St. Paul's Episcopal Church
116 South Church Street
Monroe, NC 28112-5605
Limited Structural Observations
for
Kyle Dunn
c/o St. Paul's Episcopal Church
116 S. Church Street
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by

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Photo #1
The purpose of this structural observation trip was to visually inspect the sanctuary floor framing members and the foundation walls that support them as seen from the crawl space. The clear distance between the nave walls is approximately 27'-10" and the length of the sanctuary/nave is reportedly 66' long. There is a 6" wide by 10" deep, dropped, timber girder that runs front to back which supports 2x10 floor joists that span from the inside face of the foundation walls to the centerline of the girder, a distance of 13'-8" (+/-).

Photo #2
There is a very small partial basement under a portion of the chancel or the area just behind the chancel. This picture is taken in that area looking to the right where this improper support was added to offer intermediate support to several of the floor joists spanning approximately 13'-8".

Repair per the specifications spelled out in photo caption #5, which follows.

Photo #3
This picture is taken in the crawl under the sanctuary/nave at the right/front corner. It shows that a 4"x6" dropped girder was added to intercept the 2x10 (actual dimensions) floor joists loads just to the inside of the left foundation wall.

Photo #4
This picture shows the same dropped girder with missing support. Dry-stacked brick as seen in the previous picture has simply collapsed away from the underside of the 4x6 dropped shoring girder.

Photo #5
This is the rear end of the dropped 4x6 shoring girder, where a 4x4 wood post was furnished for support. The posts rest on flat wood, which in turn relies on the earth for support. It is clear that the intent of this shoring effort was intended to be a short-term precaution to prevent failure, clearly, the time has come to address this problem and those similar to it utilizing permanent construction techniques. Dry-stacked brick is not permitted. Wood posts that are pressure treated for ground contact are not permitted. Wood posts that are not secured so that lateral translation is prohibited are not permitted.

In this case, provide 8"x16", concrete masonry unit (CMU) isolated piers to support a 3-ply, pressure treated, 2x8 girder spanning no more than 6'-0" clear between the piers with their 16" length parallel with the girders. The new 3-ply, 2x8 dropped girder may cantilever as much as 12" at each end. Therefore the total length of the dropped girder can be as much as 10'-8". Since the spacing between joists varies from 18" to 21", the dropped girder can support up to six adjacent joists with only two CMU piers. The top 4" of the pier must be clay brick or solid solite block. The footings supporting the piers must be 24"x24"x8" poured-in-place, concrete. The centerline of the new piers must be at least 16" away from the inside face of the existing brick foundation wall, to allow ample clearance for the new concrete footing to not conflict with the continuous existing foundation wall footing.

Photo #6
This is a close-up of the previous photo showing a wood shim added to the top of the 4x4 post. It was added in an effort to raise the 4x6 dropped girder enough so that it would engage the floor joist above. The visually observable gap between the top of the 4x6 girder shows that the shim at the top of the post was not adequate to provide a continuous, uninterrupted load path from 2x10 floor joists above.

Photo #7A
This picture shows the crawl access opening on the left side of the main church sanctuary/nave building. It shows that the foundation wall is four wythes of solid brick thick. It also shows rusted metal straps used as lintels for the support of the brick over an opening that is no more than 14" wide. Besides being rusted, the straps have slipped as the mortar bed joints have deteriorated over time. The result is a joist that sits on one course of brick that is sagging badly.

Photo #7B
As a part of the repointing project scheduled for the future, lintel conditions at all wall openings must be scrutinized to see if they require new steel supports in the form of wider flat plates, steel angles or even wide flange beams with flange plates. In the short term, this opening and the one on the left side of the crawl need new 1/4"x3.5"x3.5" angles installed at each wythe. The angles require a minimum of 4" of sound bearing on both sides of the opening.

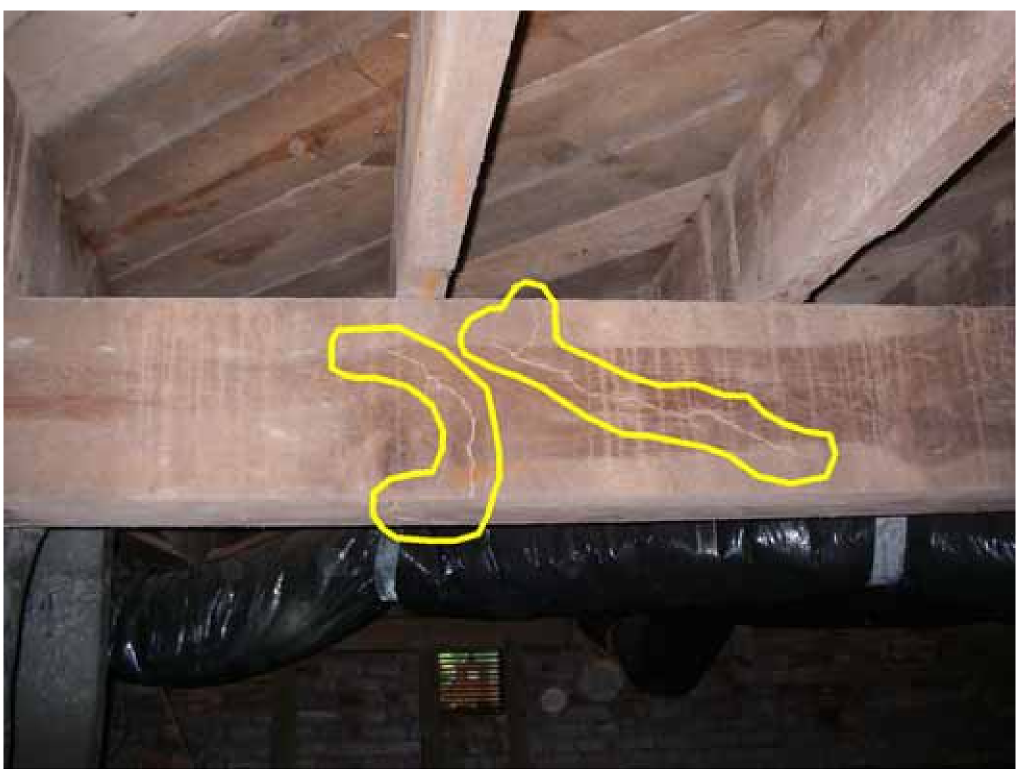

Photo #8
This picture is taken at the front of the crawl and shows the large 6" wide by 10" deep heavy timber girder that spans front to back. There is evidence of past wood destroying insect infestations. As a structural engineer, I am not certified to comment on whether or not an infestation is active or not.

Consult with a qualified specialist or with whomever you use on a regular basis to address such concerns.

Photo #9
This photo shows the left/front corner of the crawl where the joist ends are supported by a 4"x6" dropped girder in a similar manner to that reported earlier at the right/front corner of the crawl. As can be seen, an 8"x8" dry-stacked pier has failed leaving only 4x4 wood posts to provide the support for the dropped girder. There are three such posts as seen in the next picture.

The post seen to the left of the failed brick pier serves the front wall and will be discussed in greater detail in photo caption #11.

Photo #10
All three of the 4x4 wood posts assigned to support the dropped 4x6 girder are still in place, but are doomed to failure if not replaced. Their support at grade varies from a flat wood spreader to single bricks laid directly on the top of the unexcavated crawl grade.

See photo caption #5 for the repair needed down a part of the left side of the sanctuary/nave foundation wall.

Photo #11
This picture shows the left side of the front foundation wall serving the sanctuary/nave building. The 4x6 shoring member and its three vertical 4x4 posts provided temporary support for the diagonal wood subfloor planking that formerly spanned from the rim band joist to the first interior joist. Water and insect damage to the base of the rim band totally compromised the capacity of the rim band as can be seen dramatically in the photo #13.

Photo #12
This picture shows the temporary shoring used behind the front foundation wall of the crawl next to the left/front corner. It shows two of the three 4x4 wood posts used to support the 4x6 girder, which was installed to support the subflooring.

Photo #13
This is the base of the single ply, 2x10, rim band after probing with an awl. The wood disintegrated into dust. The role of the rim band as noted in the previous picture appears to have been to support only the diagonal subfloor planking. The front wall construction appears to be supported on the outer three wythes of brick.

The relationship of the foundation wall to the wall above the first floor needs to be confirmed even if intrusive measures are needed to do so. The full extent of the decayed rim band needs to be determined using destructive measures and proper support provided. As already noted, the 4x6 shoring supported by 4x4 posts is simply not working and violates a number of code provisions. Replace the band sill with a 2-ply, 2x10 pressure treated for ground contact. It should be installed tight to the underside of the subfloor planking and held in place with temporary shim stacks. Fill the gap between the new 2-ply, rim band with non-shrink grout using a metal rod to pack it and remove and voids within the mix.

Photo #14
This picture is taken about midway down the left side of the crawl foundation wall. The joist seen here is the eighth interior joist relative to the decayed rim band seen in the previous photos. There is a continuous 2x4 ribbon board used at the top of the joists that bear on the side foundation walls used to support the diagonal subfloor planking. It is notched into the joists. That notch adversely affects the shear capacity of the joists.

As can be seen, the notching at the base of the joists is a far more serious matter due to its depth. Typically, notches at bearing should be limited to one quarter of the actual joist depth. In other words, the actual depth of the 2x10's is 9.75", so the notch at the base should be no more than 2-7/16" assuming there are no other notches. As highlighted in this photo only one third the depth of the joist is available to transfer shear load to the supporting brick ledge. See the following page for additional discussion.

3.4.3.2 For notched bending members, shear force, V, shall be determined by principles of engineering mechanics (except those given in 3.4.3.1).

(a) For bending members with rectangular cross section and notched on the tension face (see 3.2.3), the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \left[\frac{2}{3}F_v'bd_n\right]\left[\frac{d_n}{d}\right]^2 \qquad (3.4\text{-}3)$$

where:

d = depth of unnotched bending member

d_n = depth of member remaining at a notch

F_v' = adjusted shear design value parallel to grain

(b) For bending members with circular cross section and notched on the tension face (see 3.2.3), the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \left[\frac{2}{3}F_v'A_n\right]\left[\frac{d_n}{d}\right]^2 \qquad (3.4\text{-}4)$$

where:

A_n = cross-sectional area of notched member

(e) When a bending member is notched on the compression face at the end as shown in Figure 3D, the adjusted design shear, V_r', shall be calculated as follows:

$$V_r' = \frac{2}{3}F_v'b\left[d - \left(\frac{d-d_n}{d_n}\right)e\right] \qquad (3.4\text{-}5)$$

where:

e = the distance the notch extends inside the inner edge of the support and must be less than or equal to the depth remaining at the notch, $e \leq d_n$. If $e > d_n$, d_n shall be used to calculate f_v using Equation 3.4-2.

d_n = depth of member remaining at a notch meeting the provisions of 3.2.3. If the end of the beam is beveled, as shown by the dashed line in Figure 3D, d_n is measured from the inner edge of the support.

Figure 3D Bending Member End-Notched on Compression Face

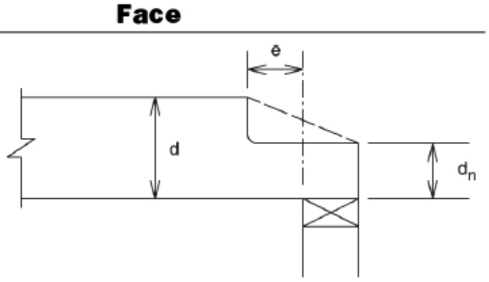

Photo #15

The data seen on the left is taken from the National Design Specification, which governs all wood construction. Using these formulas, the shear capacity of the deeply notched (top and bottom) wood joists is less than 10% of the applied dead and live loads. This is a global problem occurring on both sides of the sanctuary/nave building.

The severity of the over-notching of the 2x10 floor joists varies, but affects more than 50% of the members. This is but one of three structural deficiencies affecting the support of the typical, 2x10 floor joists at both sides of the church. Another issue will be noted in the pictures that follow.

In consideration of this, a continuous line of permanent support is needed down both side walls of the sanctuary/nave building, but not at the transept, which will be addressed separately. This line of support should be installed in accordance with the directions given in photo caption #5, with splice joints of the 3-ply girders occurring only above CMU piers. The plies of the new dropped girder should be connected together with two rows of 10d (0.148"x3") common nails spaced at 24" on center, staggered top and bottom at 12". There should be three 10d nails stacked vertically at splice joints. The nailing should be done from the outer plies into the inner ply, meaning the girders should be rolled over to connect them together. If this is not practical, connect the three plies together from one side using Simpson Strong-Tie SDS254500 (hot-dipped galvanized) screws at the same spacing designated for the nailing. Since the framing will be continuous, the pier spacing will always be 7'-4" or less. Be sure to place a 2x8x16" long pressure treated wood shim block above all 8"x16" CMU piers to limit the clear span of the 3-ply, 2x10 to six feet.

Photo #16
This is simply a close-up of the worse notched out condition of a single 2x10 floor joist.

Photo #17
This is the ninth 2x10 floor joist relative to the front foundation wall of the crawl and it has a different notching pattern, but with the same adverse effect on the shear capacity of the joist.

Photo #18
This picture is taken at the right side of the crawl and reiterates the observation that the over-notching is generally global in nature along both side walls. See the next picture for an exception.

Photo #19
This picture is taken at the right foundation wall near the transition from nave to transept. Inexplicably, the joists are not over-notched at the bottom. While they are notched at the top (the compression edge), they have sufficient shear capacity. While this is the exception and not the rule, the new 3-ply perimeter dropped girder repair may be discontinued where this condition occurs provided the rim band, ribbon board and brick support are all sound. See the next picture for an example of decay to the 2x4 ribbon band.

Photo #20
Not far from where the previous picture was taken is this decayed 2x4 ribbon board. This is shown to illustrate that there are a variety of structural issues affecting the proper support of the floor joists and the subfloor, so eliminating even a small portion of the new 3-ply, 2x10 dropped girder would require careful deliberation.

The decayed, structurally compromised, ribbon board should be replaced with new pressure treated wood blocking spanning between and secured to existing 2x10 floor joists down both sides of the sanctuary/nave building.

Photo #21
This picture is taken on the left side of the crawl and shows a dropped shoring board hanging from the ends of 2x10 joists it was intended to support. The joists are the 12th through the 15th relative to the front foundation wall. All of the vertical supports have fallen away.

Photo #22
Here are some of the vertical supports that formerly held up the shoring girder seen in the previous picture.

Photo #23
This is another example of a 2x4 ribbon board completely lost to decay and insect damage. This picture was taken between the 14th and 15th floor joists on the left side of the building. See photo caption #20 for repair specifications.

Photo #24
This picture shows one of four interior 16" square, isolated, all brick piers used to support the main 6x10 girder that spans front to back down the middle of the crawl.

Photo #25
This center girder support pier has lost the right half of the brick that forms a curb into which the 6x10 girder fits.

Reinstall the brick using mortar that matches the existing in terms of strength and hardness.

Photo #26
This picture shows the back end of the 6x10 (with considerable wane at its right bottom edge). The brick supporting the girder is distressed. Large separations are visible at both the bed and head joints.

Install a new 16" square, CMU pier with the top 8" constructed with clay brick units or solid solite block. The footing should be poured-in-place concrete measuring 30"x30"x12" thick. The new pier should be located 24" from the wall seen in this picture. Repoint the brick seen in this picture in accordance with the following guidelines:

Repointing of deteriorated or missing brick mortar is done for one or more of three reasons:
1. Improved aesthetic appearance.
2. To prevent water intrusion into a cavity usually between multi-wythe brick construction.
3. To prevent freeze/thaw action and minimize efflorescence. Freeze/thaw occurring within mortar joint gaps leads to further deterioration of mortar joints.

Repointing of brick mortar joints is the two-step process of (1) removing the remnants of deteriorated mortar, followed by (2) tuckpointing:
1. The removal of the mortar to be replaced is accomplished with a grinding wheel. If this method risk damage to the existing brick, then careful chipping of mortar with a pneumatic chisel or hand chisel is required. All deteriorated mortar remnants must be removed to a depth of ¾". The resulting bed and head joints must be free of all mortar before tuckpointing can commence.
2. ***Tuckpointing*** is performed in three ¼" deep passes of new mortar. The reason for applying new mortar in ¼" layers is to enhance compaction; therefore tooling the mortar is important. Do not apply a second ¼" deep mortar pass until the preceding mortar pass is thumbprint hard.

If repointing is localized in scope, the success of the repair will be judged by matching the color, strength and joint type of the existing. Excessively strong (hard) mortar can cause spalling of the brick.

Photo #27
This pier is located under the left side of the transept in line with the left sanctuary/nave left foundation wall. The wood shims atop the isolated masonry pier supporting the middle of a 6x10 girder are improperly utilized. See the next picture.

Photo #28
This is a close-up of the wood shim stack above the pier seen in the previous photo. As already seen in the case of wood supported shoring girders, wood must be fastened in place to avoid slippage. Nowhere is this more true than at girder bearing locations where shims are used to transfer loads from girders to piers. There are a host of rules used in a neighboring jurisdiction as printed below. While these rules have not been formally adopted by Union County, their appropriateness cannot be dismissed.

Reshim this girder in accordance with the following rules:

1. The shim must be completely under beam width or each ply of a multiply beam for complete support across beam width, also shim cannot project off pier.
2. The minimum width dimension of the wood shim must equal or exceed the length dimension of the shim, i.e. a 2x6 shim must be at least 5.5" long; a 2x8 must be at least 7.25", a 2x10 must be at least 9.25" long. Since full contact is required over the width of the girder supported, this also means that the length of the shim must be at least the width of the girder.
3. If wood shims are stacked in layers, they must be interconnected to prevent movement.
4. The wood shim(s) must be of the same grade and species of the girder supported. If a lower grade and species of material is used, the bearing stresses must be checked by an engineer. Shims can also be of steel provided they meet the criteria spelled out in 2 and 3 listed above.
5. If wood shims are stacked, the wood grain of each shim must be perpendicular to the adjacent layer.
6. Stacking of wood shims is limited to 4" maximum. For gaps in excess of 4", extend the height of the masonry pier below as required.

Photo #29
This is the fourth isolated masonry pier under the center girder relative to the front foundation wall. The shim under the 6x10 girder is too small. In accordance with rule #2 from the previous page, the length of the shim must be as long as its width. Therefore, the width is determined by the girder width. This suggests that a 6"x6" shim is needed. If steel is used, that would be the case.

Replace this shim with a steel shim stack measuring no less than 6" square.

Photo #30
This picture was taken at the left/rear corner of the transept and shows stacked CMU supporting the end of the 6x10 girder located just inside the transept left foundation wall. The bottom 12"x16" CMU unit is turned on its side, which isn't allowed. The wood shimming is incorrect. See the following pictures for additional discussion.

Photo #31
This picture shows white circles where tapered wood wedges were added to close the gaps between 2x10 floor joists and the 6x10 support girder. They were required because there was no poured-in-place concrete footing under the improperly utilized CMU girder support pier. Settlement ensued causing the gaps to materialize. See the following.

Photo #32
This is a close-up of one of the tapered wood wedges used to bridge the gap between the 2x10 joist and 6x10 girder. Note that the wood wedge is crushed due to the limited area of contact bearing typical of tapered wood wedges used as shims. Wood wedges should never be used as shims. See the next picture.

Photo #33
This picture shows wood wedges are also used above the dry-stacked CMU corner pier seen in photos #30 and #31.

Reconstruct the pier in accordance with specifications for isolated piers noted in photo caption #5. Remove wood wedges and replace with steel shim stacks in accordance with the shimming rules printed in photo caption #28.

Photo #34
This picture is taken at the left reentrant corner between the transept and the chancel. The 6x10 girder is not properly supported by solid masonry.

Add a new 16" square CMU pier support in accordance with the specifications found in photo caption #26.

Photo #35
This picture shows the reentrant corner of the right transept and the sanctuary/nave where the support of the 6x10 is reasonably sound.

The yellow highlights are to direct attention to electrical concerns that deserve the attention of a licensed electrical contractor.

Photo #36
This picture taken under the right framing bay at a point roughly 25' from the front foundation wall also highlights a possible electrical concern, which is outside the scope of this report.

Photo #37
This picture is taken just inside the crawl space, front foundation wall and shows an insulated supply duct connected to a non-insulated, metal supply boot that penetrates the diagonal plank sub-floor. While the HVAC system is also the scope of this report, it should be noted that the build-up on condensate on un-insulated metal in contact with wood can lead to fungal growth and wood decay.

Photo #38
This picture shows the right/rear corner of the transept, where more temporary shoring was added. In many ways, this area is a mirror of the left/rear transept seen in photos #30 through #33, with the exception of wood having been used to support the 6x10 girder. See the following for additional description.

Photo #39
This is a close-up of the previous picture. The framing errors seen here are similar to those first discussed in this report.

Repair per the specifications spelled out in Photo Caption #5.

Qualifications:

This report represents the professional opinions of Yates/Starnes Engineering, PA, (YSE) resulting from visual observations of readily accessible areas of the home. Structural components concealed from view were not observed. The findings bound in this report were gathered within a limited time frame. No structural calculations were performed in the preparation of this report unless noted otherwise in the body of the report. Neither non-destructive nor destructive tests were performed in the process of collecting data. YSE was not involved in the design, construction, or maintenance of this property.

YSE has no control over differential soil settlement resulting from the shrinking or swelling of expansive soils. Differential settlement can create movement in exterior masonry veneer and/or interior wall coverings, which can create new cracks or widen existing cracks. Therefore, YSE's maximum liability is limited to the amount of the consultation fee.

Yates/Starnes Engineering neither makes representations nor guarantees with respect to latent deficiencies or future conditions of this property. The recommendations of this report are applicable at this point in time. This report is not an overall review of this property but represents only those items mentioned within this report. Yates/Starnes Engineering does not do repair work and therefore has no financial interest in any repairs that are made.