TIREY & ASSOCIATES, P.C.

CONSULTING STRUCTURAL ENGINEERS

March 22, 2011

Ms. Trish Heatherton
First Congregational Church
PO Box 230
Lebanon, NH 03766

RE: First Congregational Church Structural Condition Evaluation, Lebanon, NH

Dear Trish:

At the request of the First Congregational Church of Lebanon, NH, and in accordance with our agreement for engineering services, I performed a visual structural condition evaluation of the existing church on March 16, 2011. The condition evaluation is based solely on those portions of the structure which are exposed to view or can be inferred through indicators in the finish materials on the building. No structural load capacity analysis of the existing building was performed, as those services are outside the scope of our agreement. For purposes of this report, the side of the church sanctuary containing the front entry doors, and which faces the Town Square, is called the north side.

General Building Description

The entire building complex is made up of three sections. The original church sanctuary section was constructed in about 1828. The fellowship hall and kitchen section was constructed in about the 1920's, while the rear office section was constructed in the 1960's.

In general, all the buildings are wood framed although there is a small amount of steel beam floor framing in the 1920's section.

Church Sanctuary

The church sanctuary has foundations comprised of mortared granite stone blocks at the north wall and at the north end of the east and west foundation walls. The remainder of the east and west foundation walls are concrete topped by about a 20" height of brick wall. The first floor framing is comprised of heavy timber wood beams supported by either concrete filled steel Lally columns or heavy timber wood columns at 4 locations. The wood floor joists have a mortise and tenon joinery connection to the floor beams and the exterior wall sill beams, with the ends of the joists notched to form the tenon. The balcony floor framing of the church sanctuary is hidden from view but is assumed to be wood. There is a steel hanger rod supporting the south edge floor beam, with the hanger rod carried by the roof trusses above. The roof framing is comprised of heavy timber primary wood roof trusses spanning the east-west width of the building, with members connected by pegged mortise and tenon joinery. Heavy timber wood roof beams span between the trusses to support roof rafters which run as single pieces from the eave to the ridge. The roof rafters are 3" x 5" x 3'-0"± o/c. Ceiling joists span parallel to the heavy timber trusses, supported at three interior locations plus the exterior bearing walls. Lath and the plaster ceiling of the sanctuary are attached directly to the ceiling joists. A steeple/cupola is located at the north end of the church and extends above the main roof. The

P.O. Box 639, 150 Old County Rd., Littleton, NH 03561
Tel: 603-444-6211 Fax: 603-444-0314
e-mail: tirey@tireyandassociates.com
web: www.tireyandassociates.com

steeple/cupola section has a floor at the main building attic floor level, one intermediate floor level, the church bell floor framing level, the church bell roof framing level and the large cupola above. There is no insulation whatsoever at the ceiling level of the sanctuary, or above. It is not unknown if there is insulation in the sanctuary walls, but would not be expected to be found considering the lack of insulation at the ceiling.

Fellowship Hall

The Fellowship Hall section of the building has concrete foundation walls topped by about a 20" height of brick wall. The first floor framing is comprised of wood floor joists supported by concrete masonry block bearing walls or steel beams, in addition to the exterior walls. The roof of this section of the building is believed to be wood framed, although access to the attic space was not gained during the visit.

Office Addition

The rear, southerly office addition has exterior concrete masonry block foundation walls with parging over most of the exposed wall area. The floor of the this addition which is level with the fellowship hall, is wood framed and appears to have a crawl space below it. The roof framing is a low slope monopitch roof, the framing of which was not accessible.

Condition Assessment

Office Addition

The office section of the building appears to be in good condition, with one exception and one caution.

First, the exterior concrete masonry block foundation walls have cracks throughout many of the exposed mortar joints. The cement parging which covers the masonry block has partially fallen off the block, particularly at the bottom half of the south wall. This likely results from this parging being in the “snowplow zone”, whereby the bottom of the wall is subject to exposure to salt laden snow and water, and even direct contact by snowplow blades. Thermal expansion and contraction of these walls can also lead to cracking. One spot on the east foundation wall, close to the southeast corner of the building, has the mortar fallen out of a vertical joint and the parging cracked. The presence of the cracks can permit water entry which, over the long term, leads to freeze-thaw degradation of the masonry block. The remainder of the existing parging should be removed and new fiber reinforced parging applied to the masonry block after re-pointing of cracked mortar joints.

Second, the one caution relates to the fiberglass batt insulation at the wood joist floor framing. This is visible through what once had been an exterior window of the south wall of the fellowship hall section of the building. The foil faced fiberglass insulation was installed with the foil facing down, away from the occupied space. Since the foil acts as a vapor barrier, it should be installed at the underside of the subfloor, closest to the occupied space. In its current condition, water vapor can become trapped between the subfloor and the foil facing, creating rot in the upper portion of the floor joists. The insulation should be removed, the joists inspected for possible rot, and if none is present, the insulation can be re-installed with the foil at the immediate underside of the subfloor.

Fellowship Hall

The fellowship hall is in good condition. There are no signs of cracking in the foundation walls. The interior concrete masonry bearing walls are also in good condition, without cracking occurring. The roof planes are straight without significant visible deflection.

There are a couple of minor issues or observations to be aware of, but which are not affecting the structural safety of the building. First, there is a hump in the fellowship hall floor that is located at the steel beam visible from the lower level. The hump has been created because the floor joists have been framed into the side of the steel beam, with the top of the joists originally at the top of steel beam or at the top of a wood plate on top of the steel beam. With this original construction arrangement, when the wood shrank as it dried out, the top of the joists shrank downwards while the steel beam did not, resulting in the hump in the floor.

Second, there has been a roof leak just to the west side of the emergency exit door at the northeast corner of the fellowship hall. The roof at this location has both a change of roof plane elevation and a change of slope from steep to shallow. The leak appears to be occurring at the location where of these changes occur. A roofer should be consulted to ascertain where the water is entering so that a repair can be made. Correcting the leak can prevent long term degradation of the structural framing.

There is one small cracked area of plaster and lath ceiling in the fellowship hall. This does not appear to be a widespread problem, so a local repair of that crack should be sufficient.

There is a basement connector between the fellowship hall and the sanctuary basement. One of the heavy timber wood floor beams has been damaged by powder post beetles, which burrow into and eat the wood fiber. It appears that there may still be some ongoing bug activity, so having the wood treated by a pest control professional would be advised. Because the floor beam has a relatively short span, the depth of the damage does not appear to have compromised the ability of the wood beam to carry the applied loads.

Church Sanctuary

The main wood floor framing of the church is generally in good condition.

The steel Lally columns which support the heavy timber wood floor beams have varying degrees of corrosion at the bottom of the columns due to moisture migration from the dirt floor basement space. The column adjacent to the two hot air furnaces in the basement space is particularly bad. A portion of the steel jacket encasing the concrete core has corroded away for at least a third of the circumference of the pipe column. Some of the concrete has also spalled out from inside the steel jacket. This Lally column should be replaced. The remainder of the columns which have some corrosion present should be cleaned and painted with a corrosion inhibiting paint. One of the Lally columns has a cracked cap plate which should be replaced. The cap plates on the Lally columns are generally small in size and will produce bearing stresses on the wood which are in excess of its capacity, when under full design load. There are currently no signs of crushing failures of the wood fibers associated with excessive bearing pressures. This is due to the fact that the dead load is relatively light and the live load on the floor is infrequent and has a short time duration.

There are several wood posts still supporting the main floor structure, with these post generally at the north end of the basement space. One post in particular is offset from its original position and is out of plumb. This same post bears on dry stacked granite stones. It would be prudent to replace this post with a new steel column, or Lally column if sufficient capacity is available, and a properly sized new concrete footing.

The footings for the basement Lally columns are 2' x 2' square, with their thickness not know. A quick calculation of the soil bearing stress for the column with the maximum tributary floor area, shows the soil bearing pressure under full design load to be about 8,500 pounds per square foot (psf). This bearing pressure is excessively high for soil, but would be appropriate for bearing on ledge. These

small footings should be replaced with footings, properly sized for the type of soils supporting the footings.

The east and west foundation walls for the sanctuary have brick supported on a concrete wall, for most of the wall length. The original foundations were likely granite stone which were probably removed and replaced with the brick and concrete. The use of two materials for the current foundations leads to the creation of a hinge point at the joint between concrete and brick. This means that the lower concrete portion of the foundation wall will behave like a retaining wall, needing to have a wider footing projection outside of the wall to engage more soil to resist the overturning forces created by the lateral soil pressure. The 4"± footing projection on the inside of the foundation wall suggests that the footing was not designed as a retaining wall footing, which could lead to excessive rotation of the wall under lateral soil forces. The east foundation wall is out of plumb, with the upper portion of the wall about 5/8" in from the base of the wall. It is likely that this out of plumb condition occurred during the backfilling of this wall. In order to insure the safety of the building foundation, it would be prudent to establish a monitoring program to determine whether the wall is continuing to move or rotate inward, or not.

The balcony floor framing is supported by a bearing wall on its north side and a hung beam on its south edge. A steel hanger rod supports the south edge beam near at midspan, with the steel rod running up to transfer beams at the roof truss bottom chord level, with nearly all the load from the rod transferred to one roof truss. This framing arrangement is fairly typical for balconies constructed during the time period of the original church and fellowship hall constructions. There are no signs of structural distress visible through the finishes, associated with the hanger rod or the balcony framing.

The roof and ceiling of the sanctuary have a number of issues.

All of the primary roof trusses are constructed in the same manner and with the same size timbers. The truss closest to the north exterior wall of the building though, has at least two interior post supports that the remaining trusses to the south do not. This creates a deflection differential between these trusses because the west truss span is short compared to the other trusses. The next truss to the south of the northern most truss also has the additional load of the hung balcony suspended at midspan of the truss. This additional load creates additional deflection that the other identical trusses do not have. As a result, there is a very noticeable belly (excessive deflection) in the roof at the truss location supporting the balcony. It may be prudent to perform an analysis of this second truss from the north wall to verify that it has capacity to carry the imposed loads.

There is an old brick masonry chimney in the attic space located between. and supported by, the two northerly timber roof trusses. The chimney has been taken down to just below the roof rafters, but the bulk of it is still in place. It would be prudent to remove the upper vertical section and the sloping horizontal section to remove unnecessary dead load from the roof trusses, particularly the truss carrying the hung balcony. This action can remove some of the dead load deflection from one truss. Any opening at the top of the remaining chimney should be covered over.

A short ridge beam running from the north roof truss to the south wall of the steeple/cupola has lost its post support at its north end. The post appears to have fallen away from the ridge and needs to be put back in place with suitable connections (more than just nails).

The ceiling joist framing has the lath for the plaster and lath ceiling attached directly to the ceiling joists. While the lath does not appear to be separated from the ceiling joists at the areas that I could access, there are some other points of concern.

First, at the outer section of ceiling joists, where the ceiling curves down to the exterior walls, diagonal ceiling framing creates a horizontal push on the walls, as the slightly sloping ceiling joists, which support the upper end of the diagonal joists, deflect causing vertical downward movement. Geometrically, this creates the horizontal push on the exterior walls which is visible as a vertical bow in both the east and west exterior walls of the sanctuary.

Second, the outer section of the slightly sloping ceiling joists have their bottom edge cut on a large radius curve to join the flat and tightly curved sections of the ceiling. The reduction in depth of the ceiling joists near mid-span of their length, reduces the stiffness of the joists and causes them to deflect more than if they had their full depth for their entire span. Further, at the west half of the ceiling, there are diagonal braces in a horizontal plane of the roof which interfere with some of the ceiling joists. At these interference points, the top half of the ceiling joists have been cut away so that the diagonal framing can pass through the joist. This also reduces the strength and stiffness of the joists, causing larger deflections. Both of these points are contributing to the cracking of the plaster ceiling at the east and west sides where the ceiling transitions from flat to curved.

In addition to the cracking in the plaster resulting from deflections of the ceiling framing, several other factors are likely contributing to the cracking. During the winter in particular, the church space goes through cyclical temperature variations which will cause thermal expansion and contraction. The moisture or humidity levels in the sanctuary and attic space also vary with the intermittent use of the space. Both of these conditions can cause cracking of the plaster over an extended period of time (years) that the church has been existing.

Third, the ceiling joists are supported by 1x12 vertically oriented boards spanning between trusses, which are in turn hung from the roof beams by two or three boards just nailed to the roof beams. Because the square roof beams are rotated to the slope of the roof but the hangers are vertical, the surfaces of the two meet at a point, not in a common plane. Therefore, the nails extend through some open space between the two members. This places bending forces on the nails which they do not usually experience and for which they are not designed. These nailed hanger connections should be backed up with the addition of some metal strap ties which are nailed to the vertical hangers and wrap over the top and down the opposite side of the roof beams, being nailed to both. Loss of the existing hanger nailed connections due to pull out of the nails would likely result in the loss and collapse of some large sections of ceiling. If the sanctuary is occupied at that time, there would likely be injuries or worse. If the sanctuary is unoccupied, there would be damage to the pews and floor.

The steeple/cupola framing is generally in good condition. There are no obvious signs of rot of the wood, and steel rods connect the various vertical sections of the structure to resist overturning forces from lateral loads. There is one opening in the floor of the steeple area at the level of the attic floor, located at the northeast corner of this floor area, with a shaft dropping over 10 feet downwards. This hole in the floor should be covered over for safety, to prevent anyone from accidentally falling into the shaft.

The roof structure over the church bell has board sheathing which is not protected by a roof membrane. The walls above have flashing at their bases, but the flashing just extends down to the wood roof sheathing. This condition can allow wind blown water and snow to land on the wood roof sheathing and make its way down into the structural framing, potentially causing rot of the wood. While there is not specific evidence of rot occurring in the structure yet, it would be appropriate to waterproof this wood roof to protect it against water infiltration and damage.

The steeple and cupola do have a slight tilt southward at the top. This results from the north framing aligning with the north wall of the church while the south framing extends down to transfer beams which deflect under the load of the steeple/cupola. The transfer beams span between the north

exterior wall and the first roof truss to the south. The tilt is caused by the transfer beam deflecting while the north wall framing does not deflect. While the tilt is noticeable to the trained eye, it is not excessive nor unexpected. No action is required for this condition.

At the floor framing that supports the church bell, there is a waterproofing membrane to protect the underlying floor framing. There is one drain hole through the south wall, just above the floor level. It appears that the floor to either side of the drain holes slope slightly down and away to the east and west sides of the steeple. This would make draining of water difficult and leave standing water on the floor area after wind blown rains. It would be prudent to verify the drain height with respect to the floor level and add drains if necessary at low points on other walls.

Future Renovation Considerations

If you are considering adding insulation to the ceiling of the sanctuary as part of any planned renovations, I recommend that as part of the planning process you verify the load capacity of the roof and ceiling framing. The addition of insulation will increase the dead load on the ceiling joists and supporting framing and you will want to verify that there is sufficient capacity in the joists to carry the additional load. Further, each weekend during the winter, the heat is turned on in the sanctuary area. The lack of insulation permits this heat to escape up through the roof, thereby promoting more rapid melting of snow on the roof. Lower accumulations of snow on the roof means lower actual loads. Adding insulation will significantly reduce heat loss through the roof, thereby permitting greater snow accumulations which means higher actual snow loads on the roof. Therefore, it is imperative and recommended that you verify that the existing structure has the sufficient capacity to carry the loads to meet current building code requirements, if you plan to add ceiling/roof insulation.

Interior spread footings in the sanctuary basement should be replaced with larger footings, with sizing based on a numerical structural analysis. This analysis would also provide the opportunity to verify if the existing Lally columns have sufficient strength to carry the full design load.

The sanctuary foundation walls should be analyzed to determine if they are stabile and their footings are adequate, given the observed wall rotation. This may require exposing the exterior footing projection at the east wall, if no existing drawing information is available that shows the sizes and possible reinforcing in the existing foundations. If footings are inadequate, then some form of remedial action will be required to stabilze the concrete and brick foundation walls of the sanctuary.

Replacement of the remaining wood columns in the sanctuary basement with new steel columns and footings, properly sized to carry the loads, is recommended at such time that the basement space is converted to utilized space. Conversion of the basement space to occupied space will be driven by principally egress and fire safety design requirements.

Summary

In general, the three sections of the building are in fair to good condition. The 1920's and 1960's additions are in better overall condition than the church sanctuary, not unexpected given the church's age. There are a few short term structural repairs that should be completed in the church section of the building, principally the basement corroded Lally column replacement, the short roof ridge beam post re-installation and waterproofing of the roof structure immediately over the church bell.

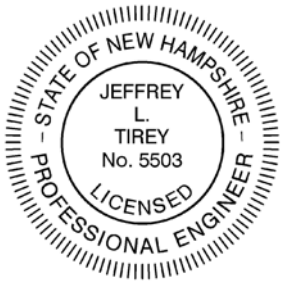
A search for any prior design drawings for the various sections of the building is also recommended, in an effort to find documentation of what has been constructed. If the Church does not have any of those documents, you may wish to check with the City of Lebanon to see if they have any drawings

that might have been submitted for permits. Old documents, if they exist and can be found, can assist in the overall planning process for any renovations you may be considering.

Lastly, any proposed changes to increase the thermal performance of the building sections or add additional dead loads to the structure, should trigger a structural load capacity analysis of the affected portions of the building structure to determine if any structural upgrades are required, or if there is sufficient existing capacity to carry the revised loads as constructed.

Please call if you have any questions or we can be of further assistance.

Truly Yours,



Jeffrey L. Tirey, P.E., SECB

jlt

Enclosure

Photo 009: View of south end of the building, at the 1960's addition. Note cement parging has partially cracked and fallen off the masonry block foundation.

Photo 011: View of west side of building, along street and sidewalk. Note cement parging on 1960's office addition at right side of photo is deteriorated and partially fallen off block.

Photo 017: View of north side of building.

Photo 020A: View of east side of sanctuary portion of building. Note change of foundation wall at red line from granite stone to brick on concrete.

Photo 005: View of east side of 1960's addition and south end of 1920's addition with stair leading into it.

Photo 007: View of 1920's addition, east side.

Photo 008: Closeup of 1960's addition deterioration of parging and cracks in masonry block foundation wall.

Photo 092A: Interior view of 1920's addition looking east. Walls and ceilings are in good condition with sole exception of ceiling cracks in red circled area.

Photo 091: Closeup view of cracked plaster ceiling from Photo 092A.

Photo 097: Interior view of 1920's addition looking west. Walls and ceiling are in good condition. Hump in floor is not easily seen in this photo.

Photo 093: Interior view of 1920's addition at southwest room, with everything in good condition.

Photo 095: Kitchen area of 1920's addition, with everything in good condition.

Photo 085: Lower level of 1920's addition showing a portion of the steel floor beam projecting below the ceiling. Hump visible at the top side of the floor, occurs at this floor beam.

Photo 086: Representative exterior foundation wall, at west side, showing good condition of concrete and brick above (to sides of windows).

Photo 084A: View of bottom of main floor framing at connector area between sanctuary and fellowship hall showing floor beam with powder post beetle damage in red circled area.

Photo 083: Closeup of damage to wood floor beam by beetle infestation.

Photo 071: View of basement area beneath sanctuary, looking southwest. Note small size of footings which are flush with the soil grade.

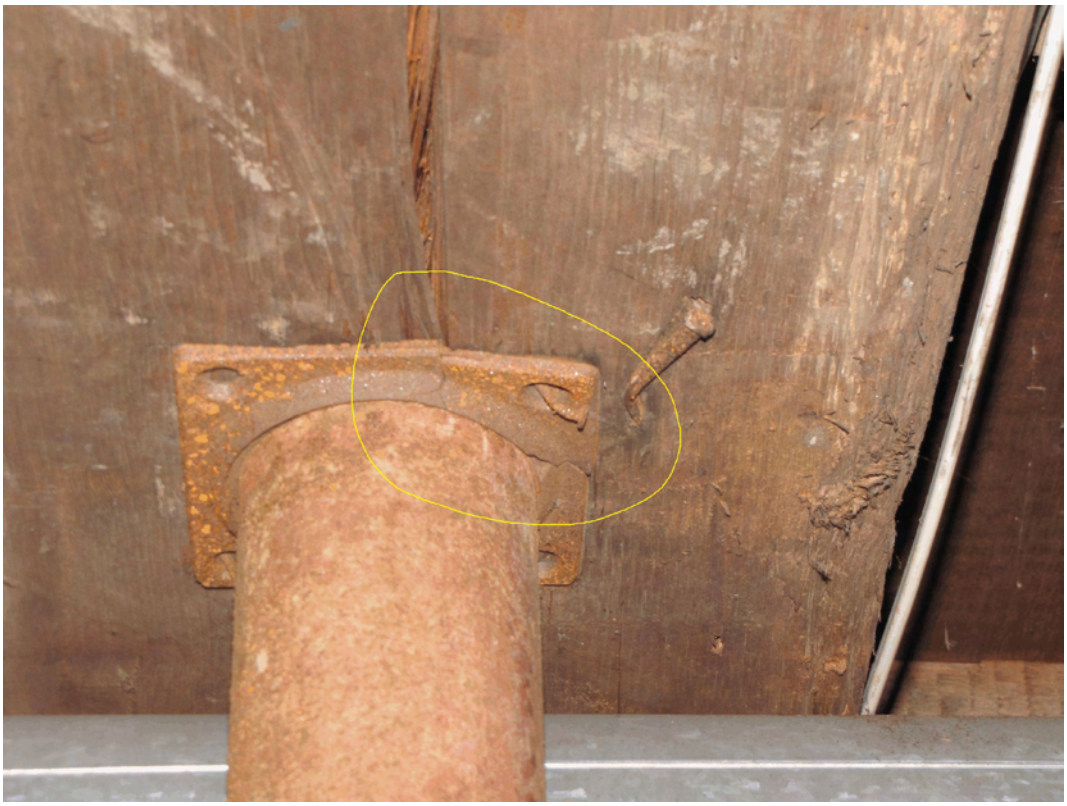


Photo 073A: Closeup view of sanctuary basement lally column support where the cap plate is cracked and displaced. The cap plate should be replaced.

Photo 078: Closeup view of sanctuary basement lally column base with corrosion.

Photo 079: Closeup view of lally column base by furnaces with severe corrosion and material loss - steel jacket and some inner concrete.

Photo 074: North end of sanctuary basement showing two of four remaining wood posts. Note raised soil grade in right corner. Mortared stone foundation wall appears to be in good condition.

Photo 076: Wood post at north end of sanctuary bearing on stacked stones and out of plumb.

Photo 080: West wall of sanctuary basement showing dampness on wall from water infiltration at bottom of brick.

Photo 064: Cracking in plaster ceiling at the underside of the balcony.

Photo 060: Sanctuary ceiling plaster cracks between and around smoke detectors.

Photo 061: Sanctuary ceiling plaster cracks running north-south, which occur at both east and west sides of the sanctuary.

Photo 022: Looking south along east wall of sanctuary with vertical bow in wall visible, which results from diagonal ceiling framing horizontal load component.

Photo 014: Steeple and cupola, viewed from the west, showing slight tilt towards the rear of the building, as a result of interior beam support deflections.

Photo 054: Interior view of sanctuary roof framing looking south. Heavy timber roof trusses clear span the sanctuary in an east-west direction. Note the ceiling joist framing with lath (for plaster) directly attached and no insulation.

Photo 051: View of east portion of roof, looking south. Note that the ceiling joists have their bottoms cut on a curve, thereby reducing their depth and stiffness near mid-span. Vertical elements on right side of photo are hangers for board supporting the ceiling joists.

Photo 047A: Attic ceiling and roof framing looking west. Note ceiling joists are notched at diagonal bracing, in yellow circle, which reduces stiffness and increases deflections. Three vertical wood hangers support 1x12 on edge, which supports ceiling joists.

Photo 043: Representative wood hanger connection to wood roof beam. Nails from hanger to beam are sloped down and away from the beam, suggesting they are pulling out over time.

Photo 024: Old unused brick chimney should be removed to reduce weight on structure.

Photo 025A: View showing support of unused brick chimney on truss, plus top of balcony hanger rod in yellow circle.

Photo 026: Short ridge beam between 1st roof truss from north wall and steeple/cupola wall framing. Right end of ridge beam is unsupported.

Photo 059A: Attic ceiling framing with electric wire at center in red circle feeding hung chandelier in sanctuary. Note that added wood plate from which the chandelier is supported, is in turn only supported by the wood lath, not the ceiling joist framing.

Photo 035: Under side of bell floor framing at steeple/cupola, showing tension rods in wall to resist structure overturning and rod bottoms in upper half of photo which tie the upper cupola framing down. Note wood framing appears to be in good condition.

Photo 031: Roof over bell showing exposed wood plank roof which is highly susceptible to wind blown rain/moisture.

Photo 032: Flashing around corner posts at walls below upper cupola. Note flashing extends down to wood roof boards. There is no waterproof membrane on this partially protected roof.

Photo 033A: Floor of bell area. Note drain hole for water in yellow circle, located at the south wall of the steeple, is at the high point of the sloped framing, reducing the effectiveness of the drain.

Photo 099: View looking north in attic, showing transfer beam that supports steeple/cupola framing bearing on bottom chord of roof truss (running right-left near bottom). Note this roof truss has interior post supports beneath it, making deflection differentials between it and the next truss to the south (supporting the balcony) more pronounced and greater. Note lack of any insulation on top of the plaster and lath ceiling.