colder air. Add to that the fact that we use a lot of water in the house that mostly turns into vapour. Think of showering, cooking, washing floors, humidifying (and the illegal grow operation that are prevalent in so many Albertan homes). We should really re-examine humidifying. So if in Alberta our average temperature is dramatically colder outside it stands to reason that the inside air is usually more humid than the outside air. Warmer, more humid air has a strong desire to flow toward and mix with colder drier air. You wouldn't think that, when the door is left open for 10 seconds on a day when it is -25. Nature always tries to come to a balance. Our poor homeless people who are huddling on ventilation grates or other openings of buildings in the wintertime on a cold day, have likely noticed that warm air readily escapes from buildings and rises (and mixes with the colder drier air).

We will not concern ourselves here with the warm air that escapes to the great outdoors, but we want to deal with the warm moist air that finds its way into the wall cavity of a wood frame house and gets trapped there.

Another way that moisture ends up inside the walls is when we use soaking wet materials in the first place. These materials don't have a chance to dry before everything is closed in.

WATER LOVES TO GET AROUND, BUT A VEHICLE (A FORCE) IS NEEDED FOR WATER TO TRAVEL.

Here is a list of forces that water uses to get around.

- The first one is gravity.
- The second one is capillary action and:
- The third one is to turn into vapour and travel by air.

SURFACTANTS IN WATER

Water will ruin building materials for another reason and that being: There are surfactants in the water. A surfactant is a chemical that is like soap. It makes water wetter. With enough exposure it will rob building papers of their water repellent qualities. Water has naturally surfactants in it, but additional surfactant contributors are wood, stucco and soap that is used to clean outside walls. Stucco contains surfactant chemicals. Additionally the stucco tradesmen will often add soap to make stucco more workable. A rather crude example would be to picture washing a duck with soap and putting it into water. The result would be that all the feathers would absorb water readily and the duck would sink immediately. Tyvek or tar paper is also damaged by surfactants.

THE FOUNDATION IS PART OF THE BUILDING ENVELOPE

In this department the buzz word is capillary action. Water could get sucked in from all sides if preventative measures are not taken. The concrete floor and the concrete walls would be a constant source of water. There is plenty of it. Just think of a high water table, ground water or even leaks through cracks or openings in the foundation walls. – Even more water in the house.

THE ROOF

The roof plays the most obvious part in keeping the water out of the house. As the human race has evolved over the last few thousand years, we have become pretty good at building roofs. You might think that after all of this time we would have worked out most of the kinks, but one thing still holds true; If your roof has a hole in it, then it will leak water into your house and that's never a good thing! A few things to bear in mind when designing the roof: Keep it simple whenever possible – Many fancy details such as Valleys, Dutch Gables, Pigeon nests, etc. make roofing more complicated and more leak prone. Never allow a roof protrusion such as a plumbing stack, heating vent, chimney chase etc. come within 18" of a valley. Slopes above 4 in 12 (18 degrees) drain better and do not need special low-slope treatment such as peel and stick membranes. Make sure to specify at least a 2 ft. overhang at your eaves and gables to reduce chances of interior leakage. In climates that have winter freezing conditions, make sure to use proper valley and eave protection material that extends past the bottom sheathing edge and up a minimum of 1 foot into the heated area of the home (2 ft. is better) for ice dam protection. On any chimney chase built towards the bottom part of the roof that is wider than 30" build a water diversion saddle; only use a back-pan flashing detail on chases smaller than 30" wide. Have a roofing inspector examine your roof for maintenance once it is in the later half of its expected service life. That would be after 10 years for an asphalt shingle, metal, or a wood shake roof, and after 25 years for a clay or concrete tile roof. After this inspection schedule regular inspections every 3 to 5 years depending on roof material type.

THE ATTIC

Condensation can happen under the roof. The best prevention is a tight vapour barrier, a tightly sealed attic access and good ventilation. All pipe, wire, vent and chimney penetration must be sealed with the appropriate sealers. Ceiling insulation stops must be installed at the perimeter of the ceiling. These baffles are available in insect resistant cardboard or plastic. The baffles keep the insulation from falling into the soffits. They also help prevent the insulation from getting wind-washed. The 2” airspace created over the baffle allows for proper air circulation where air comes in from the soffit vents and exits the vents located at the top of the roof (or at the top of the gable ends).
Make sure to have enough ventilation to achieve the minimum building code requirement of 1 sq. ft. of net free ventilation from either the soffit or roof for every 300 sq. ft. of heated ceiling area. This is best split at 50% / 50% but can be done with 75% of the venting from the soffits and 25% from the roof. You need twice the ventilation for cathedral roofs.

OPENINGS IN THE WALLS, WINDOWS AND DOORS

Your wall is built. Everything is perfect and now we start to cut holes all over the place for windows, door, vents, pipes and wires. Dealing with this properly requires attention to detail. I have personally been called out to numerous houses with reported water leaks and I found that in almost every case it was a leak that was detected in the window itself. The test is easy. Simply create a water dam on the window sill (duct tape or tuck tape works in most cases) and pour water on the sill to a height were the water touches the glass. Then you wait on the inside of the house, carefully checking the window corners and sill for any wetness that appears either on or under the sill. You may be waiting for 2 seconds or you may be waiting for a full hour before you notice anything. If this test was done on all windows, the failure rate would be a significant percentage. In a lot of cases the roof overhang is the saving grace and the water leak will never become a problem.

Having said that: a good quality window can just as easily leak around the opening if the installation is not correct.

NOW COMES THE PRESSURE COOKER

When we don't have enough problems already we start heating all this stuff and guess what, hot air wants to rise. This is called the stack effect. The only place it can rise to is the ceiling and soon you have your house pressurised. Is it any wonder that moisture ends up inside the walls? We practically force it in there. We have already established that on most days it is colder outside than inside and now suddenly we have to worry about condensation in the walls. Not a big problem in those 100-year-old-houses that were full of gaps everywhere that allow this moisture to escape harmlessly outside but it is a problem in a wall that has polyethylene, insulation and building paper to trap and seal the moisture in the ceiling area or wall cavity.

NOW FOR THE GOOD NEWS

In the tool bag of the modern home builder are a whole bunch of goodies, including:

* Vapour barriers
* Air barriers
* Insulation
* Capillary breaks
* Insulation baffles / stops
* Acoustic sealants
* Tuck tape
* Semi permeable paints
* Permeable paints
* Permeable insulation
* Non permeable insulation
* Sealers and Glues
* Galvanised and plastic flashing and the list goes on

These goodies allow you to construct:

* Face sealed walls
* Drain screen walls
* Rain screen walls and the Cadillac of them all:
* Pressure equalised rain screen walls

Study the illustrations on page 18 to understand wall design.

THE "FACE SEALED" WALL

This system, on the surface, makes more sense than the other three systems. But as soon as you consider the high interior moisture content that needs to escape, you have a serious problem on your hand. The more effort spent on having a perfectly tight outside seal, the bigger the problem becomes. In certain regions in North America, homes have been built with the face seal technology with disastrous results. Often acrylic stucco was used as the outer layer on the exterior. These walls have no way to deal with the humidity that is released from the interior. Additionally buildings move, materials expand, contraction and expansion happens and leaks develop on the outside. This allows even more water to be trapped in the wall. The greenhouse effect created inside the wall can cause these houses to rot within 3 or 4 years, to the point that they become unstable. This is serious stuff. Billions of dollars of lawsuits have been launched because of this problem in areas with minimum 500mm of annual rainfall

THE DRAIN SCREEN WALL

We are all most familiar with this system. An overwhelming majority of homes in Alberta have been built this way for the last few decades. What it boils down to is that the tarpaper (and in more recent years the "Tyvek" paper) keeps water out of the inner wall. In Alberta we have gotten away with this system for the most part but if you were to employ the same system at the coast where it rains a lot more and the humidity is much greater you could potentially have a significant problem on your hands. And problems they have, moisture related lawsuits in excess of a billion dollars. A moisture control expert refers to the Drain Screen wall as a "single line of defence" against moisture. I.e. if the building paper fails you are in trouble. Drain screen walls are recommended for areas of less than 1000mm of annual rainfall.

RAINSCREEN WALL

Picture this, you have left your window open but your screen is in place. Now it starts raining. You will find that the water that hits the screen will run vertically down on the screen and will not end up on your bedroom floor. Voilà - a Rainscreen! The same principle is built into a Rainscreen wall. Brick and Stonetile walls are typically Rainscreen walls. In each case there is an airspace behind the wall that allows for draining and venting of any of the moisture that made it past the first outside layer (i.e. the Brick or Stonetile). Stucco, vinyl and wood can be used in a Rainscreen wall but the wall would need to be strapped to create that airspace behind the siding. Now that we have an airspace, we have to make sure that any of the water that gets into this airspace is allowed to readily drain out or dry out. We have to provide small openings at the bottom and at the top so this can happen. The water that gets into this airspace typically hugs the backside of the siding until it drains at the bottom or dries to the top. This air space should be a minimum of 6mm. A bigger space would be more desirable. If we compare Rainscreen to “drain screen” and “face seal” we have a system that is far superior to these systems. The air gap should not be less than 10mm or 3/8” (Stonetile’s airspace of 6mm or ¼” was sufficient to receive its CCMC evaluation number). The Rainscreen system is recommended in areas of less than 1500mm of annual rain fall.

PRESSURE EQUALISED RAINSCREEN WALL

This system has the same features as the Rainscreen system but the air space is now compartmentalised. Picture yourself being outside and about ¾ of the way to the top of a high rise building on a rainy, stormy day. (Not much fun!) The wind gusts are pushing water up, down and sideways on the wall and as the wind swirls around the building you notice that on the other side, the wind actually pulls water away from the wall. If you had your high tech instrument pressure gage thingy, you would notice that this sucking action creates negative air pressure in front and also more importantly behind the cladding. *Why is this important?* Well, it is important because this negative air pressure now sucks water right into the air space. Holy S! How can we fix this problem? This is where the pressure equalised Rainscreen comes in. The air space gets divided (with backer rod or other materials) into compartments, perhaps 10’ x 15’. It is more important to seal vertically up and down corners, due to the fact that the pressure difference is more likely from one wall to the wall that faces another direction. This treatment reduces the vast air pressure fluctuations and it will cut down on the water that gets sucked into the air cavity. This system is recommended in areas where high rainfall can be expected but especially for tall buildings.

LOT DRAINAGE

It is very important to have positive drainage on any given property to avoid water being funnelled towards the basement walls. Remember we start building a home in a big pit (we dig basements) and you want to make sure you aren't just draining the whole roof back into that pit. Make sure the downspout extensions drain at least 10' away from the house and onto previously undisturbed soil.

MOULD, WHERE IT COMES FROM AND WHAT IT DOES.

What else can we talk about here? Oh, yes, let's talk about weather.

The weather changes everything. Ever wonder why the weather changes constantly? There are so many reasons that we could not list them all here. If the world was flat and if it did not turn we would likely be stuck with the same weather. The facts are: It is mighty cold in space. The reflection of the sun on the earth warms the earth. Problem is there is a lot more reflection at the equator (because here the sun hits the earth at a 90 degree angle) than at the two poles. Then days turn to nights and there is hardly any sun radiation and the earth wants to bring its temperature closer to the temperature that we have in space which is – 273 degrees. The next day everything starts over again and all these temperature differences start the air swirling around the globe. Now mix it with the humidity that gets picked up from the oceans and: You got yourself some weather! Weather has a great influence on our dwelling.

LET'S BUILD A HOUSE THAT CAN WITHSTAND THE HANDS OF TIME.

The perfect exterior wall for your region may not be perfect in some other places of the world. Let us just deal with a wall design that makes good sense for Alberta.

The Alberta recipe calls for the following:

** ½" drywall*

** 6 mill polyethylene*

** 2x6 exterior studs*

** R20 Friction fit insulation*

** 3/8" plywood or OSB*

** Building paper or Tyvek*

** Nails*

** Staples*

** Screws*

** Roofing materials*

** Siding materials*

** Caulking*

** Paint*

** Electrical plug boots*

** Windows*

** Doors*

** Flashings*

** Rim joist*

** 8" concrete*

** 20" x 9" concrete footing*

** Moisture proofing*

** Weeping tile*

** Gravel*

** Drain matting*

For the icing (the cladding) you can pick from the following:

** Face seal (from what we know about this one, we will just stay away from it)*

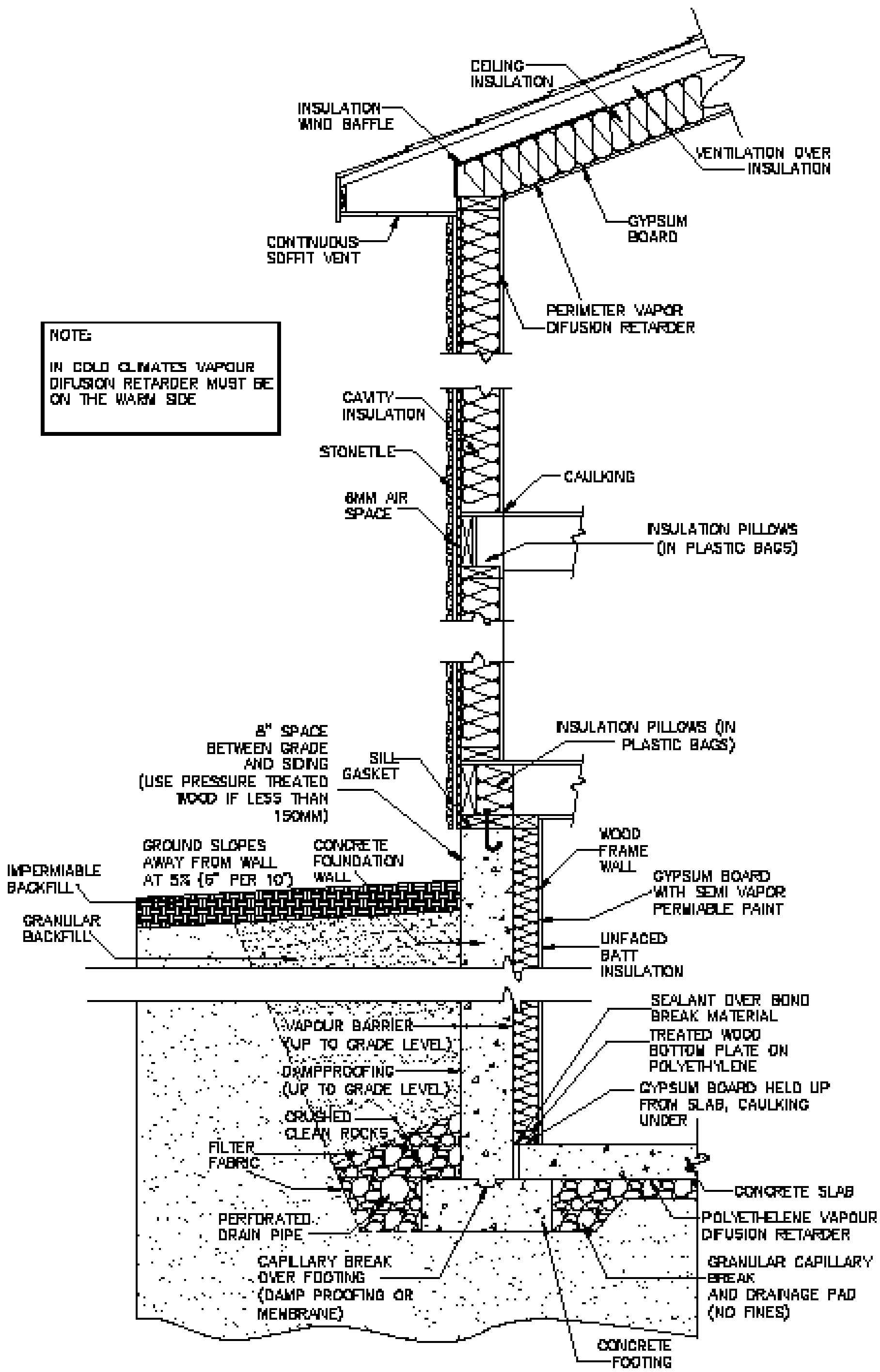
** Drain screen*

** Rainscreen or*

** Pressure equalised Rainscreen*

Directions: build a wall as per drawing………

Typical Wall Detail



STATISTICS

- ANHWP (Alberta New Home Warranty Program) reports that from all the claims received 23% were water penetration claims.
- 40% of these ANHWP reported claims were claims of water coming through walls.
- Most of these claims were leaks found around windows, patio doors, decks and rim joists/wall detail.
- If windows and door were installed correctly at least 50% of moisture problems would be avoided.
- Faulty flashing was to blame for some of the problems: low flashing risers, wrong slope on the flashing and flashing joints were not sealed.
- Faulty building paper installation also played a roll: wrong overlap, folds, tears and wrong tape
- Bad stucco mixes were also reported
- Poor caulking application, some caulking was put in wrong locations, actually trapping water and funnelling it behind the cladding
- Poor window design
- Reported damage included: Stains, mould, loss of insulation due to wetting.
- Annual average Alberta precipitation ranges from 310 mm to 600 mm or 12" to 24".
- Annual average Alberta heating degree days range from 4500 to 7000. (Calgary is 5200)
- Average DRWP (driving rain wind pressure) ranges from 60 Pa to 220Pa Calgary is 220)
- Heat loss in an old building compared to a new building can be 50% higher
- Standard winter comfort temperatures range from 20 – 24 degrees at 30 – 60% Rh
- Standard summer comfort temperatures range from 23 – 26 degree at 25 – 60% Rh
- Face seal is ok. In regions where precipitation is less than 20" per year
- Drain screen is ok in regions where precipitation is below 40" per year
- Rain screen is recommended where precipitation is above 40" per year
- Pressure equalized Rainscreen is recommended on all high buildings (more than 33 feet)
- Examples of water vapour released into the air: A clothes dryer will release 2 to 3 litres of vaporised water into the air, drying out a cord of firewood in the house will release 200 to 300 litres of water, furniture in an average house will absorb 3 to 8 litres of water.
- An air leak in a wall permits at least 1000 times more vapour to pass through it by vapour drive than if water vapour passes through a material passively (example: drywall) through diffusion.
- Per year about 200,000 litres of water will fall on a 50 x 100ft. This converts to about 20 dump trucks full of water.

This is how the different trades can contribute to moisture control:

For The Designer or Architect:

- Allow for larger roof overhangs, and or cornice treatment with built in drips or kerfs to keep rain water off of exterior walls.
- Choose a style of building that fits the site and allows for drainage.
- Allow for adequate room for plumbing and heating pipes and ducts.
- Spec Rainscreen exteriors
- Design with high heeled trusses (allows for more insulation)
- Design roofs that are not too cut up and can easily shed rain water
- Consider lot and roof drainage, sumps, weeping tile and ensure window wells drain into them.
- Recommended slopes for paved or concrete driveways is 0.5%. For a concrete swale 0.75 is recommended. For grass swales 1.5 to 2% slope is recommended.

For The Excavator:

- Excavate to undisturbed soil.
- Do not over excavate.
- If over excavating has occurred fill with unfrozen suitable fill and tamp this area.
- Fill with free draining backfill around foundation walls.
- Provide an impermeable layer (clay cap) above this backfill before loam is put into place. Compact all backfill.
- Assure all grading is positive (slope away from house). The recommended slope is 5%

For The Cribber:

- Assure that walls are plumb and square.
- Provide keys in footings.
- Provide capillary break on top of footings.
- Provide capillary break on top of concrete foundation wall before installing main floor members.

- Provide control joint at steps in footings, at corners, at window openings. (These joint could be saw cuts or goose neck joints.)
- Apply sealant to these vertical joints.
- Provide bond breaks for garage foundation where they intersect with the house foundation walls.
- Provide weeping tile tunnels in footings.

For The Weeping Tile Installer / Damp-Proofer

- Damp proof foundation walls up to the designated grade level.
- Assure that all form tie locations and control joint are sealed first.
- Place filter fabric next to footing.
- Assure it is wide enough to fully encase the weeping tile / drainage gravel assembly. Place 2" of clean crushed gravel next to the footings and place weeping tile on top of this gravel bed.
- Then place gravel around weeping tile. (Minimum coverage 6" on top and sides)
- Assure weeping tiles are perforated.
- If perforations are only on one side assure the perforations are at the bottom.
- Fold filter fabric over gravel and assure it remains in place during backfilling.
- Connect weeping tile inside the basement into the respective connections.
- Fill snap-tie holes with grout before damp-proofing (avoid tar for this job, it may pull out when soil settles)
- Consider using an air gap exterior membrane on exterior basement walls
- Top of weeping tiles must be below the bottom of concrete floor.
- Basements on lots with high water tables require water proofing not just damp-proofing.

For The Framer

- Use clips for gypsum supports on outside corners, where interior wall intersect with the exterior wall and ceiling corners (this method allows for more insulations)
- Frame walls at 24" on center
- Use single top plates where possible (use connector plates at intersections) Note: if 92 5/8" studs are used all drywall sheet will need cutting.
- Use single headers over doors and windows when possible. (More room for insulation)

- Use header hangers instead of jack studs (cripples)
- Save headers over window on non bearing walls
- Install capillary breaks wherever applicable
- Metal cross bracing could be used instead of OSB or ply sheathing. This allows for an isolative sheathing. (If using OSB use shiny side towards inside it is more water resistant)
- Install vapour barrier strips to ensure continuity of vapour barrier.
- Install attic insulation baffles / srops.

Note: These framing changes would allow for more insulation and less lumber.

For The Window / Door Installer

(This is a job that in most cases is executed by the framer.)

- Install a 12" strip of building paper on the face directly below the sill. Do not staple the bottom 4". This allows the siding installer to slide the building paper under this paper.
- Install 6" x 6" self sticking patches in vulnerable corners.
- Install sill flashing. This flashing can consist of adhesive membranes, impregnated felts or coated papers. Do not use bitumen based membranes. Use building paper as sill flashing with plastic house wraps.
- Make perfect fold of building paper to assure that it conforms perfectly to the corners. If building paper is rounded in the corners it will tear during the window positioning process. The corners are the most vulnerable area on a window.
- Install building paper up both sides of the opening. Ensure that building paper covers the wood on the inside of the opening and 12" of the perimeter of the window opening.
- Apply sealer to the backside of the window flange, top and side flanges only. Do not seal bottom of window, moisture could get trapped.
- Install window. Keep nails and screws 3" away from corners of the window. Install window true and plumb
- Install 12" strip of building paper at the top of the window opening. The bottom backside of this strip is set in sealant.
- Use low expandable foam insulation around windows to prevent jambs from warping.

For The Electrician

- Install air barriers behind all electrical outlets that are located in exterior walls.
- Seal all wire leads into electrical boxes
- Seal all wall penetrations around wires or conduit.

- Pay special attentions where interior penetrations could cause air to enter exterior walls.
- Assure all ceiling pot lights are enclosed with airtight cans (should feature airtight label) or other suitable airtight surrounds and insulation.

For The Furnace Installer / Gas Fireplace Installer

- Tape all hot air ducts with mastic.
- Duct all returns instead of using wall cavities as returns.
- Caulk all exterior wall penetrations to the drain-plain not just the siding.
- Seal flue fire stops with high temperature sealants.
- Use foil tape and not duct tape on ducts.

For The Plumber

- Keep exterior wall and ceiling penetrations to a minimum
- Seal all exterior wall and ceiling penetrations.
- Do not install plumbing pipes in exterior walls.

For The Insulator / Vapour Barrier Installer

- Check for any exterior wall penetrations that may require sealing.
- Insulate with friction fit insulation and fill all wall cavities.
- Insulate around all window and door openings. Assure this insulation fills the cavities but do not force it into these cavities causing windows and doors to malfunction.
- Seal small openings with expanding poly styrene foam insulation.
- Assure that insulation is placed in front and behind electrical wires.
- Install a continuous vapour barrier.
- Seal vapour barrier to framing members to ensure a total continuous membrane.
- Seal all lap joints of the polyethylene.
- Caulk around all joints where floor joist connect to the rim joist.
- Provide insulation pillows between each joist against the rim joist. (Suitable plastic bags filled with insulation). Eliminate spaces around these pillows.
- Don't forget to insulate and weather-strip the attic hatch.
- Airtight insulation is 30% more effective.

For The Dry Wall Installer

- Use short screws for drywall installation, they are less likely to pop.
- Use short ring nails (drywall nails)
- Keep ceiling nails 18" away from walls to allow the outer edges of the ceiling drywall to float.

- If there was no continuous vapour barrier provided the Dry Waller, must conclude that the drywall becomes the vapour diffusion retarder. In this case the drywall sheets have to be sealed to the framing to assure that complete continuity in the drywall enclosure exists.

For The Concrete Finisher

- Assure positive drainage on all concrete flatwork.
- Tie sidewalks and steps into adjoining walls with rebar to prevent sagging. (If sidewalks sag towards the building, vast amount of water can be funnelled towards the foundation.)
- Assure all capillary breaks are in place. (Example: crushed gravel and a vapour barrier under the basement floor.)

For The Roofer

- Follow manufacturer's installation instruction for the various roof systems.

Make sure to use proper low slope roofing techniques for roofs between 2 in 12 and 4 in 12. Generally this means at least 3 feet into the heated area from the eave overhang with a good peel and stick membrane, and a minimum of double roofing felt under the rest of the roof before covering with asphalt shingles. Under wood, metal, or tile the entire roof should be at least a good peel and stick membrane underneath. Proper nailing patterns are critical with laminated shingles, making sure to hit both pieces of the shingle to avoid having pieces fall out down the road. Tabbing shingles is a very good practice in windy areas. Make sure to have your air pressure properly adjusted when using a roofing nailer as too much pressure will cause the nail to go through most of the shingle on hot days, and snap pieces out of the shingle in freezing weather. Too little pressure will cause the row above to not seal properly and the roof will be at greater risk of wind damage or blowing off completely. A common leak area is on the top of metal chimney chases and around the B-Vent chimney rain collar if they are not properly caulked. Another common leak area is in closed asphalt shingle valleys when the top corners of the shingles on the overlapping side of the valley channel water along the top of the shingle if the point is not cut off. Make sure there are enough roof vents installed to properly vent the attic.

The Siding / Cladding Installer

- Follow manufacturer's installation instruction for the various exteriors
- Ensure all flashings are installed
- Window flashing should overhand ¾"

For The Home Owner

The home owner has a significant responsibility in keeping the building envelope free from trapped moisture.

- Assure that a maintenance program is in place and that it gets followed
- Keep humidity levels below 40% in the home and far less in the winter
- Allow air movement to windows and cold corners

FAILURES

I was called once to assess a roof leaking problem in Calgary. It was early spring. It was an insurance claim. I guessed the small bungalow was about 50 years old. I could see right away that the shingles were new. When inside the house I greeted the husband, the baby, the toddler and the wife who had a large pot boiling on the stove.

I noticed immediately that the entire ceiling was water damaged. There were large wet spots, a lot of mould discolouration and the drywall was badly sagging almost between every truss. In one corner small bits of drywall had already fallen down. It sure did not look like the average roof leak to me. How could it have leaked so much over the entire ceiling?

I got my stepladder and climbed into the attic where I found the insulation to contain large ice chunks. Some of these chunks were 4" thick by 20" wide and several feet long. What on earth had happened here? I looked up to check under the roof deck and I could not see any holes and neither any water stains. It sure did not look like a roof leak to me. Was all this ice caused by condensation? I cleared some of the insulation that was not iced up as badly and there was the problem: "Absolutely no vapour barrier over the drywall." But how could this much condensation end up in the insulation?

I climbed down again and told the owner that I didn't think that this was a roof leak. He was not very happy with what I was telling him, he was worried his insurance would not cover this "disaster". My question still was how could this much water end up in the ceiling? I asked to see the basement and I was lead down a small stairway (I had to duck so that I would not hit my head on something). There was a basement that was partly dug out and there was a dryer that was never vented to the outside. It all started to make sense now. There was the perfect condition for a lot of moisture in the air. Due to the fact that the ceiling was cold and had no vapour barrier (vapour diffusion retarder) all the air born moisture ended up in the attic, where it condensed and then froze. On a sunny day when the Chinook winds blew, the ice in the insulation would melt a little and it would rain in this house. At night it would freeze again.

The weight of the ice in the ceiling caused a dangerous situation for the family. The insurance claim was accepted after all and my crew replaced the entire ceiling drywall and insulation and of course installed a proper vapour barrier.

Other useful or interesting information

I would like to suggest an excellent book on moisture control. The title is Builder's Guide by Joseph Lstiburek.

A fan door test is used to determine how airtight a home is. One of the outside doors is exchanged with a door that has a built-in fan that sucks the air out of the house. At the same time the volume of air that exits is metered. If this test reveals that the total air exchanges 2 to 3 times per hour the house is considered to meet today's airtight standards. On older home the air would likely exchange 4 to 5 times per hour and this is unacceptable for today's standards.

30 lb roofing felt is considered to be non absorptive. Also Polypropylene, Polyethylene, Modified Bitumins (Peel and Stick Membranes)

"EAR" is the abbreviation for Entry, Accumulation and Removal of water.

There is a difference between Air-borne water and Air vapour. Air-born water can be seen (fog) Air vapour is not visible.

In construction we refer to materials that can be soaked and dried without damage as "durable materials".

If a home is built on the edge of a cliff or embankment it will experience the full brunt of the weather and extra precautions must be made to ensure that it can withstand the wind-driven rain conditions. A Rainscreen or pressure equalised Rainscreen exterior is recommended for these homes.

Clothes closets in homes should not be located on the outside walls of homes unless they are vented. The stagnant air can cause condensation problems here.

If excessive water runs down Tyvek paper is has been observed to pool behind the tape.

Kinetic energy is energy from momentum.

A <u>large</u> pore size prevents capillary action. Examples are sand and gravel. In gravel the pore size is large and therefore gravel offers a capillary break, sand or clay on the other hand promotes capillary action.

Here are examples of permeable and non-permeable materials: Non-permeable materials include Polyethylene, some ridged insulations and glass. Wood, concrete, paper and drywall are permeable materials.

In neighbourhoods where no storm sewers are installed and groundwater could present a problem, water can be collected in sumps and pumped out from there. An automatic sensor will activate the pump when water raises in the sump. Do not pump them into the sanitary sewer as this is illegal and a huge burden on the sewage treatment facilities.

The action of Deflection, Drainage, Drying and Durability in moisture control is referred to as the "4Ds".

There are moisture / mould detection strips available that can be installed in walls and the situation can be monitored and thus provide early detection of upcoming problems.

A CAHPI (Canadian Association of Home and Property Inspections) certified home inspectors will use a non-intrusive moisture Meter to detect hidden moisture in walls. If you suspect you may have a moisture issue this is a good place to start.

Blowing snow and rain getting into the vented soffits can cause much damage if the building paper detail has not been properly extended above the J-Trim line.

If you can break off a piece of your stucco and easily crumble it between your fingers you have an improper stucco mix that will likely cause you much moisture grief.

Propane heaters are not suitable for drying out buildings as they pump approximately 5 litres of water into the air per 100,000 BTUs per hour. If this is multiplied by 24 hours it becomes 120 litres per day.

Face seal, the cheapest exterior turns out to be the most expensive if you factor in the required maintenance over the years; especially if you factor in the destruction caused by not maintaining these “cheap” systems.

A building paper and flashing inspection would prevent a lot of future problems.

Air tight insulation offers 30% better insulation

Snap-ties leak if not properly grouted. Tar patches can be sucked out of place by sagging backfill

Wood has an insulation factor of R1 per inch thickness, for that reason it is better to minimize the studs, window headers or other framing members and maximize the insulation.

Friction-fit insulation has an R factor of approximately R 3.5 per inch.

Dense ridged insulation has an R factor of approximately R 5 per inch

Stucco sheds 92% of the water, it absorbs 7% which then subsequently dries again. 1% water ends up in the wall.

It takes 48 hour to grow mould.

A warm home interior can carry 2 or 3 time the moisture than the outside air when it is cold. It is for this reason that warm air in exterior wall cavities causes them to dry out, provided the warm air is not already at 100% humidity.

Preserved wood shall be used if wood is used at areas that are less than 150mm from the ground.

Water increases 10% in volume when it freezes

20% of schools have IAQ (indoor air quality) problems

A 1.5 time air change per hour in residential housing is considered as good. The average is more like 4 to 5 times.

A 75% increase in respiratory problems over the last 20 years have been reported

There are 1500 lawsuits in BC regarding leaky condos. Settlements average 1 million each. 10,000 moisture related lawsuits were settled at a total sum of 2.5 billion dollars in BC in 2002. Water ingress from the outside into the walls is the real problem.

Insurance companies no longer cover mould damage. The problem becomes the builders problem. No firm link has been established between these problems and mould. No personal injury lawsuits (mould) have been won in the BC leaky condo mishap

GLOSSARY

Air barrier: Is normally referred to as building paper. These papers allow water vapours to pass through and therefore breathe. Other materials can become air barriers as well. Continuous sheathing or continuous drywall can act as an air barrier. Building papers are not vapour barriers.

Air retarder: Same as air barrier but its description is more accurate. Air on a molecular level will penetrate tarpaper and Tyvek paper.

Back-priming: Primer painting of the backside of wood siding to prevent moisture entering behind the siding and causing blistering of paint or rotting.

Building envelope: The building envelope consists of the basement floor, basements walls, walls above grade (framed walls) and the roof.

Capillary action (suction): This means that water will rise in small tubes due to cohesion of the water molecules. These small tubes are present in many materials such as concrete, sand, wood and other porous materials. Paper towels when dipped in water demonstrate this well, it shows how water will travel upwards as well as in all directions due to capillary action.

Capillary breaks: A capillary break will be created by closing off the pores with a material that has no porosity. Tar and polyethylene are such materials. On the other hand gravel offers a capillary break under a concrete slab. In this case it is due to the fact that the spaces (pores) between the gravel peaces are to big to cause capillary action.

Caulking: Usually is supplied in tubes. It is basically divided into four groups: Latex, Silicone, Butyl and Urethane. Caulks are measured by their elasticity and adhesion. The better it sticks to the material and the more it stretches the better the caulking. Latex caulking is not recommended for outside work. It offers limited stretch ability and limited resistance to ultra violet radiation. This will soon take away its elasticity completely.

Silicones are usually an interior caulking. Some higher quality exterior caulks are available. Regular quality silicone caulking requires periodic replacement. Urethane caulking has proven to be most resistant to U.V. It also has excellent adhesion quality and elasticity. Caulks are rated for their elasticity. As an example: If a caulking is rated at 25% elasticity the caulking joint must be at least 4 times bigger then what it is expected to stretch. Caulking does most of its stretching in the wintertime, when building materials shrink on the outside of buildings.

Celsius: A system for measuring temperatures. Sometimes this system is also referred to by the name Centigrade. It is based on water. At 0 degrees water freezes and at 100 degree water boils. This system is used throughout the world. The USA is an exception. The Celsius system is also tied in with the metric system mostly for purposes of fine tuning and achieving accuracy. Example: One cube of water measuring 100 mm x 100 mm x 100mm at 0 degrees (before freezing) = exactly 1kg or exactly 1liter.

Cladding: The exterior of an exterior wall. (Some examples of cladding materials are Vinyl, Aluminium, Wood or Fibre Cement Siding, Stucco, Brick, Cultured Stone or Stonetile)

Concrete and mortars: Concrete and mortars are made with sand, cement, water, (and gravel for concrete). Gravel is simply stone that is crushed. Sand is simply really small stone and sand dust is pulverised stone. Stone is much stronger than cured cement (the paste that holds it all together). To make good concrete the secret is: to have the perfect quantity of cement, the minimum amount of water in it and allow it to cure (above freezing temperatures without it drying out) for a maximum of time. Water and cement causes the cement to crystallize. These microscopic crystals adhere to the gravel, sand and sand dust fusing the whole mass together. (See gradation of sand. The smaller particles lodge around the bigger particles filling all the voids thus requiring the least amount of cement paste to fill the smallest voids. This will result in a mass that is relatively dense. Efflorescence is minimised in dense concrete.) Mortar usually has lime added to it to make it more workable.

Condensation: Happens when water attaches itself to a colder surface

Cooing degree days: total annual temperatures added up that are above +23 degrees; or the time that a house would require cooling (air conditioning)

Dew point: The dew point is when the air at a given temperature reaches 100% humidity. At this point it condenses and starts to form steam and then droplets. A dew point can also be at a colder surface. If the surface is at temperature that would cause the air to reach the 100% humidity level water will then condensate only on that surface.

Dry wood: Lumber where the moisture content is below 19%

Efflorescence: A white calcium stain deposit on concrete, mortar or stucco. The calcium exits the concrete through capillary action and crystallizes on the surface. Efflorescence will appear on bricks but it originates from the mortar and not the bricks themselves. Removal is accomplished by wire-brushing or washing with a water dilution of hydrochloric acid. (As a note of interest, the human stomach produces the same acid in order to digest food). The optimum condition for efflorescence is when it is cool and damp. Water migrates very slow through capillary action and carries with it a maximum of liquid calcium. On warm dry days the concrete dries too fast and the calcium has little chance to be deposited on the surface.

Fungus: There are thousands of different fungi. There are wood fungi that will discolour wood and there are fungi that will rot wood. There are fungi that will give off toxic odours. There is currently media hype on these fungi. Proper moisture management can control the growth of fungus.

Galvanized metal: Sheet metal or screws and nails coated with zinc to prevent it from rusting. Galvanized coatings come in varying thicknesses. They are rated. G 90 (or AZ 225) is what has become the standard thickness for exterior galvanized flashing and truss plates. Stonetile hangers have a G 120 coating. Satin coatings of G 30 are not weather resistant and are not recommended outside and G 60 coatings are only permitted for indoor metal such as heating ducts.

Gradation of sand: Correct sand gradation becomes important in the manufacture of concrete and mortar. I you used normal river sand or beach sand in these materials you would end up with an unsuitable material. Concrete and mortar sands that are available from your local suppliers have been formulated. For example, you may have a sand that has 30% - 5mm sand, 20% - 2mm, 10% - 1mm, 20% - .03mm, 14% - .01mm and 6% of .005mm. Sands are formulated differently for different applications. Only a very low percentage of organic materials are tolerated in concrete or mortar sands.

Ground water: Ground water is surface water that has seeped into the ground and is basically any water present in the ground. This water will move up to the surface through capillary action.

Tuck tape: The plastic tape that is suitable for taping Tyvek paper and sealing poly vapour barrier joints and holes.

Heating degree days: Total annual temperatures added up that are below +18 degrees; or the time that a house would require heating.

Humidifying: To increase the water content of the air.

Impermeable Material: Allow no water vapor to pass through.

Insulation: There are number of insulations on the market. They include: Friction fit fibreglass insulation (predominantly used in walls), cellulose insulation (predominantly used in ceilings, this product is usually made from old news papers that have been treated with a fire retardant chemical and is then blown into attics of homes), Ridged insulation (used on exteriors of homes, roofs, walls and home foundations). There are a number of other insulation materials. Urethane sprayed foam insulation, Urea formaldehyde foam insulation (UFFI)

Insulation Pillows: Insulation wrapped in plastic. These pillows are stuffed between each joist space around the basement perimeter. Plain garbage bags stuffed with fibreglass insulation are suitable for creating these pillows.

Kiln dried Lumber: Lumber that has been dried and its moisture content is below 19%

Kinetic Energy: Pushing force, pressure

Permeable material: Allow water moisture to penetrate through them.

Polyethylene: Is a very flexible plastic often used for vapour barriers. This material can not usually be glued together.

Polystyrene: Is a more brittle plastic in its solid sheet form. It often is manufactured into ridged foam insulation

Relative Humidity: Indicates how much water is in the air compared to its 100% saturation capability at any given temperature.

Ridged insulation: Foam insulation that are supplied in sheets.

Rim joist: Is the joist that is located around the perimeter of the floor joists.

Saturation point of wood: Happens when wood has absorbed as much water as it can.

Sealer: Sealers come in different types. We are mostly referring to sealers, that are in caulking tubes and designed to close air holes in the wall or sealers that are in liquid form that allow us to seal concrete walls or floors. (Stop capillary action)

Semi-permeable material: Allow very small amount of water vapor to pass through.

Snap-ties: These are metal brackets securing the sheets of forming plywood. They are usually about 8" apart and run through the finished concrete wall as concrete is poured around them. The outer tips of the snap-ties are broken off to remove the forms from the freshly poured concrete. Since these metal ties penetrate the wall, special care should be taken to ensure that no leaks develop around these areas. It is recommended to grout the dimpled area around the snap-ties with grout first before damp-proofing. If these dimples are tarred only the tar has a tendency to sag away. This sagging will be promoted by any backfill settlement.

Stack effect: This expression refers to the heat rising and cold air sinking. This will create positive pressure in the upper portion of the building. At the bottom of the building the pressure will actually be negative and at a certain plain in the building the pressure will be neutral.

Stucco mud: See: Concrete and mortars. Stucco mud is basically mortar. The applicator often uses additives to make it more workable. For the first and second coat grey cement is used with concrete sand. For the top coat white cement, white dolomite sand and colour is often used.

Surfactants: A soap-like chemical usually contained in water. It robs building paper from its water repelling qualities.

Vaporise: Water molecules in the air, these can only be seen when they start to condense.

Vapour barrier: A material that restricts or stops water vapour from penetrating. It is usually installed in walls and ceilings. On the warm side Polyethylene is normally used for this purpose.

Vapour diffusion retarder: This is the same as a vapour barrier but its description is more accurate. Water in its vapour form is difficult to “bar” from any material. Minute traces will even go through polyethylene.

Vapour pressure: Air is held by gravity to the earth. It is made up of several gases and water vapour is one of them. Vapour pressure is the part of air pressure that is exerted by the water vapour contained in air.

Wall cavity: The space between the drywall on the inside and the sheathing on the outside of a wall. The studs and the insulation are located in the wall cavity.

Water table: The level when digging or drilling a hole when water appears.

Water vapour: Is water where the molecules are separated from one another and therefore light enough to be suspended in air. (Gaseous)

Wind washing: This is a term used when the wind blows into the insulation and thereby reduces its effectiveness. This is a different problem than insulation that has blown out of place by the wind.