Structural Support
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New Jersey Department of Community Affairs
Division of Codes and Standards
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Subject: Problems With Design & Construction Of Basement Foundation Walls

During 35 years as structural engineer, I have often been involved with design and evaluation of foundations.

- This report discusses general problem with lack of adequate design and construction of basement foundation walls, as well as lack of adequate plan review by code officials.

Recommendations for action to be taken by NJ DCA and NJ Board of Architects are listed at end of report. A few recommendations for legislation are also listed.

During the past 19 years as consulting engineer, based in New Jersey, I have inspected more than 200 residential and commerical buildings throughout New Jersey that had major problems with foundation walls around full basement, including several collapsed walls. Most often, the basic condition is horizontal cracks in mortar joints along with inward movement of the cracked wall.

Vast majority of foundation wall problems have been caused by excessive lateral soil pressure against concrete block walls, resulting in extensive cracking and inward movement, especially for 8-inch block walls.

Basic cause for horizontal cracking and inward movement of block foundation walls is excessive height of soil backfill relative to lateral strength of wall. Primary contributing factor (that can be readily identified) is improper surface drainage causing saturated soil backfill conditions. Defective construction methods, such as backfilling before mortar has gained adequate strength, may be another factor, however the extent of such problem is practically impossible to identify conclusively many years later.

Relatively high rainfall amounts result in saturated backfill and even hydrostatic conditions that increase lateral pressure. Walls already weakened by previous cracks are susceptible to collapse, as seen in September 2011 for a group of retail stores in Pennington.

Most foundation inspections have been performed for a buyer during real estate transaction, although sellers also request inspections; typically when buyer wants to back out of deal or does not want to pay for further inspection after general home inspection. During discussions with either party, and in reports, I explain reasons for the basic problem, including references to standard provisions in current and previous building code that specify limits for height of soil backfill.

- I am constantly asked how the basic defect of excessive height of soil backfill could have occurred when construction was "approved" by the "building department".

Among homeowners and home buyers, a very common misconception is that the local building department "approves" the structural integrity of their house. When informed that this assumption is not correct, the vast majority are truly surprised, or even shocked.

Explaining that designer and builder have primary responsibility (for structural integrity) typically does not satisfy those asking this question. Reaction from home owners tends to be that; (1) They do not want to believe the explanation, and (2) They have been cheated.

In general, code officials are not qualified to review structural design, for any building, except for the limited elements and conditions that are validly governed by prescriptive code provisions. Consideration of the basic fact that code officials are not (with almost no exceptions) licensed architects or professional engineers should make this situation clear.

Most homeowners do not have any conception that an architect might be responsible for design of foundation walls. They tend to "see" only the builder and, perhaps, the building inspector.

Home owners and buyers tend not to fully understand the difference between design and construction. Legal requirement for builder to provide copy of design plans to new home buyer should help to inform buyers. Currently, home buyers do not know enough to insist that the builder provide plans.

Distribution of Report

This report is available online at www.structural101.com.

Sealed copies of this report have been sent to the following;

New Jersey Board of Architects
New Jersey Board of Professional Engineers & Land Surveyors
New Jersey Societey of Professional Engineers
New Jersey Builders Association
National Concrete Masonry Association (NCMA)

Summary Of Conclusions

Even though I have inspected only a small number of basement foundation walls relative to the very large number of buildings with such walls in New Jersey, my experience indicates a widespread problem with deficient design and construction of foundation walls.

One reason of course, as noted below in description of actual cases, is that the basic features of foundation walls (including height of soil backfill) are often repeated for many homes within each of the numerous residential developments throughout New Jersey.

Based on many years experience with inspection of foundation walls, as well as review of design plans prepared by architects, builders and home owners, I believe it is reasonable to conclude the following;

- Basement foundation walls for tens of thousands of houses (and quite possibly many more) built in New Jersey during the past 40-plus years grossly violate code requirements (Including prescriptive provisions) that govern resistance to lateral soil pressure. Even for houses built within the past 20 years (after issuance of former Bulletin 90-9), numerous major violations have occurred.

- Most basement foundation walls that violate code provisions (relative to resisting lateral soil pressure) have not been damaged. This benign result is due primarily to design capacity being much less than ultimate (failure) capacity. However, even that healthy margin for error is exceeded all-too-frequently, resulting in tens of thousands of dollars of repair costs for all-too-many owners.

- Numerous architects have failed to perform proper design of basement foundation walls. Many architects simply specified 8-inch concrete block regardless of height of wall or height of backfill. Even when design was performed, prescriptive code provisions were often used incorrectly. As houses became larger, with increased height of basements, "standard" details tended to be copied from other projects, without properly considering effects of higher backfill.

- For years, too many code officials have essentially failed to perform proper plan review of foundation wall design, especially for large developments. All-too-often, standard prescriptive code provisions have not been enforced. Plan review continues to be a problem, even though recent building codes have included more detailed prescriptive provisons.

Design of Foundation Walls

Person responsible for overall building design is usually responsible for foundation design.

For large developments, the building designer is generally a licensed architect. Some architects delegate responsibility for foundation design to a professional engineer. However, for the majority of new homes, foundation design is performed by the architect.

Examples of severe foundation wall defects described later in this report are generally for houses built many years ago. However, based on results of numerous inspections for relatively new homes, as well as review of plans by architects in recent years, it is evident that defective foundation wall design remains a problem.

- ➡ Many architects today do not fully understand how to design a block foundation wall for resistance to lateral soil pressure, without using prescriptive code provisions (and sometimes even with code provisions). Although this situation was also the case in the past, the problem has become more severe as houses and foundation walls have become larger. For many years, to the extent that architects performed any specific design for lateral resistance at all, they relied on prescriptive code requirements that, for many foundation walls, were not applicable. In general, code violations were not noted by code officials during plan review.

For the case of owner-occupied house, UCC regulations have allowed the owner to prepare design plans. However, in practice, this regulation tends to be "stretched" such that some other person (such as builder) ends up as the designer. The result is very often defective foundation design.

Plan Review

Code officials might reasonably claim that, since they are not architects or engineers, they are not qualified to review foundation design, with or without prescriptive code provisions.

- ☑ Evidence demonstrates that plan review by code officials has not prevented gross violations of basic code provisions governing design and construction of foundation walls, for tens or perhaps hundreds of thousands of new homes. Along with many other problems caused by lack of effective plan review, the problem with defective foundation walls throughout New Jersey raises the much larger issue (for another day) of whether plan review for structural design should be performed by qualified professional engineers.

Building Code Requirements

Standard prescriptive provisions governing design of foundation walls for lateral resistance have been included in building codes for many years.

Since IBC 2000 and IRC 2000 were adopted by New Jersey, each edition of the code has included detailed provisions for prescriptive design of masonry (block, brick) and plain concrete foundation walls that must resist lateral soil pressure.

Although BOCA codes before 1996 did not include such detailed provisions, BOCA codes did include basic prescriptive requirements as well as other provisions intended to emphasize the need for proper design to resist lateral soil pressure.

BOCA and IBC / IRC codes have included provisions for "engineered masonry" to account for cases that do not satisfy conditions for use of prescriptive requirements.

UCC Bulletin 90-9

Former UCC Bulletin 90-9 (issued in 1990) highlighted problems with design and construction of foundation walls. However, Bulletin 90-9 was withdrawn about 12 years ago (apparently due to change from BOCA to IBC & IRC codes) and was not replaced.

BOCA 1990

Review of provisions from the BOCA 1990 building code is instructive to show that building codes have included basic provisions governing foundation wall design for many years.

Note that basic provisions of BOCA 1990 (for foundation walls) were not changed from the previous BOCA code (1987), as seen by lack of vertical line alongside text in the page margin.

Table 1222.2.2 specified maximum height of "unbalanced fill" for standard thicknesses of block and plain concrete foundation walls. Type of soil (sand, clay) was not a factor.

Exceptions were permitted with "approval of the code official where soil conditions or local experience warrant such increase." Unfortunately, builders often abused this exception by claiming that, even if height of backfill exceeded standard code limits, foundation walls were acceptable since the code official had "approved" their construction.

Architects often ignored the primary code provisions in the various BOCA codes, such as the following from BOCA 1990 (with italicized words as emphasized in the code);

> 1222.1 Design: Foundation walls shall be designed to resist frost action and to support safely all vertical and *lateral loads* as provided for in Article 11. The maximum stresses caused by combined *loads* shall be within the values specified for the materials used in the construction. Unless properly reinforced, tensile stresses shall not exceed those permitted in plain masonry.
>
> 1222.5 Lateral stability: Foundation walls of buildings and structures which serve as retaining walls shall conform to the applicable requirements of Section 1223.0, and shall be strengthened with buttresses or additional wall thickness to resist lateral soil and hydrostatic pressure where subjected thereto.

Architects often also ignored conditions for use of prescriptive provisions, such as those in 1222.2.2, which limits "equivalent fluid weight of unbalanced fill" to 30 pounds per square foot. Backfill that contains significant amounts of clay or silt does not comply with this key condition. As shown by reference to later codes (such as BOCA 1996), even mixed soils (sand & silt) do not satisfy this condition.

That architects (and code officials) routinely neglected these basic code provisions can be shown by reference to BOCA 1996 and later codes.

However, when BOCA 1990 and earlier codes governed design, specific design was required when code conditions were not satisfied. Design properties of block walls (section modulus, allowable flexural tension stress) had to be obtained from other sources. BOCA 1990 referenced ACI 530 (Building Code Requirements For Masonry Structures).

BOCA 1996

Major changes were made for BOCA 1996, which included much more detailed tables for prescriptive design of basement foundation walls. Although table values were generally consistent with those from earlier BOCA codes, there was now more variables to consider.

Most important was emphasis (in tables) on engineered design when conditions resulted in excessive flexural tension stress.

Required wall thickness was made a function of wall height, backfill height and soil class.

Table 1812.3.2(1) specified minimum thickness for masonry (block, brick) and plain concrete walls. Three soil classes were included, based on standard soil classifications. Clay / silt soils were now listed with equivalent fluid pressure of 60 psf per foot of depth, two times the 30 psf limit in BOCA 1990.

For various combinations of wall height, backfill height and soil class, Table 1812.3.2(1) required "analysis in compliance with ACI 530" or steel reinforcing bars per Table 1812.3.2(2).

Key condition for use of the standard tables, per 1812.3, was that top of wall must have adequate lateral support along top of wall. This condition has been routinely ignored by architects and code officials for walls that are parallel to first floor joists.

IRC Codes

IRC 2000 expanded prescriptive provisions of BOCA 1996 to include more conditions.

Initial version of IRC 2006 included detailed new provisions to ensure that top lateral support was provided along foundation walls that were parallel to first floor joists. However, later amendments eliminated these prescriptive provisions, apparently due to complaints from builders and code officials.

- ➡ Elimination of prescriptive requirements intended to ensure adequate lateral support along top of foundation walls that are parallel to floor joists does not mean that the design issue should be neglected. Adequate lateral support is especially important for foundation walls resisting relatively high backfill (over 7 feet).

IRC 2009 is essentially the same as IRC 2006, without the top lateral support provisions.

Results of Defective Design

Over many years, defective foundation wall design has resulted in many thousands of houses throughout New Jersey with cracked foundation walls, many of which have been pushed inward noticeably.

Even with proper design, defective construction methods also result in major foundation wall problems. Yet, much defective construction begins with lack of adequate design.

Although cracked-wall conditions can and do remain relatively stable for many years, cracking and inward movement also increases over time for a large percentage of these walls.

Foundation wall defects are often "discovered" during a general home inspection performed for a real estate transaction, resulting in extra cost for attorney fees as well as added stress for sellers and buyers.

Cost to repair major damage to foundation walls can range from a few thousand to $30,000 and more, especially if one or more foundation walls must be replaced.

Risk Of Collapse

For many cracked foundation walls, the eventual result will be total collapse unless repair work is performed.

Frequency of total collapse of foundation walls due to lateral soil pressure has been low. However, total collapse is often prevented by replacement of foundation wall.

Total catastrophic collapse does occur, often when soil becomes saturated with water. Homeowners have explained that collapse "sounded like a bomb went off".

Risk of total collapse increases when there is a finished wall inside the foundation wall, since progression of inward movement is not seen.

Examples of Foundation Design & Construction Defects

Examples of foundation wall design and constructon defects discussed below emphasize the more severe conditions. Many other less severe, but significant defects have also occurred.

Note that, except for case of precast concrete wall, foundation walls for each house were built with hollow-core concrete block.

Collapsed Foundation Wall; Hamilton NJ

In early spring of 2004, sudden total collapse of an 8-inch block foundation wall (about 34 feet long) supporting back wall of single-family house occurred in Hamilton (Mercer County). Inside face of foundation wall was covered by finished wall, apparently hiding a cracked-wall condition.

Extensive damage occurred to finished basement.

House appeared to have been built in 1950s or 1960s.

As often happens when a foundation wall collapses, the wood-framed back wall (above) remained essentially intact, with relatively small amount of downward movement. Wall sheathing enabled the framed wall to act as a deep beam or vertical diaphragm. However, there will always be a risk that the house wall might also collapse, or deflect several inches, with major damage to supported elements such as windows, water pipes and gas pipes.

Foundation Wall On Verge of Collapse; Deal NJ

In September 2009, contractor performing remodeling work within finished basement in Deal discovered major damage to block foundation wall, behind finished wall.

Based on appearance of materials and construction methods, house appeared to have been built in 1960s or 1970s.

The 8-inch block wall was severely cracked and pushed inward as much as 3 inches. Inward force from the wall had kinked a cast-iron drain pipe and twisted several light-gage steel wall studs forming the finished wall. Soil backfill (surprisingly pure clay) was 5'-8" high, much greater than the typical code limit of 4 feet (especially for clay backfill). If the contractor had not found this condition, the wall would have eventually collapsed into the basement.

See web site www.structural101.com for photos.

Cracked Foundation Walls in Development; Marlboro NJ

I have inspected several houses in Marlboro with cracked foundation walls.

In November 2009, owner of two-story single-family house within development in Marlboro (built about 1995) requested inspection and evaluation of a 62-foot long block foundation wall supporting back wall of house. Owner explained that foundation wall had recently been repaired by contractor without a building permit. Repairs were performed to address severe cracking and inward movement of the wall (more than one inch, as measured). Owner was selling house and had to obtain an after-the-fact permit.

The 7'-8" high (above floor slab) foundation wall was built with 5 courses of 8-inch block on top of 7 courses of 12-inch block. Height of soil backfill (6'-8" above basement slab) greatly exceeded lateral-strength capacity of this wall, even without additional problems. However, drainage problem in back yard was also a contributing factor.

Steel tierods had obviously been installed through the wall. However, owner explained that contractor had also installed vertical steel reinforcing bars in the wall. Luckily for owner, contractor remained available to discuss details of repair work. Otherwise, without any design documentation, it would not have been practically feasible to determine details of vertical bars. Structural analysis showed that repair work could reasonably be considered adequate, allowing owner to obtain a permit and sell the house without much greater cost and delay.

At request of owners of adjacent property, inspection of cracked foundation walls was performed in August 2011. Owners were selling property and buyer requested that owners provide engineering evaluation of block foundation walls, due to comments made by general home inspector. Block foundation walls are built the same way as the neighboring house, with 8-inch block on 12-inch block. Height of wall and backfill height are essentially the same as well.

Back foundation wall has extensive horizontal cracks, although there is not any major inward movement, or drainage problem, as occurred for the neighboring house. However, not only are two other foundation walls also cracked, but the basement is more than half finished. Cracks clearly extend behind finished walls.

I had to advise owners that, even though current damage is not severe, and risk of additional damage may be relatively low, structural capacity of cracked walls has been weakened such that repair work is warranted.

A buyer facing this situation is understandably concerned. Options are to back away from the deal, require that owner have repair work performed or seek a credit to cover cost of repairs.

Even if the wall had been designed as full-height 12-inch block (and built per plan), height of backfill would still have exceeded the standard code limit of 6 feet. However, the use of 8-inch block for upper half of wall results in a grossly deficient condition.

There is not enough information to determine if the builder might have altered the original design. If so, the builder could then be considered responsible for design. However, code officials should not allow any such builder-modification without specific written approval of a qualified design professional.

- The point of course is that the main causes of major foundation wall problems with these two adjacent houses are; (1) Deficient design (even if builder modified original design) and, (2) Lack of adequate plan review by code officials.

It is reasonable to conclude that many other houses in this development likely have similar foundation problems, some of which may be escalating behind finished walls.

Inward Movement of Precast Concrete Wall; Sea Girt NJ

In spring of 2009, owners of a relatively new two-story single family house in Sea Girt reported problems with precast concrete foundation wall. House had been built in 2003.

Top of the 8'-8" high back foundation wall had been pushed inward up to 2 inches (relative to bottom of wall), partially sliding out from under, and twisting, the edge joist supporting the two-story high wood-framed back wall.

Key problem was lack of any lateral bracing along top of wall (with first floor joists parallel to wall) and high soil backfill.

Builder made the decision to use a precast concrete wall system as substitution for the block walls specified by architect. Height of foundation wall was increased 8 inches.

- As best as could be determined, no design plans for the precast wall system were ever submitted to code officials for the precast wall system. The manufacturer could not produce any plans when requested.

Builder had neglected to install any blocking to brace top of foundation wall, as specified in the installation guide. However, recommendations in the installation guide did not consider the actual lateral force to be resisted and did not constitute proper design by a licensed professional.

Building design plans (by architect) had specified 8'-0" high foundation walls built with 12-inch hollow-core concrete block (CMU). Maximum height of backfill was specified to be 7'-0". For three walls, two block pilasters were specified, at spacing of 10 feet or more.

The only detail at top of wall showed floor joists bearing on a single-layer sill plate with anchor bolts at 6'-0" spacing. Condition with floor joists parallel to foundation wall was not shown.

Foundation design specified on architectural plans was deficient for the following reasons;

- Height of soil backfill exceeded 6-foot limit in code table for 12-inch hollow-core block.
- Specification of hollow-core (unreinforced) pilasters, spaced at 10-feet or more, did not provide adequate lateral bracing for the relatively large inward lateral force from 7-feet of backfill.
- Lateral capacity of anchor bolts along top of wall, at 6-feet spacing, did not provide adequate shear capacity. There was also no specification for connection of floor joists to sill plate.

In this case, the building subcode official could have legitimately considered block foundation walls to be "properly" designed since the architect had specified pilasters. However, the code official also could have demonstrated a reasonable concern and requested design calculatiosn by a professional engineer. This might have been one reason that the change was made to the precast foundation wall system.

Yet, even if design plans for the precast wall system were sealed by a professional engineer and submitted to the code official, a major design problem would have remained.

Compared to plain concrete and block walls, precast foundation walls are are much more dependent on adequate lateral support along top of wall since the precast wall spans in the vertical direction only. Adequate engineering design for connections along top of wall are therefore essential.

However, as is the case for all "component" design, the precast wall manufacturer does not take responsibility for design of connections between their precast panel and other building elements designed by others (such as the architect).

Yet, the code official did not (apparently) request revised plans by the architect or any other design professional to show essential connection details. The all-too-predictable result was large-scale movement resulting in the need for major repair work.

Severe Damage To Foundation Wall; North Brunswick NJ

In spring 2010, owners of a single-family house in North Brunswick requested evaluation of cracked foundation walls. Owners did not apparently realize the severity of damage.

House appeared to have been built in 1970s or 1980s.

Block foundation walls were built with 4 courses of 8-inch block on 7 courses of 12-inch block. Soil backfill was 6'-4" high.

For long back foundation wall, wide horizontal cracks had occurred in mortar joints of the 8-inch block. Most importantly, back wall was pushed inward almost 2 inches. Front and side walls were also extensively cracked and pushed inward. Plans for remedial work specified installation of reinforced block piers on concrete base to brace these walls.

Collapsed & Damaged Foundation Walls for Retail Stores; Pennington NJ

During hurricane / tropical storm Irene at the end of August 2011, 45 feet of the front foundation wall of a retail-store ("strip mall") building collapsed into the basement. Concrete sidewalk along front of store, with benches, also collapsed. If anyone had been on the sidewalk at time of collapse, severe personal injury could easily have occurred.

Front foundation wall that had collapsed was built with 12-inch concrete block. Height of wall was 6'-8" above basement slab. Top of concrete sidewalk was above top of foundation wall, such that height of soil backfill was actually greater than height of wall. Height of soil backfill (at 7'-6", including sidewalk) was much greater than standard code limit of 6'-0", even before considering saturation of backfill.

Other foundation walls were 8-inch block. Height of backfill along back wall varied from 5'-0" to 6'-0", much greater than standard 4'-0" limit. Back foundation wall was severely damaged.

This building was apparently constructed in the 1950s based on information from owner and appearance of materials. Design and construction may not have been governed by any building code. Reinforcing work had previously been performed to brace one of the short side walls.

Existing building elements in good condition are generally allowed to remain, without reinforcing, unless there is an obvious safety problem. However, severe damage to these walls, including total collapse of a long segment of front wall, demonstrates the importance of proper evaluation during life of the structure.

Severe Damage to Foundation Walls; South Brunswick NJ

In September 2011, waterproofing contractor performing remedial work within finished basement in South Brunswick discovered major damage to two block foundation walls, behind finished walls.

Instead of having engineer evaluate damage, contractor barged ahead and installed FRP strips on these severely damaged walls. Owner was skeptical of this "repair" work and requested independent engineering evaluation.

First floor joists are parallel to front wall, such that lateral support along top of foundation wall was weak at best.

House was built in 1973. Foundation walls were built with 8-inch concrete block. Height of walls is 7'-4". Height of soil backfill, at 7'-0", greatly exceeded standard 4'-0" limit.

Roots from a large tree about 5 feet from front corner of basement had almost certainly been pushing against front and side foundation walls.

Although tree roots were very likely a major contributing factor for severe damage, grossly excessive height of soil backfill was the primary cause of structural damage.

Top of front foundation wall was pushed inward about 3 inches relative to base of wall. At several locations along the wall, wood blocking had been installed between sill plate and nearest interior floor joist. There was no effective lateral support along top of wall. Due to excessive lateral earth pressure and (perhaps) additional inward force from tree roots, lateral force along top of wall overwhelmed the very limited resistance provided by interior floor joist, which simply twisted in response, as should be expected.

Front part of side foundation wall was also severely damaged. Remainder of side foundation wall was cracked and pushed inward.

Installation of FRP strips on front foundation wall was worse than useless. If the owner had allowed contractor to "complete" such work, the front wall would very likely have collapsed into the basement within a very short time.

Front foundation wall had to be completely replaced. Although about half of the side foundation wall could have been braced, owner decided to replace that wall as well.

Severely Damaged Foundation Walls; Freehold Twp NJ

In early 2012, owners requested evaluation of severely damaged block foundation walls around full basement of two-story single-family house in residential development.

Front, back and side foundation walls were severely cracked and pushed inward.

Per owners, house was built about 1982.

Foundation walls were built with 8-inch concrete block. Height of foundation walls is 7'-2". Height of soil backfill, at 5'-8", is much greater than typical 4'-0" limit.

Side foundation wall (parallel to first floor joists) was pushed in 2 inches relative to base of wall. Top of wall was also pushed inward. Very wide horizontal crack had occurred in mortar joint near mid-height of wall.

Front and back walls were pushed in 1-1/4 inches relative to base of wall. Wide horizontal cracks had occurred in mortar joints.

Repair costs are estimated to be $15,000 ore more, especially if side wall is reconstructed.

Cracked Foundation Wall in Finished Basement; Plainsboro NJ

In late March 2012, prospective buyers of two-story single-family house, built about 1995, requested evaluation of foundation walls due to comment noted in home inspection report.

Foundation walls were built with 12-inch concrete block. Height of walls is 7'-8" above floor slab. Height of soil backfill, at 7'-0", is greater than typical code-specified 6'-0" limit.

Most of basement is finished, such that inside faces of foundation walls are obstructed. Inside face of back wall was accessible from storage room. At least two horizontal cracks were seen in mortar joints of the accessible part of back wall, which was also pushed inward a small amount.

The report noted that damage was not severe and emphasized that, when evaluating foundation wall capacity, actual performance over many years should be considered more important than design requirements for new construction. However, the basic code violation had to be noted. Potential for even greater damage behind finished walls also had to be discussed.

After considering their risk tolerance, the buyers "walked away" from the purchase. Although the risk of further damage may be relatively low, the "unknown" factor causes enough uncertainty that many prospective buyers will not be willing to take the risk without (at least) significant reduction in purchase price.

Additional Problems After Construction

Various additional problems after construction can occur due to inadequate design of foundation walls (for original construction) and lack of adequate evaluation when alterations are made.

In recent years, I am aware that code officials from some municipalities (such as Marlboro and West Windsor) have been issuing orders for homeowners to obtain permits after construction (without a permit) of raised patio along house wall.

Owners often have contractors install a raised patio along back wall of house without obtaining a building permit. Whether the owner does or does not understand (or at least sense) that a permit is required, just about every owner in this situation does not comprehend the importance of having the basement foundation wall evaluated prior to installation of the raised patio.

When lack of permit is noted by code officials, an owner is typically instructed that they must obtain engineering certification of the relevant foundation wall. However, in general, certification is not warranted unless the condition has already existed for many years, demonstrating that the wall has adequate capacity, even though height of soil backfill typically exceeds the limit per standard code provisions. Result of evaluation is most often a conclusion that the owner must; (1) Brace or reinforce foundation wall along raised patio, or (2) Remove the patio. For owner with finished basement, cost of bracing or reinforcing foundation wall is much greater than for an unfinished basement.

New Home Warranty Program (NHWP) generally denies claims for repair of cracked foundation walls, even when it is (or should be) clear that design and construction is grossly deficient relative to building code requirements. Lack of coverage is a travesty since buyers of new homes are "sold" on the belief that "major structural defects" are covered.

Use of FRP ("carbon fiber") strips to reinforce cracked foundation walls is growing. However, considering how this product is being sold, many (very likely the vast majority) of these FRP installations have been performed without a building permit and without any specific engineering. Buyers of homes with FRP strips typically then have no reliable way to determine if design and construction is adequate, unless detailed information about the as-built installation is available. Without such documentation (as should be the case if a permit is obtained), an engineer that certifies design and construction of as-installed strips would be taking on high risk of liability for future problems.

Recommendations

NJ Department of Community Affairs (DCA)

After investigation as may be warranted to learn more about the extent of foundation wall problems throughout New Jersey, DCA should take the following actions as soon as feasible;

- ☑ Issue letter to construction officials and building subcode officials emphasizing the importance of proper design in accordance with code requirements, especially for concrete block walls.

- ☑ Publish a new Bulletin similar to former Bulletin 90-9. Highlight new Bulletin in the Construction Code Communicator. See below for detailed discussion.

- ☑ Issue letters to New Jersey Board of Architects and New Jersey Builders Association, highlighting need for better design of foundation walls. Emphasize that an architect should obtain advice from qualified professional engineer if the architect is not qualified to perform foundation wall design, especially for conditions that are not within the scope of standard code tables.

- ☑ Consider modifications, made to NJ versions of current and future model building codes, specifically addresssing requirements when two different block thicknesses are used for foundation walls. At the very least, a note should be added to Table R401.1.1(1) to clarify that a wall built with two different thicknesses of block must be considered the lesser thickness for use of prescriptive requirements per standard table.

- ☑ Consider new UCC provisions to address permit requirements for installation of FRP strips to repair cracked foundation walls.

New Bulletin should discuss the following issues;

1. If height of soil backfill will be more than 4 feet, the use of 8-inch hollow-core concrete block will generally violate standard code provisions. If height of soil backfill will be more than 6 feet, the use of 12-inch hollow core block will generally violate code provisions.

2. If foundation wall along full basement is to be built with courses of 8-inch block on top of 12-inch block, the wall must be considered 8-inch block for use of standard code tables. If the standard table is not used, design using two different block thicknesses must be performed by a qualified engineer.

3. Design must include necessary details to ensure that top of basement foundation wall has adequate lateral support to resist design lateral soil force. If (as is common) the wall is designed to span vertically, proper design requires not only adequate anchor bolts (connecting sill plate to wall), but also adequate lateral resistance from first floor. When first floor joists are parallel to foundation wall, design must specifically address lateral support along top of wall, or the wall should be designed to span horizontally between reinforced block (or concrete) piers.

4. Precast foundation wall panels are designed by the manufacturer to span in the vertical direction only. Building designer is responsible for ensuring that top of precast foundation wall has adequate lateral design capacity from first floor and all connections.

5. For single-family house with full basement, back foundation wall should be designed for future raised patio unless grade is at or very close to elevation of basement floor slab ("walk-out" basement).

6. Basement foundation walls along attached garage, and driveway, must be designed to resist "surcharge" pressure from weight of vehicles. This requires engineered design.

7. If block pilasters are relied on for lateral resistance, pilasters must be reinforced with steel reinforcing bars that extend into a properly sized base (footing). Plain (unreinforced) pilasters do not have adequate strength to resist lateral force distributed from adjacent wall.

8. For any block wall to be reinforced with steel reinforcing bars, proper details on design plans are essential to show bar position and splice requirements.

9. Basement foundation walls must be allowed to gain strength before excessive soil backfill is placed against the new wall. This essential requirement becomes more important in cold weather.

10. In general, for a basement foundation wall designed to span vertically, first floor must be adequatetly connected to top of wall before too much backfill is placed against the wall. Requirements for adequate connection must be provided by qualified designer (architect or engineer) per design plans.

11. Perimeter drains must have a positive outlet to be effective.

12. For finished basement, access panels should be installed in finished walls to allow for periodic inspection of foundation wall conditions.

NJ Board of Architects

NJ Board of Architects should inform licensed architects about problems with foundation wall design, using effective methods of communication. The following specific issues should be addressed;

1. Extensive problem of defective foundation wall design in New Jersey.

2. For use of prescriptive code provisions, all conditions for use of such provisions must be satisfied.

3. Prescriptive code provisions do not address all design requirements. Requirements for proper lateral support along top of wall is a key omission.

4. Foundation wall design should be performed by qualified professional engineers if the architect is not qualified for such design.

5. Total lateral force from earth pressure against foundation walls increases with the square of soil backfill height. Required bending strength is a function of lateral force and wall height. Relatively small changes in backfill height and wall height therefore have effects that are much larger than might be expected.

6. Foundation walls must be designed for weight of surcharge pressure from weight of vehicles on garage floor slab or driveway adjacent to foundation wall.

7. Foundation walls supporting back of single-family house should be designed for backfill at top of wall, to account for later installation of raised patio. If such design is not provided, design plans should include a highlighted note explaining that raised patio must not be installed along back wall unless back foundation wall is reinforced or braced from inside basement.

8. For precast concrete foundation wall systems, recommendations provided in publications by wall manufacturer must be verified. In particular, recommendations for lateral support along top of foundation wall may not provide adequate capacity based on typical design standards.

Legislation

The following requirements should be considered as part of legislation governing design and construction in New Jersey;

1. Along with home warranty policy, notice should be provided to buyers of new homes emphasizing that the home warranty policy does not cover design defects. Examples of potential major defects should be listed, including foundation walls. Buyers should be informed that they may want to have an inspection and evaluation performed by qualified professional engineer and architect to identify the risk of design defects.

2. For purchase of newly constructed home, notice should be provided to buyer explaining that issuance of a certificate of occupancy by municipal building department does not constitute any guarantee that design and construction of the house complies with building code requirements governing structural capacity. Such notice might also extend to any other aspect of house design and might also extend to purchase of all homes (new & old) in New Jersey.

3. Builders of new homes should be required to provide complete set of design documents (plans, specifications) to the buyer (new owner). Set of plans must be the set "released" by code officials for construction. Any "as-built" changes made by the builder must be noted on the original plans or in revised plans. All additional plans for "component" elements (such as roof trusses) designed by others, including precast concrete foundation walls, must be included in design documents. Preferably, all plans provided to owner should be sealed by the responsible design professional when applicable.

4. DCA or some other agency should be responsible for collecting and storing digital versions of all design documents for new homes.