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Lowering Basement Floors (Underpinning, Benching)

One way of obtaining additional living space in a home is to renovate a basement area and convert it into habitable living space. This is a very common renovation, especially in urban areas where additions are not possible due to space limitations.

Many older homes have shallow basement with limited headroom and in order to convert these spaces into habitable living spaces, it is desirable to lower the basement floor.

Lowering of a basement floor usually means that the foundations of the house need to be underpinned.

By underpinning a house, the foundation walls and footings are extended down to a lower level so that the basement floor can be safely excavated in order to gain extra headroom.

However, before you consider lowering the basement floor, it is important to understand the structural implications of such a renovation.

Structural Support:

Most homes are built on concrete, concrete block, or masonry foundation walls. The purpose of the foundation wall is to:

1. Provide support for the house structure so that the weight of the house and its contents are properly supported above the surrounding ground level, usually a minimum of about 6" above the exterior grade level.
2. Provide for continuous support walls which extend below the ground level to competent soil or rock capable of supporting the loads from the house at a level which is below the frost line, and
3. Provide for a basement area below the house where the furnace and water heater can be located, along with drains and water service connections.

If a basement floor is excavated down to a level below the level of the original underside of the foundation walls of a house, then this will undermine the structural support of the foundation walls…and this can lead to severe settlement or collapse of the house itself. This is why underpinning or benching is almost always required in order to lower a basement floor. (Note: In some cases where the foundation wall resists a very shallow height of soil, is it possible to lower a basement floor to the level of the original footings…possibly gaining about 2"-3" in basement height. However, this should not be done without first consulting a structural engineer.)

Underpinning:

Underpinning is the process of extending the underside of a foundation wall to a lower level. This is normally achieved by excavating below the existing foundation wall in short, discrete sections, and then by infilling these sections with concrete in such a way that the foundation wall is made to extend to a lower level. For existing houses, this is usually done from the inside of the basement in a series of stages determined by a structural engineer. A staged approach (usually 3 stages) is used since the existing foundation wall is still carrying load and it is normally only acceptable to undermine a short section of foundation wall at a time. It is vitally important to leave undisturbed sections of soil between each stage to ensure the continued support of the foundation wall during construction. Depending upon the type of foundation wall present, the underpinning sections may be shorter or longer, but typically the underpinning segments are installed in maximum 4' lengths for concrete or concrete block foundation walls, and sometimes shorter lengths for stone and rubble foundation walls (possibly 3' lengths). By following a staged sequence of underpinning, the

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entire foundation wall can be successfully lowered in a safe and controlled manner without causing any significant shifting or settlement of the original house structure.

Benching:

The term "Benching" refers to the concrete bench which is constructed over top of a stable excavations slope when a basement floor is lowered without extending the foundation wall footings to a lower level. In benching, a stable excavation slope is maintained below the foundation wall footings and a concrete protection "bench" is constructed over top of the stable excavation slope. This process is used for several possible reasons:

1. To reduce construction cost

2. To avoid undermining another nearby structure this might be undermined by the underpinning process.

If there is less than about 48" between your house and a neighboring house, it will be important to carefully consider the proposed basement lowering method so as to avoid undermining the neighboring footings.

Typically, a stable soil slope not steeper than 7V:10H must be left in place in front of the footing and this means that the resulting bench can be quite large, sometimes prohibitively large. For example, in order to lower a basement floor by 6", the bench typically must extend out beyond the foundation wall face by approximately 12". As the depth of the basement lowering increases, so does the width of the concrete bench. A basement lowering of 18" results in a bench which is 27" wide.

Also, the bench needs to be structurally reinforced with steel re-bars and tied-into the new basement floor, since the bench and floor structure need to provide a horizontal "strut" to keep the bottoms of the original footings from sliding inwards once the excavation is complete. It is also very important that the base of the foundation wall be braced from sliding inwards during construction of the bench since the removal of the original basement floor eliminates the strut action which was previously present to resist horizontal soil forces pushing on the foundation wall from the outside…these are forces which want to push the foundation wall inwards into the basement. Benching should really be done under the direction of a professional engineer when the original foundation wall is resisting a height of soil exceeding about 5' since horizontal sliding forces and stability of the exposed soil slope can lead to collapse of the foundation wall. Caution should also be used in loose granular soil conditions and in soft wet clay conditions and the use of motorized equipment such as a bobcat can disturb the stable soil slope and cause failure of the soil slope, leading to collapse.

Before starting a basement lowering project, make sure that you educate yourself about the entire process and make sure that you have a good contractor to carry out the project.

Other things that you should know about Basement Lowering:

1. **How is it done:** The perimeter of the basement floor is broken up and typically 3 stages of underpinning lengths are laid-out on the foundation walls in accordance with the approved building The contractor starts by excavating in front of each of the first stage 3' lengths of wall which are to be underpinned. Once a hole is excavated in front of each 3' length, the contractor then further excavates the soil from below the foundation wall itself at each hole. The hole is carefully dug out below the footing (yes, the footing and wall is literally suspended in the air during this process) and a short shovel is used to scrape away any loose soil from the underside of the footing. Obviously, it is important to stay out of the small space below the footing since there is always some risk that a loose brick or block or piece of concrete could come loose. Once each section is dug-out, plywood forms are placed in front of the hole with the inside surface flush with the inside face of the original footing, leaving about a 2" space between the underside of the original footing (to allow a space to pour the concrete) and the top of the form. After all of the first stage sections are filled with concrete and the concrete is cured for about 72h, the top 2" gap which remains between the top of the concrete and the underside of the footing is hand-packed with non-shrink grout. The top 2" should be packed with non-shrink grout to ensure that there are no air voids between the underside of the original footing and the top of the new concrete. Note that many underpinning contractors try to eliminate this step by using a concrete vibrator to eliminate air voids. This sometimes does not work well at all since the vibrator actually increases the amount of air which

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seeps to the surface of the fresh concrete. Also, the fresh concrete shrinks shortly after pouring the concrete, possibly leading to very minor settlement of the structure following construction. It is generally best to leave the 2" space and pack the gap with non-shrink grout, unless other site conditions warrant using an "over pour" method. For example, if the footing can be removed prior to underpinning, then the "over pour" method is generally acceptable since the width of contact area is reduced and there is less likelihood of air pockets being left in place. Also, when underpinning a rubble foundation wall, it is often difficult to pack the very irregular surface of the underside of the wall with grout, and it may then be just as well to use an "over pour" method with stone rubble foundation walls, provided that there are air gaps between stones to allow air to escape with the rising surface of underpinning concrete.

Once the first stage of underpinning is complete, then the second stage of excavation and underpinning can take place, followed with the third stage of underpinning. Once all three stages of underpinning are complete, then the contractor can go ahead and excavate the soil from the basement. It is important to **not** excavate the soil from the basement until all stages of underpinning are finished since doing so will leave the bottom of the foundations walls laterally unrestrained from resisting the inward soil pressure on the exterior of the foundation walls. This author is aware of several house collapses which have taken place when this procedure was not utilized, resulting in the loss of the entire house due to collapse.

2. **Should it be inspected:** We strongly recommend that you verify that your Contractor has called the Municipality for inspections during construction, or that he has retained the Design Engineer for the project to inspect the work. It is important to ensure that the width of each underpinning section is at least as wide as the original footing, or at least as wide as specified on the approved permit drawings and that the 2" non shrink grout has been fully packed into place.
3. **Headroom:** We recommend that you and your designer carefully consider the amount of underpinning that will be carried out so that the final finished headroom in the basement meets your expectations. Note that most building codes require a minimum headroom clearance for a living area inside a single family home, and even more stringent requirement for a minimum headroom clearance for a separate dwelling unit, such as a basement apartment. Also remember that the new basement floor must have a gravel layer (usually 4") and a minimum concrete thickness (usually 3") above the underside of the underpinned foundation. Also, ceiling finishes and bulkheads reduce ceiling height. The required thickness of drywall, plus additional thickness for furring-out (leveling) uneven or sagging floor joists or for providing sound insulation should be taken into account.

4. **Restrictions on Lowering a Basement:** there are several constraints on basement lowering:
    a. *Depth of existing sewer drain:* If your existing sewer drain is not very deep below your basement floor, you may need to re-consider your plans. In this situation, a sanitary pump can be used to pump sanitary water back up to the original drain level at the location where it discharges from the house. Note that, in this situation, sanitary drain pipes originating from the upper levels should be re-routed so that they continue to flow by gravity to the original sanitary drain; only new drains from the basement discharge to the new sanitary pump so as to minimize pump operation. Sanitary pumps are very reliable and clean, and can be fitted with battery backup power and alarms in the event of a power failure.
    b. *High Water Table:* If your existing basement floor is just above the prevailing water table, then lowering the basement floor level could result in your new floor level being below the water table and this condition would cause constant flooding of your basement. While it is possible to install sump pits and sump pumps to manage this type of condition, it is not recommended. We recommend that, prior to moving forward with a basement lowering project, that you first dig two test pits in the basement down to a level about 7" below your proposed new basement floor level and then observe these pits for a few days, preferably over a period of wet weather. By doing this, you will become aware of potential water problems prior to starting the project and your contractor will be in a better position to price the work.
    c. *Close Proximity to another Structure:* If the foundation wall that you are proposing to underpin is shared or very close to another structure, then you may not be able to carry out your project without obtaining the consent of the neighboring property owner. Municipalities vary in their requirements, however you may still be obliged under civil law to inform, obtain consent from, and protect, neighboring property Owners.
    d. *Boulders and Other Unforeseen Problems:* Lowering a basement mean excavating into soil which has never been previously exposed, and for this reason, it is possible that rocks or large boulders may be

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present which are difficult to remove. Unfortunately, there is no way to ensure that no boulders are discovered, and your contract with your Contractor should ideally make provision for such a possibility. In cases where moderate sized boulders are uncovered, it is often possible to dig a hole next to the boulder and to then roll the boulder into the hole and bury it below the level of the new basement.

e. *Original House is on Piles:* Although very unlikely, it is possible that the house which is to be underpinned is on piles. In circumstances such as this, careful consideration must be given to the prevailing soil conditions. Professional advice is absolutely needed when lowering a basement where the foundation walls are on piles.

5. **Stairways:** If the basement is to be lowered, then the stairs to the basement need to be extended. It is important to ensure that the new basement stairway, when extended, will still allow for sufficient headroom. It is also important to note that the underpinned or benched portion of a foundation wall usually extends out into the basement at least 4-5 inches and this may interfere with the "extended" stairway if the original stairway is beside the foundation wall. In cases where benching is to be installed, a landing can be installed to facilitate a directional change in the basement stair, or, a short section of underpinning can be installed which is flush to the original foundation wall, to eliminate the interference of the bench. It is also important to take into account the size of furniture or other equipment which will be taken into the new basement and increasing the width of the original basement stairway and stairway opening should always be considered ahead of time.

6. **Beams and Posts:** When the basement floor is going to be removed and lowered, any original posts will undoubtedly need to be removed and re-constructed with new footings at or below the level of the new basement floor. It is usually not cost effective to underpin original spread footings or masonry posts, but rather, to simply replace them with new concrete spread footings and steel posts. It is also often desirable to eliminate support posts from a basement in order to provide for larger, open concept living spaces. Since most basement support beams are not continuous across the top of a support post, the only way to eliminate a post is to design and install a new support beam which is longer (and stronger) than the original beam and allow for the post to be installed elsewhere. The re-work of beams and posts is common in basement lowering projects and does not usually dramatically increase the overall cost of a basement renovation. It is also common, as part of a basement lowering project, to provide new beams which are partially or fully recessed into the basement ceiling space, leaving a "flush" beam installation. This kind of installation can significantly impact existing electrical, heating, and plumbing services which may be currently located within the floor system. It is common to provide for holes through new flush beams in basement installations to facilitate re-working electrical, heating, and plumbing pipes. Significant holes can usually be provided for in the web of new steel beam installations for houses without significantly affecting the strength of the steel beam itself.

7. **Electrical, Heating Plumbing:** Usually there are no electrical, heating, or air conditioning services present at the basement floor level in a house and these services are only affected by new beam installations which may be required in order to provide for a new interior layout of the renovated basement. Plumbing drain pipes located under the basement floor are usually removed and replaced as part of a basement lowering project, and it is also common to provide new floor drains (complete with p-trap primers and backflow check valves) as part of the basement lowering project. New floor drains should be provided at regular locations in a new basement floor area to allow for water drainage in the event of a flood, however it is not necessary to slope the basement floor dramatically towards these drains since presumably, a more-or-less leak-proof basement will result from the renovation. Floor drains are always connected to the sanitary drain which discharges to the municipal sanitary sewer and as such, a p-trap and p-trap primer is required at every floor drain location to prevent the migration of sewer gases into the house. Some municipalities, such as the City of Toronto, now require that all new basement floor drain installations also be supplemented with a back-flow prevention device to eliminate the risk of a sewage back-up.

8. **Waterproofing and Damp proofing, Weeping Tiles and Sump Pumps:** If the original basement suffered from water leaks or dampness, it may be worthwhile to waterproof the basement after the underpinning is carried out. Waterproofing of a basement requires that the exterior foundation walls be excavated and cleaned and that a new waterproofing membrane be installed. Waterproofing Contractors usually provide a written warranty for this type of work. If waterproofing the exterior of the foundation wall is not possible or cost prohibitive, then an interior water management system can be installed which will serve to damp-proof the

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interior surface of the foundation wall and prevent water which leaks through the foundation wall from damaging new interior insulation, wall studs, and drywall. In cases where no exterior waterproofing is to be carried out, then a new interior weeping tile will need to be installed around the interior perimeter of the underpinning, so as to collect any ground water which may appear below the floor level. This ground water is not considered sanitary water and must therefore be discharged to a new interior sump pit which allows the water to be pumped out to the exterior grade; the idea here is that ground water should not be discharged to the sewer (the sanitary sewer systems in many municipalities are already overloaded) and it make good environmental sense to locally replenish the water table wherever possible at the source. It is also important to ensure that rainwater leaders from existing eaves troughs do not discharge into old perimeter weeping tiles since such installations can saturate the soil around the foundation wall of the home and cause leaks and other water damage at the level of the new underpinning. It is preferable to discharge eaves trough downpipes to garden areas while ensuring a minimum 5% exterior grade directed away from the foundation wall. Most municipalities do not allow eaves trough downpipes to discharge to the sewer system.

9. **Radiant Floor Heating:** It is very common to install new radiant floor heating pipes in new basement floors immediately prior to pouring the new concrete floor slab. Even if radiant floor heating is not intended in the short term, the cost of roughing-in these pipes is not great and gives the homeowner the option of using the pipes in the future. It is important to remember that a new basement living space may have been previously poorly serviced with heat and the provision of new heating to the basement may be required anyway. The most common type of radiant floor heating used in basements is hydronic heating which utilizes a series of plastic water pipes which are embedded inside the concrete floor and circulated through a water heater and pump. These pipes do not weaken the floor structure in any significant way but can be damaged if holes are cut into the concrete floor at a later date. If radiant floor heating is to be installed, then an insulation layer is laid down over top of the gravel floor base prior to installing the heating tubes and concrete to reduce heat loss to the underlying soil.

10. **Putting Bedrooms in the Basement:** Most building codes require that special fire and emergency egress window exits be provided in bedroom windows located in basements of houses, and changes to basement window openings should be considered at the time of carrying out basement lowering work which involves concrete and masonry trades.

11. **Adding a Basement Walkout:** It is very popular to provide stairway access into a basement from the exterior grade. This is often done to provide for a basement apartment access, or to provide for improved accessibility to a basement from a backyard area. It is important to note that a basement walkout needs to be designed and built properly to ensure that the foundation walls on either side of the stairway access are able to resist the horizontal soil forces pushing inwards, and to ensure that the footings to the original house are underpinned within 4' of the new basement doorway entrance to prevent frost heave. A drain at the base of the basement walkout needs to be provided such that it discharges to a frost protected p-trap and interior sump pit.

12. **Furnaces and Water Heaters:** When a basement lowering is carried out, the original furnace and water heater may need to be removed and then re-installed at the new basement floor level. It is also common to leave the original furnace and water heater as-is and bench around the perimeter of this room. It is also important to remember that the basement renovation may result in significantly improved air-tightness of the basement, which can lead to oxygen starvation of oil and gas fired appliances within the basement area. In any basement renovation, consideration should be given to providing a new combustion air feed to the original furnace and water heater if they are oil or natural gas fired.

13. **Contractors and Special Insurance Binders for Underpinning:** In addition to Workplace Safety and Insurance Board (WSIB) insurance coverage, you should make sure that your Contractor carries General Commercial Liability Insurance and that his insurance coverage **specifically includes a special binder for underpinning operations.** Many Contractors insurance policies specifically **exclude** underpinning operations and many residential general contractors don't even know that they are not covered. Demand verification of this insurance from your Contractor and ask to see a copy of the actual insurance document. Finally, check with your home insurance broker to make sure that your policy remains valid and intact during your renovation project. Many home insurance policies are voided by construction operations since the Contractor's insurance is supposed to insure the project during construction.

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