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JUNIPER/TRINITIE TRAIL CULVERT STRUCTURAL INSPECTION

September 2, 2014

Rachel Patrick
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Re: Juniper/Trinitie Trail Culvert

Photo 1
Juniper/Trinitie Trail Culvert looking West

Introduction:

This report has been prepared for Rachel Patrick and the Town of Southern Shores to address the settlement issues on the roadway above the Juniper/Trinitie Culvert.

Background:

Portions of the roadway across the Juniper/Trinitie Culvert are settling. There are currently two depressed areas on each side of the culvert centerline. The cross section of the bridge is attached to this report which shows the base course and surface course put down on top of the bridge. John Abel, NCDOT, in a conversation with Rachel Patrick of the Town of Southern Shores, stated that there were settling issues previously prior to tie-backs not initially being either properly installed and/or missing. As a result, NCDOT went back and reconstructed/added the tie-backs several years ago. The last time settlement occurred one could visibly see the metal culvert starting to slightly collapse. At the time of this report there were no soil compaction records available to review or drawings other than the one attached.

Pavement depressions (settlement) in localized areas of limited size are sometimes accompanied by cracking. When water collects in these depressions they become not only a source of pavement deterioration but also hazards to motorists. Depressions are caused by traffic loads heavier than that for which the pavement was designed for either because of poor construction methods, and/or by consolidation deep within the subgrade.

Observations:

The centerline of the culvert under the roadway is the road high point as it crosses over the culvert. Unfortunately, there is one area to the North and one area to the South of the culvert centerline which have settled significantly across the entire width of the road. This settled areas are upwards of several inches on each side and occur in an area eleven to thirteen feet from the culvert centerline/high point and occur on each side of the culvert centerline. The depressed areas have resulted in two consecutive significant dips for motorists traveling over the bridge. Water now ponds in these areas despite the overall relatively aggressive drainage slope from the culvert centerline North and South.

Photo 2
Centerline of culvert looking West

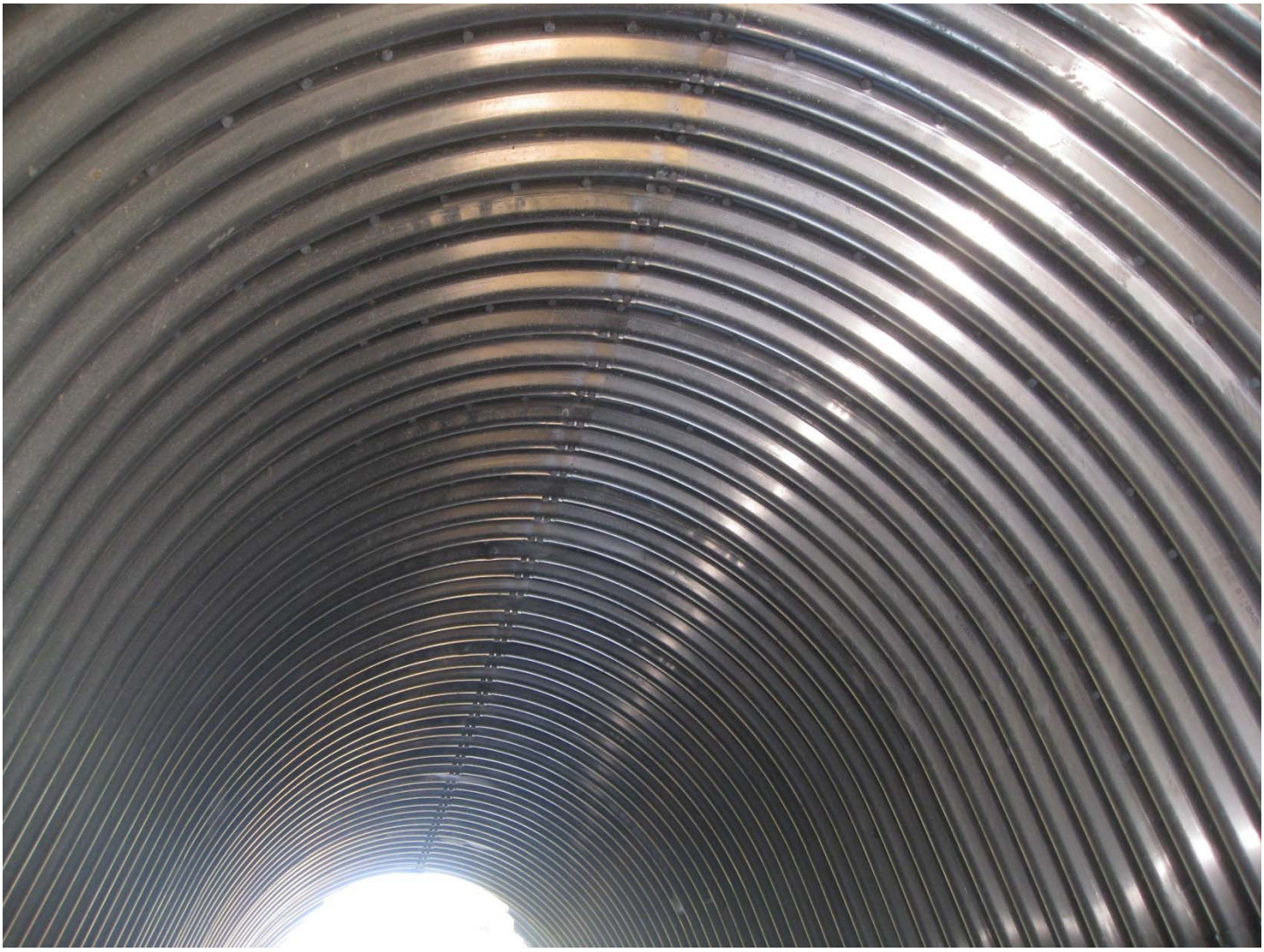

Photo 3
Interior ceiling of the culvert looking West

Photo 4
Centerline of culvert looking West with a stress crack visible in the center foreground from the adjacent settlement

Photo 5

Continuous cracks are difficult to see in the photo above but extend the full width of the roadway at the culvert centerline as the adjacent portions of the roadway settle.

Photo 6
Evidence of ponding in the depressed areas is evident where areas of sand and sediment have accumulated and settled along the yellow curb.

The differential settlement (greater in some areas than others) has resulted in two, consecutive, significant and noticeable dips. These are present on each side of the culvert centerline and are spaced about twenty-four feet on center or about twelve feet from the culvert centerline. Consequently, a “BUMP” sign has been posted to alert motorists. There are numerous potential causes for this differential settlement including the five detailed and discussed below.

1. Improperly compacted backfill.
2. Substandard backfill materials (material with excessive amounts of decaying organic material).
3. Erosion and soil migration from under the road bed (down into the canal).
4. Inadequate asphalt subgrade.
5. Natural settlement combined with repeated vehicular traffic loads.

Conclusions:

It is difficult to determine the exact cause of the settlement and it may not be a single cause. The settlement could be a combination of the above-mentioned factors. Soil borings could help provide some insight but may not lead to a conclusive diagnosis and resolution of the problem.

Improperly compacted backfill
There are no soil compaction records to review so it is impossible to determine if this may be directly related to the cause. However, considering there is upwards of eighteen feet of backfill adjacent to the culvert under the depressed areas, this is a definite possibility.

Substandard backfill materials (material with excessive amounts of decaying organic material)
Given the prevalence of locally available inorganic material (sand) it is unlikely that backfill material consisting of organic matter, in sizeable enough quantities to result in the settlement taking place, has occurred.

Erosion and soil migration from under the road bed (down into the canal)
No evidence was seen of erosion or soil migration from under the road bed into the canal or to the sides of the embankments. The interior of the culvert was inspected and it looked clean, no soil migration was observed anywhere around the culvert or embankments.

Inadequate asphalt subgrade
Inadequate asphalt subgrade support could result in differential settlement from repeated vehicular wheel loads just as a poor house foundation can lead to a home settling over time. The better the subgrade preparation prior to AC (asphalt concrete) placement, the better and longer lasting the AC. Borings could provide some insight as to the AC subgrade adequacy and current condition.

Natural settlement combined with repeated vehicular traffic loads
Natural settlement of backfill (under repeated vehicular traffic loads) over time can be expected. The goal is to expedite that settlement during the construction and compaction process thereby reducing future, post-construction, settlement as much as possible. Deeper backfill depths (as we have) will naturally result in greater settlement when compared to shallower backfill depths. Regardless of how well backfill is compacted, a certain amount is likely over time, especially with repeated vehicular loads.

It takes time to properly compact upwards of eighteen vertical feet of backfill as it is typically compacted in vertical “lifts” or sections. If these lifts are too large or not properly compacted at each stage they will see an increased amount of settlement, especially with repetitive vehicular traffic loads. Even properly compacted backfills can and do settle over time, more so with repeated loading.

Recommendations:

The settlement is likely due to several of the above-mentioned factors including natural settlement. While soil borings may provide some additional insight into the root causes of the settlement, a full depth repair/dig out of the existing AC and base material is the most sensible course of action to take at this time.

Full Depth Repairs (“Dig Outs”)

The material in the area needs to be repaired and removed to a depth as deep as necessary to reach firm support (by definition typically a minimum of 4 inches). This may entail removing some of the subgrade. The excavation should also extend horizontally a minimum of at least one foot into the "good" (non-depressed) pavement surrounding the area to be patched. This equates to a removal section of eight feet in length for the full width of the roadway at each recessed area. The area to be removed shall be outlined on the pavement with paint. A pavement saw shall be used to make neat rectangular cuts. The outlined area of the asphalt surfacing to be removed shall be saw cut to a depth of not less than 0.15 ft (45 mm) before removal.

The surface and base materials shall then be removed, as necessary, and without damage to the materials that are to remain in place. The hole should be square edged. No loose material shall remain. If the existing AC pavement surface is on an aggregate base, care shall be taken to prevent the aggregate material from collapsing from under the edge of the remaining pavement. If the edge support is damaged, the pavement surrounding the patch may cause future failures. After removing the AC surfacing one of the following three options below shall be followed:

- the underlying base is cement treated base in "good" condition (no visible cracking), the base shall remain in place and its integrity preserved (no additional compaction is required).
- the underlying base is an unbound aggregate in "good" condition (no signs of deformation or evidence of migration of the fine materials or when probing with a soil's probe -- a 3/8-inch metal conical-shaped pointed rod --the rod should not penetrate firm material by more than 0.10 foot), the base should remain in place and its integrity preserved.
- the base material(s) is in need of removal (there are signs of deformation or evidence of migration of the fine materials or when probing with a soil's probe - a 3/8-inch metal conical-shaped pointed rod - the rod penetrates the base material by more than 0.20 feet), the base material(s) is to be removed down to firm compacted material. A depth of 0.25 feet shall then be removed and the remaining material investigated again to see if it is firm/compacted through the use of the soil's probe. Continue to probe and examine the base, sub-base and backfill material in 0.25 feet depth intervals until firm/compacted material is reached. Once the depth of removal has been determined, the material remaining in place shall be graded to a plane, moisture added and compacted. Any locations where the base material is low, as a result of over excavation, shall be filled at the time of paving with asphalt concrete.

After one of the preceding three options above is completed, the bottom and sides of the cut sections shall be primed using either liquid or emulsified asphalt. If the "dig out" is more than six inches deep, the backfill shall be placed in layers (aggregate base and AC) and each layer compacted thoroughly. As an alternative recommendation, primarily because of constructability reasons, the "dig out" can be backfilled with a dense graded hot asphalt plant mix, however, this option is a secondary, alternative recommendation. A vibratory plate compactor is excellent for small patches. A roller may be more practical for large areas such as this. The repair is complete when the AC surface layer is placed and compacted flush with the surrounding pavement surface. Traffic must not be allowed on a patch repaired with only granular base material.

In addition, the cracks in the roadway across the centerline of the culvert shall be sealed so as to prevent water migration from further undermining the AC foundation as shown below.

Limitations

No calculations have been completed for this report. Any opinions expressed in this report are based upon the site observations, engineering judgment and experience. Professional services have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable engineers practicing in the structural engineering field in this or similar localities at this time. No other warranty, expressed or implied, is made as to the professional advice included in this report. Estimated repair costs have not been provided in this report.

This report has been prepared for Rachel Patrick and The Town of Southern Shores to be used solely in their evaluation of the subject facility areas and may not contain sufficient information for purposes of other parties or other uses. There may be additional other substantial deficiencies not visible from the site visit. Recognition that this document may not capture all the potential structural vulnerabilities at this time shall be acknowledged by the reader and factored accordingly into the decision making process. The report has not been prepared for use by other parties and may not contain sufficient information for purposes of other parties or other uses.

Please don't hesitate to contact me if you have any further questions, comments and/or concerns.

Sincerely,

Barrett C. Crook

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