FOUNDATION WALL FAILURES

Over the past several years, I have witnessed dozens of residential house foundation collapses in both new and older homes, which I believe could have been avoided. A typical foundation under a residential dwelling is approximately 24 feet wide and 50 feet long built of concrete masonry block. Block thickness varies between 8, 10 and 12 inch sizes depending on the length, height and loading conditions. The typical height of basements is 7 to 9 feet (10 to 13 course).

Loading Conditions

Foundation failures which push the foundation walls into the basement are typically due to three loading conditions; soil pressure, hydrostatic (water) pressure and surcharges due to high loads directly behind the wall such as an automobile or backhoe. Under normal, dry soil conditions, a hollow masonry wall 9 feet high and 40 feet long, whether load-bearing or non-load-bearing, can provide years of useful service. However, the problem arises when wet climatic conditions combined with susceptible soils (clays, shale clays, silty clays) rest directly behind the unreinforced masonry wall. While masonry walls have excellent vertical carrying capacity, they are extremely weak in lateral load resistance. Residential house construction does not typically load walls enough to offset the horizontal (lateral) loads of saturated soils. Wall collapses frequently occur just after laying the walls and during backfilling due to the surcharge of the equipment, and while the walls were unloaded, this problem would occur on the same wall under saturated soil conditions regardless of the house loads.

Warning Signs

Often a distressed wall will reveal the potential for complete collapse prior to the event. Look for horizontal cracks in the mortar joints the width of a human hair in the upper half of a wall which spans over 20 feet. Sometimes diagonal cracks emanating from the end walls, following the mortar joints, are associated with the distressed wall. Seldom do vertical cracks have anything to do with lateral earth pressure problems and can sometimes be linked to soil settlement, shrinkage and volume changes (see attached sketch).

Prevention

The CABO Building Code, which focuses totally on residential construction, stipulates that walls resisting more than five (5) feet of earth have reinforcing provided. Three types of wall reinforcing are acceptable. The most difficult but best is grouting the hollow vertical cores of the blocks solid with concrete grout and installing vertical reinforcement in the cores which are connected to the footing (see attached sketch). Mason contractors seldom select this option due to the fact that the bars are difficult to work around. I have experienced many collapsed foundation walls which were grouted, but the vertical reinforcement was not attached to the footing, and the wall did not have horizontal bed joint reinforcement. Horizontal or bed joint reinforcement is installed in the mortar joints and looks similar to a ladder except it is made of wire the thickness of a coat hanger. Bed joint reinforcement installed without grouting the cores is useless, and often I see this concept misused. An acceptable means of bracing is achieved if the wall is grouted solid without vertical reinforcement, and the horizontal reinforcement is installed in every horizontal joint (8 inches on center). While horizontal reinforcing is desired over vertical it too often omitted due to the cumbersome task of installing.

Finally, pilasters protruding from the wall are often the most popular bracing selection. A common mistake is to build these next to the wall without them being tied integrally to the wall. For pilasters to be effective, they must be built into the wall at the same time the wall is laid. A minimum projection of eight (8) inches is necessary and a spacing of 18t (as mentioned previously) is required.

Due to the obstruction of living space, contractors often leave these braces off severely reducing the structural integrity of a wall.

It should be noted that the potential for collapse often does not occur for years due to the fact that all the right conditions, such as an extended rain storm deep snow melt, clogged trench drain, or a concrete truck pouring a new patio on the back of a house don't occur annually.

Inspection

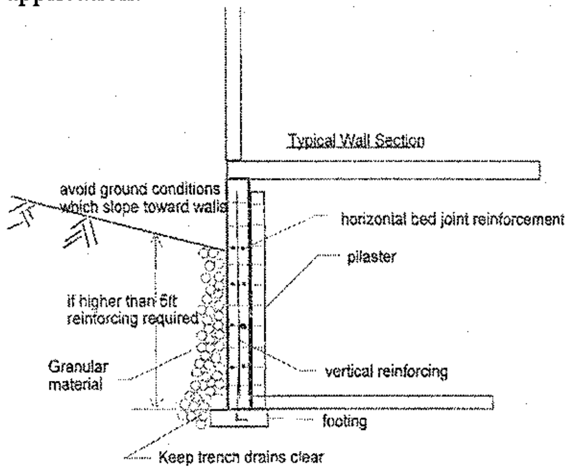
To see if your house has these problems, look in your yard to see if any of the ground surfaces slope towards your house foundation instead of away from the walls. A quick glance in the basement will verify if pilasters are present. If pilasters are not observed, tapping the wall with a hammer for varying sounds will determine if the contractor filled the voids with concrete on an even spacing. If you have walls unbraced for over 15 feet and over 8 feet high with a sloping yard, you have a potential problem.

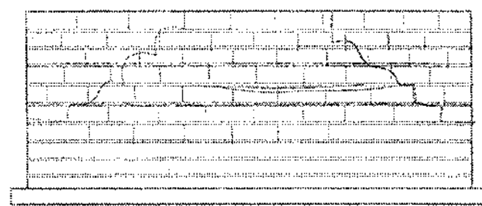
Repair

Walls which show signs of distress can be braced to stop the movement by installing pilasters to the existing walls. The pilasters can be either added to the interior face or the exterior face, depending on accessibility.

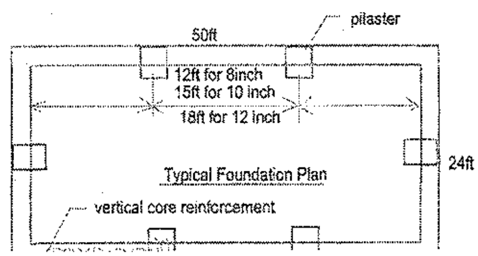
Conclusion

Many masonry contractors believe that the bracing is not necessary because they have built hundreds of walls without them, but they do not consider the effects of saturated soils and ground water, plus they are not qualified to determine which soils and sites are more susceptible. And they cannot predict the future use or weather conditions. The new building codes are not allowing builders to determine when the bracing is not required unless the soil behind the wall is less than five (5) feet high. Considering effects of wind, it would be a prudent building practice to include bracing or reinforcing in all masonry construction regardless of application.





Typical Crack Planes



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CONCRETE SLABS

The most common problems I see with concrete slabs are shrinkage cracks, scaling of the top surface and frost heave cracks.

Concrete, after it is placed and starts to cure, will shrink naturally. This is a well-known phenomenon, and while it cannot be stopped, it can be controlled. As the concrete hardens, centers of mass occur in the drying slab, which start to draw outlying concrete toward this point. These mass centers are typically in the area that starts to dry out first or was the first place poured during the pour. If the distance from the outer reaches of this center of mass exceed 20 feet, other mass centers will form, and the material will separate and cracks will result. These cracks occur overnight in large slabs, and the joints are small micro cracks at first and manifest themselves into larger cracks as the slab dries out.

It takes approximately 54 days for 95% of the slab to dry. Instead of having random irregular jagged cracks occur in the concrete, industry installation practices require control joints to be installed in the concrete before it hardens. These joints can either be tooled or saw cut while the concrete is still wet.

Many times I have gone out to a site to inspect a terribly cracked slab to discover saw joints. What I later find out is that the tired crew left at the end of a long day and returned the next morning to start the cutting. By this time it is too late, and the micro cracks have already started.

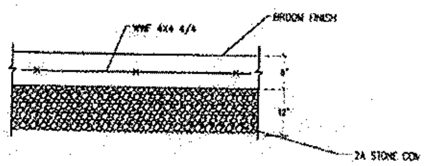
It should be noted that cracks that are .008 of an inch wide (the width of a line on a piece of paper) or less are considered water tight. Shrinkage cracks typically pose no threat to the structural integrity of the slab, and they are classified as cosmetic scars. However, cracks distract and alarm people when reselling, and buyers typically do not receive discounts when the slab is riddled with cracks. As a rule of thumb, I use a 30% discount on the price of a concrete pour if the shrinkage cracks are noticeable and not controlled. While the homeowner is using the slab, this is not industry standard. In other words, it would be like buying a new car and just before you drive it off the lot someone takes a key to the paint job. The car will last for 100,000 miles, and you will be able to use the car, but that is not what you paid for.

A lot of times cracks could have been prevented if the curing of the slab was slowed by applying water continuously or by using compounds to the top surface. If too much water is added to the mix prior to placement or if the top surface dries too sudden in glaring heat of the summer, it will also have severe shrinkage. Reinforcement in floor slabs is predominantly used to control the size of the cracks and has little effect on the carrying capacity.

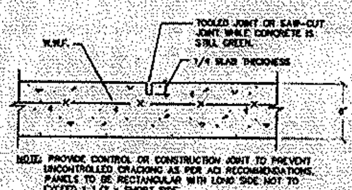
A concrete slab-on-grade is only as good as the stone sub-base underneath the slab. Without a compacted well draining sub-base, voids will develop which will ultimately cause pavement cracking or frost heave cracking. Frost heave cracking is due to uplift of the slab. Crack patterns often form star shapes.

With regards to the top surface scaling or flaking, this phenomenon is sometimes due to foreign material, i.e., dirt or shale in the mix that retains water and freezes and pops in the winter months. Another problem which causes scaling is the lack of adequate curing of the slab prior to cold weather. A slab needs at least 60 days of warm (above 40 degrees) weather to cure properly before attacked by salts or deicing chemicals. If a slab is poured in cold weather and immediately subjected to chemicals, the top surface will flake off. Another common cause of surface deterioration is over-finishing the top surface. As concrete cures, moisture in the concrete rises to the top of the slab. If this moisture is not allowed to evaporate but is troweled into the concrete, flaking could occur.

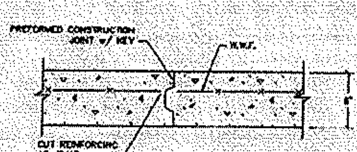
Quite often I see where problem concrete was immediately subjected to core boring. I find core boring to be an overkill for 90% of the problems. Core borings are typically drilled to determine the strength of the concrete, and once the sample is in a lab a thin slice can be observed under a microscope called petrographic analysis which can measure air entainment, aggregate and cement types plus bonding. The most important feature of concrete is the ratio of water in the mix to the amount of cement. The higher the ration, the lower the durability. As a rule of thumb, a W/C ratio of .4 is what you want to see from the ready-mix plant. Whether the concrete is 3,500 or 4,000 psi is not as relevant for durability and longevity.



CONCRETE PAVEMENT DETAIL
SCALE: NONE



4 S1 SAW JOINT DETAIL
SCALE: N.T.S.



5 S1 CONCRETE CONSTRUCTION JOINT DTL.
SCALE: N.T.S. FOR SLAB ON GRADE

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FROST DAMAGE

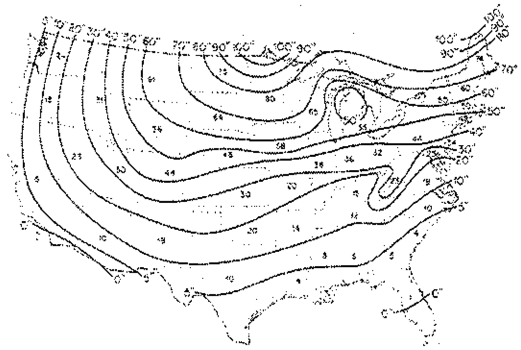

Fig. 5 Extreme frost penetration, inches, based upon state averages. (National Weather Service, NOAA, U.S. Dept. of Commerce.)

Foundations of structures must be placed below-grade in the Northeast to prevent frost heave. The soil acts as an insulator, and the depth of the footing is a function of the weather conditions. Typically every consecutive day of below-freezing temperatures will drive the frost one inch deeper into the strata. A day above freezing will also thaw the ground. In Pennsylvania, it is not uncommon to have 30 consecutive days of below-freezing temperatures for 24 hours. Therefore, research stipulates that footings should be between 50 inches in the northern tier of Pennsylvania and most of New York and drop to 36 inches along the border of Pennsylvania and Maryland. Footings in northern Minnesota can reach 8 feet deep.

Shallow footings subjected to frost have side effects which are a function of the moisture content of the soil. Simply stated, the more moisture in the soil the more uplift and disturbance to the soil once it is frozen. Soils have an interconnected crystalline structure, which once it is frozen it is irrevocably damaged, and the structural integrity of the material is weakened. Frozen water creates an uplift pressure of 400 psi which is a tremendous force, and the downward load of a typical footing is less than 5 psi, and therefore the footing is lifted. Unfortunately, once a thaw occurs the material never settles in the exact same place, and a structure will not uplift exactly the same amount due to the variation of moisture in the specific material underneath the entire structure.

Signs of frost heave in a masonry foundation wall or concrete footing are vertical cracks which do not run diagonally through the mortar joints. If only a corner of a footing under a building has a shallow footing and is uplifted, the cracks may follow the mortar joints in a diagonal pattern. One must keep in mind that frost heave can occur in the basement of a residential structure even though the foundation is 8 feet below-grade, but if the basement is unheated or accidentally went unheated, the footings under the floor slab are most likely only 12 inches into insulated material which is not enough. Remember, the extent of damage is a function of soil characteristics to hold moisture and the severity of the temperature and duration.

Typical sidewalk and concrete driveway construction stipulates a 6-inch base of stone under the concrete. This stone has two purposes; first it supports the wearing surface of the pavement, and second, the stone ensures no entrapment of moisture that will cause uplift. The stone typically replaces topsoil which is very hydric and is most susceptible to expansion. Various types of clays and shale have different expansion characteristics and may require even further excavation and replacement.

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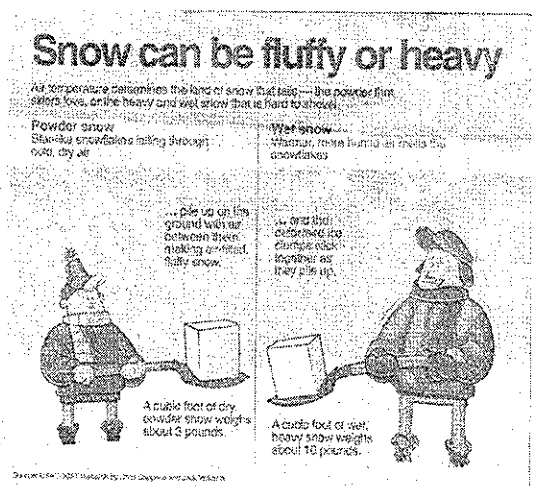
WEIGHT OF ICE AND SNOW ON ROOFS

What is the weight of snow? The weight is a function of the moisture content in the flakes. As a rule of thumb a cubic foot of dry powder snow weighs about three (3) pounds (see attached). However, it can reach as much as ten (10) pounds.

In this region of Pennsylvania, roofs must be able to safely carry 70% of the snow load on the ground (30% is thought to blow off from wind or roof pitch). Research has shown that Central Pennsylvania receives 30 psf of ground snow load, whereas the lake region of Erie receives 40 psf. Therefore, 70% or 21 psf snow load must be carried by the framing system.

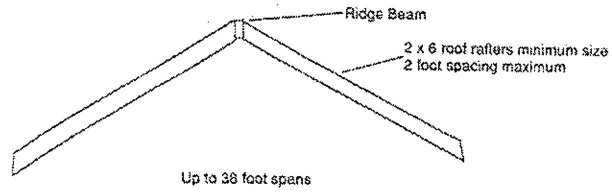
Ice on the other hand weighs 56 psf, and roofs in this region can safely carry only 4.5 inches of ice.

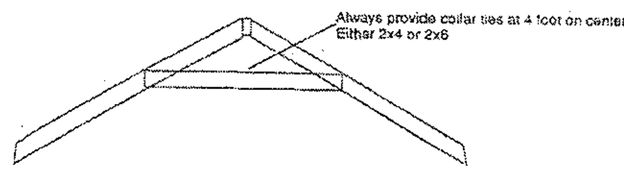
Standard timber trusses with 1/2 or 5/8 sheathing spaced at 2'-0" cc will typically handle two (2) feet of wet snow or 4 ½ inches of ice. If abnormalities exist in a roof it is most likely due to air circulation and not structural load from snow.



The most common flaw in roof framing is lack of collar ties in framed rafter systems. Collar ties connect opposing joists to each other and prevent sag in the ridge of the roof. They also prevent severe horizontal thrust loads at the exterior walls.

Permanent creep or sag in roofs result when the system does not have collar ties and is subjected to its own self-weight, not to mention snow loads.





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WIND DAMAGE

Each year in the northeast, wind gusts and storms cause severe damages to buildings. Structurally speaking, the most common forms of damage experienced are porch roofs, awnings, shingles and an occasional sign or window.

The level of damage experienced is always a function of the speed of the wind and its associated pressure. The IBC Building Code stipulated that dwellings constructed in this region be capable of resisting a mean wind speed of 70 mph and occur every two to four years in Pennsylvania. F-1 storms are wind speeds of 112 mph and cause severe roof damage and window damage. F-2 storms reach 120 mph and overturn cars and uproot trees.

Wind pressures exceeding this value typically break panes of glass. Of course, when wind gusts strike a structure, you have windward forces and leeward forces. The windward forces are associated with the surface of the structure, which first comes in contact with the wind. The leeward surface is actually a suction force on the opposite side created by a low pressure pocket when the wind wraps around the building (see attached sketch). It is quite easy to determine wind direction by examining a severely damaged structure by inspecting the windows in the building. On the windward side they will be collapsed inward, while on the leeward side (suction) they will be pushed outward.

Porch roofs and awnings are often lifted and thrown off a structure. This phenomenon is the same as in an airplane wing. When wind flows over the top and underneath the roof system, a low pressure pocket develops on the top side which cannot resist the high pressure from underneath. Once the pressure exceeds the weight of the roof, the structure will begin to uplift and pry itself away from the house similar to the lift of an airplane going down a runway at high speed.

Shingle damage to the roof at low wind speeds is typically due to unsealed tar tabs, which never adhered from the day the roof was installed. The wind rolling up the surface of the roof literally lifts the brittle shingles and snaps them off.

To estimate wind speed levels, I like to first look for glass damage and then look at the surrounding structures to see how they fared the storm. Did they too sustain damage or was it localized to the structure I am inspecting? Were leaves stripped from the trees; were objects in the yard moved? The lifting of roof systems and shingles often occurs at speeds lower than 70 mph and is a function of the gross weight of the roof and its connections to the building and footings. New buildings that are not properly constructed often fail at low levels due to connection failures of brackets or fasteners.

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BEAUFORT WIND STRENGTH SCALE

Format: Beaufort Number – Wind Speed in Miles/Hour (Km/Hour) – Description

0 - < 1 (<1.6) – Calm: Still: Smoke will rise vertically

1 – 1 – 3 (1.6 – 4.8) – Light Air: Rising smoke drifts, weather vane is inactive.

2 – 4 – 7 (6.4 – 11.3) – Light Breeze: Leaves rustle, can feel wind on your face, weather vane is inactive

3 – 8 – 12 (12.9 – 19.3) – Gentle Breeze: Leaves and twigs move around. Lightweight flags extend.

4 – 13- 18 (20.9 – 29.0) – Moderate Breeze: Moves thin branches, raised dust and paper.

5 – 19 – 24 (30.6 – 38.6) – Fresh Breeze: Move trees away.

6 – 25 – 31 (40.2 – 50.0) – Strong Breeze: Large tree branches move, open wires (such as power lines) begin to "whistle", umbrellas are difficult to keep under control.

7 – 32 – 38 (51.5-61.2) – Moderate Gale: Large trees begin to sway, noticeably difficult to walk.

8 – 39 – 46 (62.8-74.0) – Fresh Gale: Twigs and small branches are broken from trees, waling into the wind is very difficult.

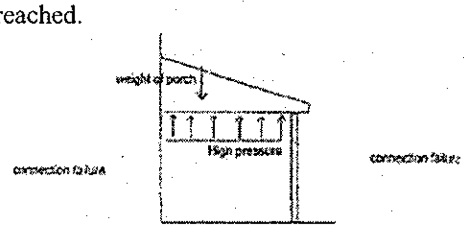
9 – 47 – 54 (75.6 – 86.9) – Strong Gale: Slight damage occurs to buildings, shingles are blown off of roofs.

10 – 55 – 63 (88.5 – 101.4) – Whole Gale: Large trees are uprooted, building damage is considerable.

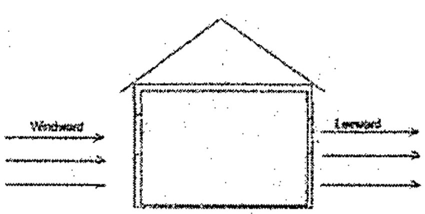
11 – 64 – 72 (103.0 – 115.9) – Storm: Extensive widespread damage. Glass starts to break. These typically occur only at sea and rarely inland.

12 - > 73 (>115.9) – Hurricane: Extreme destruction.

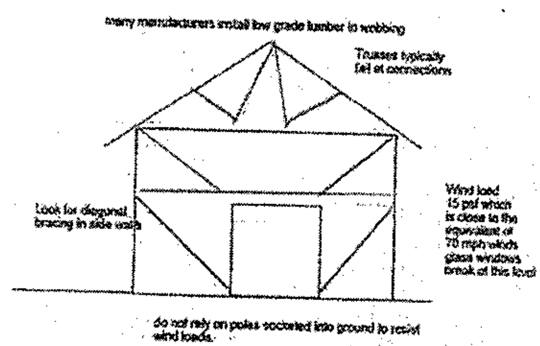
NOTE: the Beaufort number is also referred to as a "Force" number, for example, "Force 10 Gale". To calculate knots, divide miles/hour by 1.15. Small Craft advisories are usually issued when force 6 is reached.



Cross section of porch



Wind Forces acting on Structure



Elevation view of typical pole building

TRUSSES

Prefabricated timber trusses are the industry standard for residential roof building construction. Ninety percent of the trusses manufactured are built entirely out of 2x4's and metal plate connectors. Ninety-nine percent of these trusses are designed to span from exterior wall to exterior wall in a building. However, quite often framing contractors will install partition walls in a structure and frame the studded walls tight underneath the low chord of the truss at intermediate or random locations. At first glance one might think that this will give the roof additional support and capacity, but actually its impact is the contrary. Instead of the truss having two supports it has several supports, and under snow load conditions the load paths become much more complicated and can be hazardous to both the truss and the floor system below.

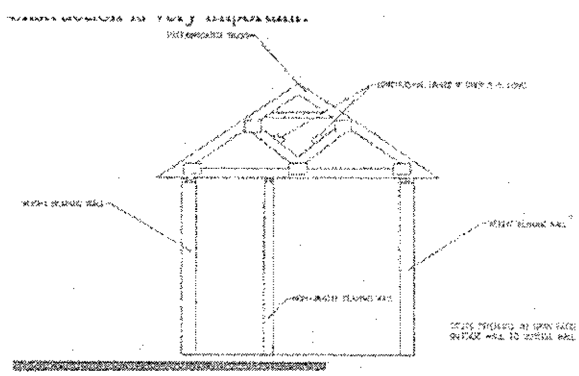
Side effects will be cracked drywall in the partitions and distressed floors and ceilings directly below the load path, or a ripple in the roof sheathing where one truss deflected normally and an adjacent truss remained undeflected due to the addition of supports.

Trusses under a snow load of 30 psf may deflect only 1/32 of an inch at midspan, but if a wall is present at this location and the truss cannot deflect, it will transfer the load. Drywall will stretch, and upon rebounding after the snow has melted, the ceiling will have cracks at the intersection of the wall and the ceiling. While most often these cracks are due to volume changes in the house, they too can be the side effect of improper roof support. What can be very alarming is if a wall partition is pushing upwards on a slender 2x4 it could actually snap the bottom chord of the truss.

Another phenomenon that often occurs is truss arching. The moisture content of the lumber used in trusses is typically 10-20%. Once this material is placed in an attic space of 110 degrees, the lumber dries and shrinks causing the trusses to lift or arch upwards.

While the truss in most instances is structurally unchanged, any sensitive ceiling finish such as drywall may be separated at intersections of walls and ceilings. Cracks at intersections of walls and ceilings may sometimes be due to this phenomenon, and this usually occurs after the first year of occupation while the snow effects can happen at any time. The cracks will be located in the same place and look the same but are due to two different problems. A 1/4 inch gap should always exist between a wall and truss to allow for normal deflection.

Finally, the most common form of truss failure is lateral buckling of a compression member. Some of the webbing in the trusses are under great compressive loads when under full live-load and self-weight. If the member consists of a typical 2x4, these members when lengths exceed 8 ft. are very susceptible to buckling sideways and causing a large successive collapse. Installing the proper lateral braces transversely on these members during construction is very important.



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MOLD

Every summer I receive calls from homeowners complaining and worrying about the mold in their basements, attic spaces or walls. Over the last several years many articles have been published in common news publications or on the internet, which have raised awareness and in some cases manifested of mold or as some people call it mildew. Some people become alarmed when they read "excessive exposure to molds can lead to adverse health issues".

Remember the exposure to mold by humans is not new. Mold contains toxins which when in contact by certain hypersensitive individuals causes allergic reactions and respiratory problems. For humans to be in contact the spores most likely are airborne and in large quantity.

Mold growth is directly related to moisture levels and carbon. While we are not interested in removing carbon from a house since it is the primary ingredient, we can remove moisture. The most common place for mold to develop in houses is in the basement. The two most common sources are due to a leak from ground water or from condensation. Both of these problems occur typically in the summer months. If severe rain raises the ground water in a house it will leak in even the best foundation systems. Mold will grow on any carbon material, wood, carpet, textile, books, leather, food, etc.

Condensation occurs in basements during summer months when air humidity levels are high (70%) and the basement walls and floor are cool 60 degrees causing moisture to settle out of the air.

Increasing humid air circulation into a basement will only propagate the problem. Heating the basement above 70 degrees can be expensive. Dehumidifiers are recommended if the area contains carbon materials on the floors or walls.

If inhabitants are sensitive to mold spores, then dehumidifiers or heating may be necessary.

With regards to air ducts, air conditioning systems dump 50-degree cold air into ducts. Any warm humid air around or inside the ducts will condensate, causing mold. If units are on and off for long periods of time, mold could develop on the inside of the ducts. Insulation on the outside of the ducts prevents condensation in attic spaces of the ductwork.

The most common form of mold in attics is due to lack of air circulation. While mold in basements form in the summer months, mold also forms in winter months when improper thermal barriers cause condensation on the underside of roof sheathing due to improperly placed insulation. Proper attic venting will eliminate the problem.

A lot of people have gone to the expense of having the mold analyzed. I prefer to focus on eradication. If someone in the house is experiencing symptoms of allergic or respiratory reaction to the mold, then simply get rid of the mold regardless of its type.

Quite simply if there is no moisture, there is no mold. Spores can lay dormant for years, therefore a good wet cleaning of the area is suggested.

In conclusion, humans have been living with mold for thousands of years. It has been only most recently that we have been able to eliminate the phenomena that is a problem for some people.

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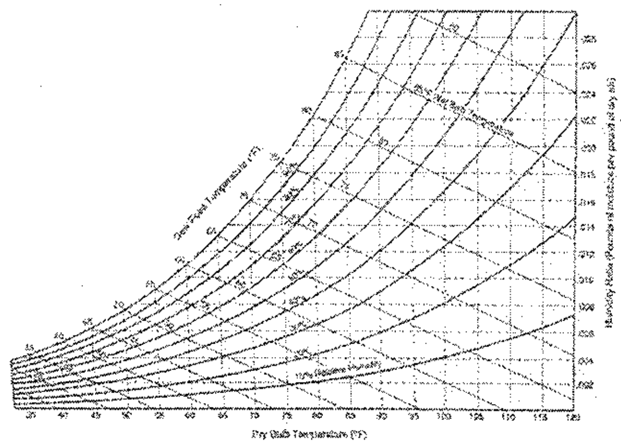
MOISTURE IN HOMES

I am often asked to inspect a newer home in the northeast during the winter months that has severe condensation on the windows and exterior doors. All the products involved are the latest technology including double and triple pane windows and blown-in insulation with a vapor wrap on the walls.

The problems with these houses are that they are too tight! Moisture is being developed inside by cooking, people, bathrooms, and the moisture has no place to escape. When it comes in contact with the cold windows the condensation occurs. The better the window the colder the temperature must be before the condensation occurs. The simplest way to solve this problem is by installing an outside air exchanger. This device will bring in lower humidity air from outside. Another means would be to use dehumidifiers. If an exchanger is used it must evenly distribute the new mixed air. Discharging through air conditioning or heat ducts will ensure uniform distribution.

The newer homes do not "breathe" like older structures. While this is an energy saving advantage, it allows the moisture to build up. The moist air is a combination of atmospheric air and water vapor. Relative humidity ratios between levels above 40% will start to show effects of condensation on double paine windows when the outside temperature is 10-20 degrees and inside is 72 degrees. The higher the quality of window, the lower the temperature before condensation.

Dehumidifiers will also remedy the problem but not remove moisture uniformity due to various room and floor levels.



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Lightening Strikes

Each year hundreds of homes are damaged due to lightening strikes. Some of the strikes are obvious and are direct hits to a dwelling. Antennas and chimneys sometimes act as conduit grounds, and the sudden increase in temperature caused by high voltage will cause a localized explosion which will sometimes send bricks flying. I have seen nails explode through plaster on a wall that was next to a chimney that was hit. Metallic fixtures next to wood along the grounding route have also caused homes to ignite. Other strikes occur to a tree in the vicinity of the house, which while not a direct strike it causes a fissured or a whole host of smaller charges into the ground and surroundings including the wiring system in a home.

While physical damage to a home is a concern, electrical damage to a home is typically what is noticed from a direct or vicinity strike. Appliances within a dwelling such as computers, televisions, microwaves, clocks, stereos and toasters are very sensitive to either sudden drops or high spikes in electrical current. A sudden surge can be from not only a lightening strike but problems with a transformer.

Of utmost concern is buried damage to the wiring or service panel when subjected to high voltage. Deteriorated wires can lead to fires. Typical Romex wire with a plastic coating of insulation has the capacity to carry 600 volts even though used for only 115 volts. Above this level the coating melts. Older wire solder connections melt at 374 degrees, and taped joints melt at levels of over 150 degrees. The tape will melt before the wire insulation.

A house can be subjected to a lightening strike and not have any wiring damage. This phenomenon would occur if the wiring in the home was not the direct conductor and or the strike was remote. A quick test to see if the home has damage is to look at receptacles, junction boxes and wiring along the damaged appliance line. Is there melting of old taped joints? Has solder been melted in junction boxes? Is the plastic on the wire nuts melted? Are there any signs of wire insulation melting? This physical evidence would mean high voltage, high heat, and the line should be replaced. A Megger reader device can be attached to buried wall wiring to check for Ohm loss along the line which would be an indication of insulation damage.

At the service panel there may or may not be damage to the panel itself, but a good precautionary measure would be to replace the circuit breakers on the lines that sustained appliance damage. If the damage to appliances is on multiple circuits then a complete replacement of the panel such as a Square D QO series is suggested along with a receptacle inspection instead of complete replacement of the wiring in the entire home. If the service line from the pole to the house was hit or a nearby transformer, the panel could be destroyed and the home left without power. It takes a large conductor such as the service wire to destroy the panel.

Finally, the use of lightening arresters can limit the extent of damage to a structure, but they will not prevent strikes nor will they prevent damage. They typically but not always attract local strikes instead of a wall or roof and redirect them to the ground, but if a nearby tree is struck the arrester are useless.

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CHIMNEYS

Each year I am asked to look at damaged chimneys on houses. I have noticed approximately three or four common causes of chimney problems. The most common cause is when the entire stack has pushed away from the house leaving a gap between the house and the stack. This problem is due to one of two phenomena. Either ground disturbances were present, such as severe drought or a saturated soil caused by excessive rains or snow, or the framing of the house has caused the problem.

Typically, the chimneys that move are on the end of the home. If the roof framing is classical rafters with a ridge beam and collar ties, the creep over time from self weight or snow causes deflection of the ridge line that may push out on the top of the stack. However, the shallow small footings attached to the side of a house which support the chimney have no excess size to resist any lateral loads other than its vertical self weight.

If the ground has been subjected to wild swings in moisture content from either a drought or snow melt, or sustained rain or a misdirected roof down spout, the soils may consolidate directly under the footing. Remember, in a lot of instances chimney footings are resting on disturbed soils which were backfilled around a dwelling during original house construction. The chimney foundation may not go down to the undisturbed soil depths and therefore was never compacted properly. The 3' x 3' footing may stand undisturbed for 50 years and suddenly move due to a unique weather condition. It only takes a settlement of 1/32 of an inch on the back corner of a footing to have a 2-inch separation gap 24 feet up on the side of the house. Keep in mind that this outward movement may open a gap between the furnace flue and the chimney causing a future fire hazard.

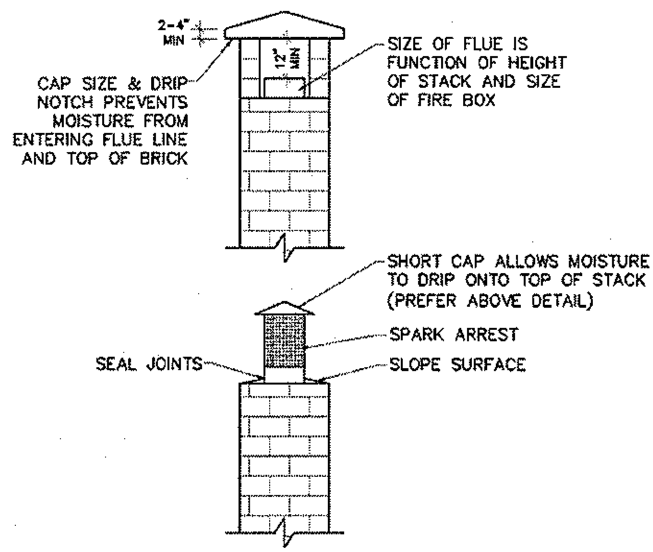
Another type of problem with chimneys is the top bricks falling off. Quite often this is blamed on lightening or wind, but actually it is caused by water intrusion.

Chimneys which are over 25 years old will experience deterioration of the brick mortar joints from snow melt or rain. Chimneys seldom have a proper cap on the top, which also has a drip edge. Consequently, water will directly enter the top or through capillary actions will wrap around a cap and into the joints.

Vertical splits in the bottom third of a brick chimney stack can sometimes be attributed to water entrapment and sudden freezing. Various creosote fumes only add to the attack of the mortar. Typically, creosote stains are in the top 1/3 of a stack after the air has cooled considerably and the gases start to form solids. Slow burning fires with dampers using green wood is the recipe for problems. In March, severe snow melts can be followed by sudden freezing temperatures which will cause cracking and splitting of not only the bricks, but also the flue liners. Clay liners are gently installed with little contact to the brick stack to allow for thermal expansion. Unfortunately, water, snow and ice can accumulate in the caps, causing the liners to split. Flue fire damage to the liners is more distinct and forms spider web patterns.

The key to a good chimney starts with an excellent cap that keeps the moisture away plus an excellent foundation.

CHIMNEYS



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BRICK MASONRY WALLS

It is not uncommon for me to be asked to look at an old brick masonry wall which has suddenly collapsed on a large elevation of either a commercial building or even a residence.

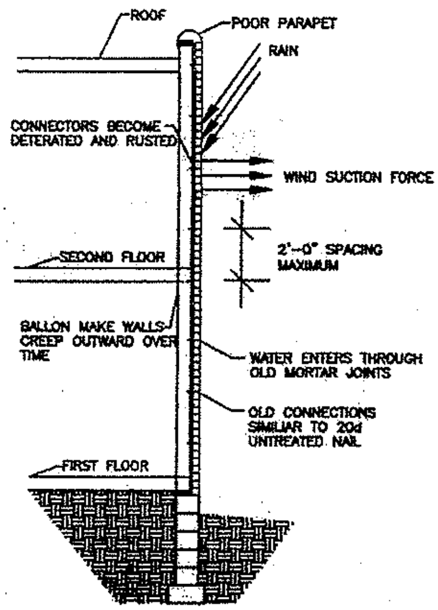
A close-up inspection reveals that the walls are old (over 75 years), and that their lateral tiebacks are corroded from years of exposure to the elements. Most often, the mortar has high lime content, is porous and has deteriorated.

Modern building codes stipulate that a mechanical tieback should be located on an approximately 24" grid. The tiebacks are galvanized to prevent corrosion.

Seventy-five to one hundred years ago the tiebacks were not galvanized metal but rather simple 20d nails or plain bare metal hooked devises similar in size to a 20d nail. Old brick masonry veneers on buildings are typically attached directly to the timber framing which is often balloon framing. I quite often notice that the wall that failed was on the weather side of the building which receives the driving rains, or a poor parapet cap has allowed water to run down the brick over the years.

What triggered the collapse? It could be due to a slight wind which induced a suction force on the leeward side (opposite of wind direction) of the building. Another force of nature which will trigger a collapse is thermal expansion and contraction. A large wall is constantly moving, and it would take hundreds of these cycles combined with a rusted tieback to finally fail. Since this connection is hidden, this problem goes unnoticed until a drastic collapse has occurred. Old balloon framed walls bulge outward over time due to creep in the wood fibers. Therefore, creep can also contribute to these failures, but typically it is a function of the condition of the tiebacks.

Keep in mind that in most instances the tieback has worked over 100 years through wind, rain and thermal changes, and only the mortar and tieback have changed.



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SEISMIC / BLASTING DAMAGE

Ground vibrations are very disturbing to homeowners. Construction, waterline or quarry excavation activities often require the use of explosives to remove the rock. Due to complaints and reckless explosive activity the Pennsylvania Department of Environmental Protection, Title 25 Rules and Regulations, Chapter 211, along with the United States Department of the Interior Bureau of Mines Report on Investigations 8507, "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting"; 1980, have set up strict guidelines.

For one, blasting activity which is going to be within 600 feet of a structure will typically have a preblast inspection report filed. This report will document the condition of the dwelling prior to the blasting. Quite often I am called by an irritated homeowner who complains about the ground motion and indicates that the entire house has shaken. They then proceed to explain that they have been looking at their house, and they have found cracks in their walls and ceilings, doors are ajar, and all of the above is due to the blasting. While they may be correct, I often find that blasting activity causes people to inspect their house with a magnifying glass, blaming every blemish on the blasting. Seldom would a person randomly perform such an inspection under normal circumstances.

A threshold I like to see is whether pictures were knocked off of the wall, which is associated with a Richter level of 5. The Bureau of Mines limits ground particle velocity to 1 inch per second. Scaled distances between the blast source and protected structures are limited to a minimum of 60 feet per pound only when a blast is not monitored by a seismograph. Air blast pressure is limited to 128 decibels. Research by the Bureau of Mines established particle velocity criteria that would safeguard against threshold damage to drywall and masonry, two of the most susceptible construction materials. Threshold damage is defined as loosening of paint, small plaster cracks at intersecting joints or widening of old plaster joints.

When vibration frequencies are 40 Hertz and above, the USBM recommended particle velocity is 2 inches per second or less. Only when frequencies are between 4 and 12 Hertz does the USBM recommend .75 inches per second velocities as an additional safeguard against drywall cracks.

A structure which has been subjected to blasting will have similar characteristics to a car antenna that is swiped into motion by a kid. The top of the antennae will travel further in an oscillating pattern than the base. Likewise, the top of a chimney or other top-heavy components will move and displace more than the base of the house.

I typically like to see the connection of the house to the foundation. If this location shows signs of recent movement, then I will look further at drywall and chimneys. Foundation walls which have long slender spans perpendicular to the ground waves motion may also experience some cracking. But remember not all cracks are typically due to just the seismic activity.

To install a seismograph in someone's yard after the blast is somewhat useless in the sense that a blast cannot be duplicated due to their depth, amount of charge, type of geology at that specific location and the distance. Any slight change will give a different reading.

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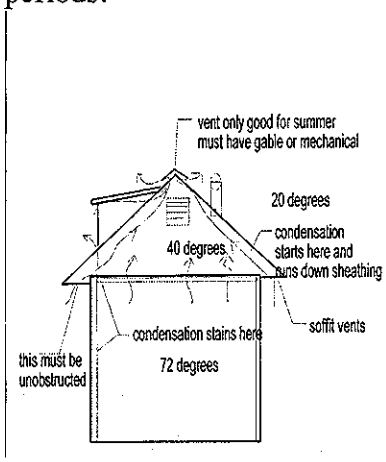
AIR CIRCULATION OF ROOF SYSTEMS

Proper air circulation in attic spaces is not only important during summer months but also essential in the winter. Traditionally, air circulation provisions have been provided by either gable louvers and ridge vents combined with soffit louvers. The IBC Building Code specifies as a minimum .03% voids of the gross area of an attic space to provide the necessary air movement. The poor installation of insulation in contact with both the roof sheathing and the ceiling joist caused significant damage the last several years. For one, the insulation became an obstruction for free air circulation, and the heat loss in contact with the underside of the sheathing caused ice dams, interior leaks and edge of roof damage. The most severe damage occurred when condensation developed on the underside of the sheathing. Again, this was due partially from lack of soffit louvers or obstructed soffit louvers and snow covered ridge vents (see figure).

While ridge vents are fine in southern states, the deep snow loads in the northeast completely cover over and trap air in the attic. The condensation buildup is forgiving on older homes with 3/4 inch sheathing boards, but the newer homes with plywood warp easily, and a wave pattern shows up on the roof. The plywood is very sensitive to moisture contact, and in many instances the structural capacity of the roof was reduced below standards due to the pulling of nails, cracking of shingles and delamination and deterioration of plywood sheathing. Ceilings and sheathing will also show signs of mold and mildew and start to deflect.

Ventilation problems can typically be spotted in homes by an attic inspection. Ventilation should be a combination of soffit vents with a gap left between the roof rafters and either gable vents (one on each end minimum) or a mechanical vent. If a home does not have overhangs or soffits, then a mechanically operated exhaust fan is suggested to draw and circulate the air from the attic. Again, this system should be coordinated with a gable louver as to eliminate drawing air from the living spaces. Both ridge vents and membrane vents at the cap theoretically provide circulation in summer months, but they fail in heavy snow periods.



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SWIMMING POOLS

There are basically two types of pools that I frequently inspect, and both are pre-manufactured with some on-site construction required.

Each year I am asked to look at above-grade pools which have collapsed suddenly and without warning.

Typically, no one saw the event, and the pools are over five (5) years old. When it comes to these above-grade pools which often are four (4) feet deep and 16 feet in diameter, they are most often do-it-yourself installed. As part of the installation, a metal channel is laid directly on the ground, and the thin metal walls are laid into this track. As years pass, the soils attack the metal channel and cause corrosion to both the channel and the metal liner. It only takes a short section (2-3") of deteriorated metal wall to cause a sudden tear which ultimately rips the neoprene liner resulting in a complete collapse and loss of water.

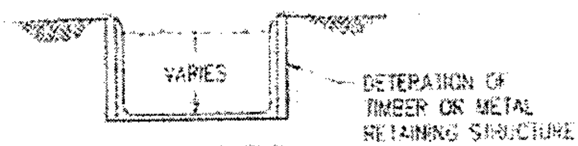
A mild wind wrapping around the walls causing a combination of hydrostatic pressure due to the water in the pool and negative wind pressure could trigger the collapse, but the problem is the contact and corrosion at ground level. Most installers illustrate burying the bottom several inches of the pool, yet they fail to mention corrosion and the stability of the entire pool is dependent on this buried channel.

Another problem occurs if too much backfill is installed against the perimeter walls and the potential of an inward collapse if the pool is drained or water evaporates over time.

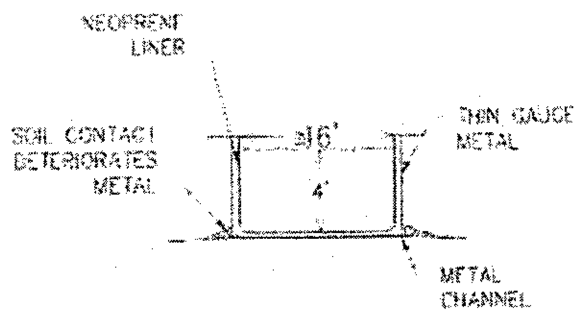
In conclusion, keep a lookout at the ground line. If the channel or metal wall is deteriorated, replace or repair immediately.

With regards to in-ground pools, I find that the pools longevity is a function of the materials used to frame the structure below-grade. Whether wood or metal, these materials will be constantly in contact with ground moisture and over time will deteriorate.

Connection failures of the framing system cause walls to push inward, plus exposure to frost heave when left unfilled is another problem. Most of the above- and below-grade pools have a 15-year warranty which covers both the structure and the liner. Ultraviolet light breaks down and deteriorates a pool liner, and one cannot blame a tear after 15 years on a wind storm.



IN-GROUND POOL



ABOVE GRADE POOL

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