GEOTECHNICAL ENGINEERING STUDY 
AND PAVEMENT THICKNESS DESIGN 
PROPOSED BENNETT PUBLIC WORKS BUILDING 
NORTH OF TRUMAN AVENUE 
AND EAST OF 4TH STREET 
BENNETT, COLORADO

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Project No. 19-3-157 
June 27, 2019
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**FIGS.**

- FIG. 1 – LOCATION OF EXPLORATORY BORINGS
- FIG. 2 – LOGS OF EXPLORATORY BORINGS
- FIG. 3 – LEGEND AND NOTES
- FIGS. 4 and 5 – SWELL-CONSOLIDATION TEST RESULTS
- FIG. 6 – GRADATION TEST RESULTS
- FIG. 7 – MOISTURE-DENSITY RELATIONSHIPS
- TABLE I – SUMMARY OF LABORATORY TEST RESULTS
SUMMARY

1. Subsurface conditions at the site were explored by drilling a total of six (6) exploratory borings to depths of approximately 5 to 30 feet. The borings generally encountered about 3 inches of topsoil underlain by layers of natural clayey soils and natural granular soils extending to the explored depths. The clayey soils consisted of lean clay with sand to sandy lean clay. The granular soils consisted of silty sand to clayey sand to poorly graded sand.

Groundwater was not encountered in the borings at the time of drilling. A subsequent water level measurement made 7 days after drilling encountered groundwater in Boring 4 at a depth of about 27.5 feet below the ground surface.

2. We recommend supporting the building on shallow spread footings placed on a minimum of 4 feet of properly compacted structural fill. Footings bearing on structural fill may be designed for a net allowable bearing pressure of 3,000 psf.

3. Slab-on-grade construction is feasible at the site. We recommend that slabs on grade be placed on a minimum of 7 feet of properly compacted structural fill material to mitigate against potential heaving movements of the underlying soils due to moisture variations.

4. Parking areas should consist of a full-depth asphalt section of 6 inches. Areas that will be accessed by multi-unit trucks as well as fire lanes elsewhere on the site should consist of 6.5 inches of full-depth asphalt.

5. We recommend that all pavement sections be underlain by at least 2 feet of properly compacted fill material. The following table presents the minimum pavement thickness recommendations for this facility and roadways.

<table>
<thead>
<tr>
<th>Location</th>
<th>Full Depth Asphalt Pavement (inches)</th>
<th>Composite Asphalt over Aggregate Base Course (inches)</th>
<th>PCCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Duty</td>
<td>6</td>
<td>4 over 8</td>
<td>7</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>6.5</td>
<td>4 ½ over 8</td>
<td>8</td>
</tr>
</tbody>
</table>

PCCP = Portland Cement Concrete Pavement
PURPOSE AND SCOPE OF WORK
This report presents the results of a geotechnical engineering study and pavement thickness design for the proposed Bennett Public Works Building to be located north of Truman Avenue and east of 4th Street in Bennett, Colorado. The project site is generally shown on Fig. 1. The study was conducted for the purpose of developing recommendations for foundations, floor slabs, site grading and site pavements. The study was conducted in accordance with the scope of work presented in our Proposal No. P3-18-297 dated November 26, 2018 and revised on May 30, 2019.

A field exploration program consisting of drilling six (6) exploratory borings was conducted to obtain information on subsurface conditions. Samples of the soils obtained during the field exploration program were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration program and laboratory testing were analyzed to develop geotechnical engineering recommendations for use in site earthwork and in design and construction of the proposed development.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction of the proposed development are included in the report.

PROPOSED CONSTRUCTION
The project concept plans we have been provided indicate that a single-story building will be constructed on the site with a footprint of about 10,000 square feet. We anticipate the building will be constructed with metal-framing and masonry walls. The area surrounding the building will consist of an approximate 10,000 square foot paved parking lot with access drives.

If the proposed construction varies significantly from that described above or depicted in this report, we should be notified to reevaluate the recommendations provided herein.

SITE CONDITIONS
At the time of our field exploration program, the site was vacant of structures and was partially covered with native weeds and grasses. The site contained two stockpiles of material on the site approximately 15 feet tall at the time of field exploration. The project site was bounded to the south and east by undeveloped fields, to the west by 4th street followed by an undeveloped field,
and to the north by the Bennett Wastewater Treatment Plant. The project site was gently sloping down to the north.

**SUBSURFACE CONDITIONS**

The subsurface conditions at the site were explored by drilling a total of six (6) exploratory borings depths of about 5 to 30 feet at the approximate locations shown on Fig. 1. Graphic logs are presented on Fig. 2 and legend and notes describing the soils encountered in the borings is presented on Fig. 3.

**Subsurface Soil Conditions:** The borings generally encountered about 3 inches of topsoil underlain by layers of natural clayey soils and natural granular soils extending to the explored depths. The clayey soils consisted of lean clay with sand to sandy lean clay. The granular soils consisted of silty sand to clayey sand to poorly graded sand.

The natural clayey soils were fine to medium grained, dry to moist and tan to brown. The natural granular soils were fine to coarse grained, moist and light brown. The sandstone bedrock with interbedded claystone was fine to coarse grained, dry to moist and tan to brown. Based on sampler penetration resistance, the natural clayey soils were stiff to hard, the natural granular soils were loose to very dense.

**Groundwater Conditions:** Groundwater was not encountered in any of the six borings at the time of drilling. A subsequent water level measurement made 7 days after drilling encountered groundwater in Boring 4 at a depth of about 27.5 feet below the ground surface.

Groundwater levels are expected to fluctuate with time, and may fluctuate upward after wet weather or subsequent to landscape irrigation.

**LABORATORY TESTING**

Laboratory testing was performed on selected soil samples obtained from the borings to determine in-situ soil moisture content and dry density, Atterberg limits, swell-consolidation characteristics, and concentration of water soluble sulfates. The results of the laboratory tests are shown to the right of the logs on Fig. 2 and summarized in Table I. The results of specific tests are graphically plotted on Figs. 4 through 7. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM).
**Swell-Consolidation**: Swell-consolidation tests were conducted on selected samples of the natural soils in order to evaluate their compressibility and swell characteristics under loading and when submerged in water. Each sample was prepared and placed in a confining ring between porous discs, subjected to surcharge pressures of 200 psf or 1,000 psf, and allowed to consolidate before being submerged. The sample height was monitored until deformation practically ceased under each load increment.

Results of the swell-consolidation tests are plotted as a curve of the final strain at each increment of pressure against the log of the pressure and are presented on Figs. 4 and 5. Based on the results of the laboratory swell-consolidation testing, a sample of clayey soil exhibited high swell potential (7.6%) upon wetting under a 200-psf surcharge pressure. Samples of natural clayey soils exhibited low to moderate swell potential (0.1% to 4.6%) upon wetting under a 1000-psf surcharge pressure. Based on the laboratory results and experience we believe the high swell potential is likely due to the low moisture contents and high dry densities.

**Index Properties**: Samples were classified into categories of similar engineering properties in general accordance with the Unified Soil Classification System. This system is based on index properties, including liquid limit and plasticity index and gradation characteristics. Values for moisture content, dry density, liquid limit and plasticity index, and the percent of soil passing the U.S. No. 4 and No. 200 sieves are presented in Table I and adjacent to the corresponding sample on the boring logs.

**GEOTECHNICAL CONSIDERATIONS**

Based on conditions encountered in the borings, it appears that the site has natural clayey soils that exhibit low to high swell potential. The site, in its present condition, is considered unsuitable for support of foundations, slab-on-grade floors, and pavements.

In our opinion, with proper site preparation, shallow spread footing foundations and slab-on-grade construction should be feasible. Site preparation should include providing a layer of compacted structural fill below spread footing foundations and slab on grade floors. Including a minimum thickness of structural fill would result in more uniform bearing conditions beneath footings and floor slab support, and in more predictable foundation settlement. Depending on site finished grades, some overexcavation into natural soils may be required in places.
Natural onsite soils should be suitable for use as site grading fill and may be suitable for use as structural fill beneath buildings and other structures provided they can be properly moisture conditioned and compacted.

FOUNDATION RECOMMENDATIONS
Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we recommend structures be founded on spread footings placed on a minimum of 4 feet of properly compacted structural fill. The structural fill is intended to provide a zone of relatively low swelling material below the foundations to help mitigate heaving movements. Criteria for structural fill is addressed in the Site Grading section of this report.

The design and construction criteria presented below should be observed for a spread footing foundation system. The construction details should be considered when preparing project documents.

1. Footings placed on a minimum of 4 feet of properly compacted structural fill extending to natural soils should be designed for a net allowable bearing pressure of 3,000 psf. The footings should also be designed with a minimum dead load pressure of 500 psf.

2. Based on experience, we estimate total settlement for footings designed and constructed as discussed in this section will be approximately 1 inch. Differential settlements across the building footprints are estimated to be approximately ½ to ¾ of the total settlement.

3. Spread footings placed on natural soils or properly compacted structural fill should have a minimum footing width of 16 inches for continuous footings and 24 inches for isolated pads.

4. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 36 inches below the exterior grade is typically used in this area.

5. The lateral resistance of a spread footing placed on properly compacted structural fill material will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.3. Passive pressure against the sides of the footings can be calculated using an equivalent fluid unit weight of 185 pcf. These lateral resistance values are working values.
6. Care should be taken to provide adequate surface drainage during the excavation of footings, and the contractor should have equipment available for removing water from excavations following precipitation, if needed. Footing excavations that are inundated as a result of uncontrolled surface runoff may soften, requiring possible moisture conditioning and recompaction of the exposed subgrade soils, or removal of soft subgrade soils and replacement with new compacted structural fill.

7. Areas of loose and/or soft material or deleterious substances encountered within the foundation excavation should be removed and the footings extended to adequate natural bearing material. As an alternate, the loose and/or soft material or deleterious substances may be removed and replaced compacted to 98% of the standard Proctor (ASTM D 698) maximum dry density at moisture contents within 0 to +3 percentage points of the optimum moisture content. New fill should extend down from the edges of the footings at a 1 horizontal to 1 vertical projection.

8. Existing fill material, if encountered, should be removed and the structural fill extended to adequate natural bearing material. New fill should extend down from the edges of the footings at a 1 horizontal to 1 vertical projection.

9. Care should be taken when excavating the foundations to avoid disturbing the supporting materials.

10. A representative of the geotechnical engineer should observe all footing excavations, observe and test compaction, and evaluate the suitability of all fill materials prior to concrete placement.

FLOOR SLABS
We recommend that slabs on grade be placed on a minimum of 7 feet of properly compacted structural fill material to mitigate against potential heave due to swelling of clayey soils.

To reduce the effects of some differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement. Interior non-bearing partitions resting on floor slabs should be provided with slip joints so that, if the slabs move, the movement cannot be transmitted to the upper structure. This detail is also important for wallboards, stairways and door frames. Slip joints which will allow at least 1½ inches of vertical movement are recommended.
Floor slab control joints should be used to reduce damage due to shrinkage cracking. Joint spacing is dependent on slab thickness, concrete aggregate size, and slump, and should be consistent with recognized guidelines such as those of the Portland Cement Association (PCA) and American Concrete Institute (ACI). The joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. We suggest joints be provided on the order of about 12 to 15 feet apart in both directions. The requirements for slab reinforcement should be established by the designer based on experience and the intended slab use.

If moisture-sensitive floor coverings will be used, mitigation of moisture penetration into the slabs, such as by use of a vapor barrier, may be required. If an impervious vapor barrier membrane is used, special precautions may be required to prevent differential curing problems which could cause the slabs to warp. A minimum 2-inch sand layer between the concrete and the vapor barrier is sometimes used for this purpose.

EXTERIOR FLATWORK
To limit potential movement due to swelling soils, and frost conditions, subgrade preparation beneath exterior flatwork immediately adjacent to the buildings, including sidewalks and patio areas, where reduction of heave potential is considered critical should be done in accordance with the recommendations provided in the “Floor Slabs” section of this report, including depth of subexcavation and backfilling with compacted fill. Where reduction of heave potential is less of a concern, such as for sidewalks located more than 10 feet from building, subgrade preparation may be done in accordance with the subgrade preparation recommendations provided in the “Pavement Design” section of this report. Proper surface drainage measures as recommended in following sections of this report are also critical to limiting moisture- or frost-related movement.

It is extremely important that exterior flatwork and pavements be isolated from the building foundations. Many problems associated with expansive soils are related to ineffective isolation between pavements and exterior slabs and foundation-supported components of structures. Careful design detailing is necessary at locations such as exterior stairway landings and entry points.

Upward heave-related movement of exterior flatwork adjacent to the building may result in adverse drainage conditions with runoff directed toward the building. In addition, upward
movement of exterior flatwork may restrict movement of outward swinging doors. Site grading
and drainage design should consider those possibilities, particularly at entryways.

SEISMIC DESIGN CRITERIA
The soil profile is anticipated to generally consist of natural fine grained soils layered with natural
granular soils to the explored maximum depth of 30 feet. Natural lean clays and new structural
fills will generally classify as International Building Code (IBC) Site Class D. Based on the soil
profile and our experience with similar profiles, we recommend a design soil profile of IBC Site
Class D. Based on the subsurface profile, site seismicity, and the depth of ground water,
liquefaction is not a design consideration.

WATER SOLUBLE SULFATES
The concentration of water soluble sulfates measured in a sample of the onsite soils obtained
from the exploratory borings was 0.03%. This concentration of water soluble sulfates represents
a Class S0 severity exposure to sulfate attack on concrete exposed to these materials. The
degree of attack is based on a range of Class S0, Class S1, Class S2, and Class S3 severity
exposure as presented in ACI 201.

Based on the laboratory test results, we believe special sulfate resistant cement will generally not
be required for concrete exposed to the natural on-site soils.

SURFACE DRAINAGE
Proper surface drainage is very important for acceptable performance of the building during
construction and after the construction has been completed. Drainage recommendations
provided by local, state and national entities should be followed based on the intended use of the
structures. The following recommendations should be used as guidelines and changes should
be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of the foundation and slab subgrades should be avoided
during construction.

2. Care should be taken when compacting around the foundation walls and underground
structures to avoid damage to the structure. Hand compaction procedures, if necessary,
should be used to prevent lateral pressures from exceeding the design values.
3. The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration. A minimum slope of 3 inches in the first 10 feet is recommended in the paved areas. These slopes may be changed as required for handicap access points in accordance with the Americans with Disabilities Act.

4. Ponding of water should not be allowed in foundation backfill material or in a zone within 10 feet of the building.

5. Roof downspouts and drains should discharge well beyond the limits of all backfill or be tight-lined to planned storm water facilities.

6. Landscaping adjacent to buildings underlain by moisture-sensitive soils should be designed to avoid irrigation requirements that would significantly increase soil moisture and potential infiltration of water within at least ten feet of foundation walls. Landscaping located within 10 feet of the building should be designed for irrigation rates that do not significantly exceed evapotranspiration rates. Use of vegetation with low water demand and/or drip irrigation systems are frequently used methods for limiting irrigation quantities.

   Lawn sprinkler heads and landscape vegetation that requires relatively heavy irrigation should be located at least 10 feet from the building. Even in areas away from the building, it is important to provide good drainage to promote runoff and reduce infiltration. Main pressurized zone supply lines, including those supplying drip systems, should be located more than 10 feet from the building in the event leaks occur. All irrigation systems, including zone supply lines, drip lines, and sprinkler heads should be routinely inspected for leaks, damage, and improper operation.

7. Plastic membranes should not be used to cover the ground surface adjacent to foundations.

SITE GRADING AND EARTHWORK

Temporary Excavations: We assume that temporary excavations will be constructed by overexcavating the slopes to a stable configuration where enough space is available. Excavations generally will extend through natural clay soils and are not anticipated to encounter groundwater, although seasonal shallow perched groundwater may be present. All excavations should be constructed in accordance with OSHA requirements, as well as state, local and other...
applicable requirements. Existing fills, if encountered, should generally classify as OSHA Type C soils. The natural clay soils will generally classify as Type B soils. Excavations encountering groundwater could require much flatter side slopes than those allowed by OSHA.

Excavated slopes may soften due to construction traffic and erode from surface runoff. Measures to keep surface runoff from excavation slopes, including diversion berms, should be considered.

**Fill Material**: Unless specifically modified in the other sections of this report, the following recommended material and compaction requirements are presented for fill materials on the project site. A representative of the geotechnical engineer should evaluate the suitability of all proposed fill materials for the project prior to placement.

1. **Structural Fill beneath Footings, Slab-on-Grade Floors, and Settlement-Sensitive Exterior Flatwork**: Structural fill should consist of moisture conditioned on-site soils. Imported soils, if necessary, should be non-expansive and have a maximum of 60% passing the No. 200 sieve, a maximum liquid limit of 35, and a maximum plasticity index of 12. Imported fill source materials not meeting one or more of these criteria may be acceptable if they meet the swell criteria presented below.

   Fill source materials for the structural fill zone beneath foundations and/or floor slabs not meeting the above liquid limit and plasticity index criteria may be acceptable if the swell potential when remolded to 95% of the standard Proctor (ASTM D698) maximum dry density at optimum moisture content and wetted under a 200 psf surcharge pressure does not exceed ½%. Potential off-site structural fill sources not meeting the above liquid limit and plasticity index criteria should be tested to assess their acceptability prior to importing them to the site.

2. **Base Course**: Material should satisfy material requirements for CDOT Class 6 aggregate base course.

3. **Utility Trench Backfill**: Materials excavated from the utility trenches may be used for trench backfill above the pipe zone fill provided they do not contain unsuitable material or particles larger than 4 inches.

4. **Material Suitability**: Unless otherwise defined herein, all fill material should be a non- to low-swelling, free of vegetation, brush, sod, trash and debris, and other deleterious substances, and should not contain rocks or lumps having a diameter of more than 4
Based on the results of laboratory testing, the on-site soils should be suitable for reuse as compacted site grading fill and as structural fill beneath foundations and floor slabs provided they do not contain organic material or other deleterious materials.

**Compaction Requirements:** We recommend the following compaction criteria be used on the project:

1. **Moisture Content:** Fill materials consisting of the predominantly clayey soils should be compacted at uniform moisture contents between optimum and 3 percentage points above optimum moisture content. Considerable processing will likely be required to achieve a uniform moisture content in the on-site clays. Fill materials consisting of imported predominantly granular soil should be compacted at moisture contents within 2 percentage points of optimum. The contractor should be aware that the clay soils, including on-site and materials, may become somewhat unstable and deform under wheel loads if placed near the upper end of the moisture range.

2. **Placement and Degree of Compaction:** Structural fill beneath foundations and exterior flatwork, and adjacent to foundations, should be placed in maximum 8-inch lifts. The following compaction criteria should be followed during construction:

<table>
<thead>
<tr>
<th>AREA</th>
<th>MINIMUM PERCENTAGE OF STANDARD PROCTOR (ASTM D698) MAXIMUM DRY DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneath spread footing foundations and underslab fill more than 3 feet below slab subgrade</td>
<td>98%</td>
</tr>
<tr>
<td>Upper 3 feet of fills beneath building floor slabs</td>
<td>95%</td>
</tr>
<tr>
<td>Retaining structure backfill</td>
<td>95%</td>
</tr>
<tr>
<td>Fills beneath pavements and exterior hardscape</td>
<td>95%</td>
</tr>
<tr>
<td>Utility trenches</td>
<td>95%</td>
</tr>
<tr>
<td>Foundation backfill</td>
<td>95%</td>
</tr>
<tr>
<td>Landscape areas</td>
<td>95%</td>
</tr>
</tbody>
</table>

3. **Subgrade Preparation:** All areas receiving new fill should be scarified to a depth of 12 inches and recomprecated to at least 95% of the standard Proctor (ASTM D698) maximum dry density at the moisture content recommended above.

Excessive wetting and drying of excavations and prepared subgrade areas should be avoided during construction.
Construction Monitoring: A representative of the geotechnical engineer should observe prepared fill subgrades and fill placement on a full time basis.

PAVEMENT DESIGN
A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Pavement design procedures are based on strength properties of the subgrade and pavement materials assuming stable, uniform conditions. Soils are represented for pavement design purposes by means of a soil support value for flexible pavements and a modulus of subgrade reaction for rigid pavements. Both values are empirically related to strength.

Subgrade Materials: Based on the results of the field and laboratory studies, the subgrade materials at the site classify between A-2-4 and A-7-6 soils with group indices between 0 and 19 in accordance with the American Association of State Highway and Transportation Officials (AASHTO) classification system. These soils are generally considered to provide poor subgrade support. For design purposes, a soil support value of 3,025 psi was selected for flexible pavements.

Design Traffic: Since anticipated traffic loading information was not available at the time of report preparation, an equivalent 18-kip daily load application (EDLA) of 5 was assumed for automobile and light truck traffic areas and an EDLA of 10 was assumed for drive lanes as well as fire lanes elsewhere on the site.

Pavement Design: The pavement thicknesses were determined in accordance with the 1993 AASHTO pavement design procedures. For design purposes, a reliability of 75% was assumed for all pavement areas. The following table presents the required pavement thicknesses:

<table>
<thead>
<tr>
<th>Location</th>
<th>Full Depth Asphalt Pavement (inches)</th>
<th>Composite Asphalt over Aggregate Base Course (inches)</th>
<th>PCCP</th>
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</table>

PCCP = Portland Cement Concrete Pavement

An alternative pavement section to the above sections would be to incorporate a chemically stabilized subgrade into the pavement section. If a minimum of 12 inches of chemically stabilized subgrade is provided below the pavement section, a full depth asphalt thickness of 3.5 inches
would be required in parking areas and 4 inches of asphalt would be required in the heavy duty/drive lanes. Chemical stabilization should consist of blending the clayey subgrade materials with cement or flyash such that the final product provides a minimum compressive strength of 160 psi at 5 days under moist curing conditions. The total pavement section would still consist of 2-feet of processed subgrade materials. Specifically, the lower 12 inches of material (between 12 inches and 24 inches below the subgrade elevation) should be moisture conditioned and compacted. The upper 12 inches (between the subgrade elevation and 12 inches below subgrade elevation) would be chemically conditioned and compacted. There is no requirement for base course material between the chemically stabilized subgrade and the asphalt; however, providing a thin layer of base material would result in a bond breaking condition that would mitigate cracks in the subgrade from propagating through the asphalt surface.

**Pavement Materials:** The following are recommended material and placement requirements for pavement construction for this project site. We recommend that properties and mix designs for all materials proposed to be used for pavements be submitted for review to the geotechnical engineer prior to placement.

1. **Aggregate Base Course:** Aggregate base course (ABC) used beneath hot mixed asphalt (HMA) pavements should meet the material specifications for Class 6 ABC stated in the current Colorado Department of Transportation (CDOT) “Standard Specifications for Road and Bridge Construction”. The ABC should be placed and compacted as outlined in the Site Grading section of this report.

2. **Hot Mix Asphalt:** Hot mix asphalt (HMA) materials and mix designs should meet the applicable requirements indicated in the current CDOT “Standard Specifications for Road and Bridge Construction”. We recommend that the HMA used for this project is designed in accordance with the Super Pave gyratory mix design method. The mix should generally meet Grading S or SX specifications with a Super Pave gyratory design revolution (NDESIGN) of 75. The mix design for the HMA should use a performance grade PG 58-28 asphalt binder. Placement and compaction of HMA should follow current CDOT standards and specifications.

3. **Portland Cement Concrete:** Portland cement concrete pavement (PCCP) should meet Class P specifications and requirements in the current CDOT “Standard Specifications for Road and Bridge Construction”. Rigid PCCP is more sensitive to distress due to movement resulting from settlement or heave of the underlying base layer and/or
subgrade than flexible asphalt pavements. The PCCP should contain sawed or formed joints to ¼ of the depth of the slab at a maximum distance of 12 to 15 feet on center.

The above PCCP thicknesses are presented as un-reinforced slabs. Based on projects with similar heavy vehicular loading in certain areas, we recommend that dowels be provided at transverse and longitudinal joints within the slabs located in the travel lanes of heavily loaded vehicles, loading docks and areas where truck turning movements are likely to be concentrated. Additionally, curbs and/or pans should be tied to the slabs. The dowels and tie bars will help minimize the risk for differential movements between slabs to assist in more uniformly transferring axle loads to the subgrade. The current CDOT “Standard Specifications for Road and Bridge Construction” provides some guidance on dowel and tie bar placement, as well as in the Standard Plans: M&S Standards. The proper sealing and maintenance of joints to minimize the infiltration of surface water is critical to the performance of PCCP, especially if dowels and tie bars are not installed.

Subgrade Preparation: Prior to placing the pavement section, the entire subgrade area should be thoroughly plowed and well mixed to a minimum depth of 24 inches, adjusted to a moisture content as listed in the “Site Grading” section of this report and compacted to 95% of the standard Proctor maximum dry density. The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle. Pavement design procedures assume a stable subgrade. Areas which deform excessively under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving. Areas of existing fill may also require deeper removal and replacement if they are either unstable or not well compacted.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of pavement. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils.

DESIGN AND CONSTRUCTION SUPPORT SERVICES
Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in
subsurface conditions from those encountered in this study so that we can re-evaluate our recommendations, if needed.

LIMITATIONS
This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon data obtained from the exploratory boring at the locations indicated on Fig. 1, and the proposed construction. This report may not reflect subsurface variations that occur between the explorations, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

Swelling soils occur on this site. Such soils are stable at their natural moisture content but will undergo high volume changes with changes in moisture content. The recommendations presented in this report are based on current theories and experience of our engineers on the behavior of swelling soil in this area. The owner should be aware that there is a risk in constructing a building in an expansive soil area. Following the recommendations given by a geotechnical engineer, careful construction practice and prudent maintenance by the owner can, however, decrease the risk of foundation movement due to expansive soils.

JAG/as
Rev. by: JAH
cc: book, file
WORK BACK SOUTHWARD FROM LEAVING EXPANSION AREA HERE - AT NORTH END

FLIP AND MIRROR BUILDING TO ALLOW FOR SOUTHERN SUN EXPOSURE ON ENTRY, AND SO THAT ENTRY DOORS ARE VISIBLE FROM "4TH STREET"

PROVIDE 3-STALL PARKING LOT ON SOUTH SIDE - MOVE SOUTH ENTRY SOUTH AS NEEDED / IF NEEDED

APPROXIMATELY 300' TO TRUMAN AVE

SHOW IN LARGER OVERALL MAP VIEW, SHOWING MORE OF ENTIRE SITE
LEGEND

TOPSOIL.

LEAN CLAY WITH SAND (CL) TO SANDY LEAN CLAY (CL), FINE TO MEDIUM GRAINED, STIFF TO HARD, DRY TO MOIST, TAN TO BROWN.

Silty sand (SM) to Clayey Sand (SC) to Poorly Graded Sand (SP), Medium to Coarse, Loose to Very Dense, Dry to Moist, Tan to Brown.

DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.

29/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 29 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

DEPTH AT WHICH BORING CAVED.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON JUNE 12, 2019 WITH A 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.

2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.

3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.

4. THE EXPLORATORY BORING LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.

6. GROUNDWATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.

6. LABORATORY TEST RESULTS:

WC = WATER CONTENT (%) (ASTM D2216);
DD = DRY DENSITY (pcf) (ASTM D2216);
-200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
LL = LIQUID LIMIT (ASTM D4318);
PI = PLASTICITY INDEX (ASTM D4318);
NV = NO LIQUID LIMIT VALUE (ASTM D4318);
NP = NON-PLASTIC (ASTM D 4318);
WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103);
OMC = OPTIMUM MOISTURE CONTENT (%) (ASTM D698);
MDD = MAXIMUM DRY DENSITY (pcf) (ASTM D698).
SAMPLE OF: Sandy Lean clay (CL)
FROM: Boring 1 @ 1'
WC = 13.1 %, DD = 116.8 pcf
-200 = 67 %, LL = 44, PI = 33

EXPANSION UNDER CONSTANT PRESSURE UPON WETTING

CONsolidation - Swell (%)

APPLIED PRESSURE - KSF

SAMPLE OF: Sandy Lean Clay (CL)
FROM: Boring 3 @ 4'
WC = 14.6 %, DD = 115.7 pcf
-200 = 58 %, LL = 36, PI = 24

EXPANSION UNDER CONSTANT PRESSURE UPON WETTING

CONsolidation - Swell (%)

APPLIED PRESSURE - KSF

These test results apply only to the samples tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell Consolidation testing performed in accordance with ASTM D-4546.

19-3-157  Kumar & Associates  SWELL–CONSOLIDATION TEST RESULTS  Fig. 4
SAMPLE OF: Sandy Lean Clay (CL)
FROM: Boring P-2 @ 4'
WC = 8.5 %, DD = 101.8 pcf
-200 = 78 %, LL = 35, PI = 22

EXPANSION UNDER CONSTANT PRESSURE UPON WETTING

CONSOLIDATION - SWELL (%)

APPLIED PRESSURE - KSF

These test results apply only to the sample tested. The testing reported shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell consolidation testing performed in accordance with ASTM D-4591.
### HYDROMETER ANALYSIS

<table>
<thead>
<tr>
<th>TIME READINGS</th>
<th>U.S. STANDARD SERIES</th>
<th>CLEAR SQUARE OPENINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 HRS 9 HRS</td>
<td>12 MIN 3 MIN 60MIN 1HMIN 4MIN 1MIN</td>
<td>600 400 300 250 200</td>
</tr>
</tbody>
</table>

### SIEVE ANALYSIS

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<tr>
<th>DIA. (INCHES)</th>
<th>3/8&quot;</th>
<th>3/4&quot;</th>
<th>1 1/2&quot;</th>
<th>2&quot;</th>
<th>3&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
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<tbody>
<tr>
<td>PERCENTAGE</td>
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<td></td>
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### Diameter of Particles in Micrometers

<table>
<thead>
<tr>
<th>CLAY TO SILT</th>
<th>SAND</th>
<th>GRAVEL</th>
<th>COBBLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINE</td>
<td>MEDIUM</td>
<td>COARSE</td>
<td>FINE</td>
</tr>
</tbody>
</table>

- **Gravel**: 2%
- **Sand**: 27%
- **Silt and Clay**: 71%

**Liquid Limit**: 33

**Plasticity Index**: 26

**Sample of**: Sandy Lean Clay (CL)

**From**: Borings 1, 2, 3 & 4 @ 1'-5'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc.

Sieve analysis testing is performed in accordance with ASTM D6915, ASTM D7928, ASTM C136 and/or ASTM D1140.
COMPACCIÓN TEST REPORT

Curve No. 2209

Preparation Method
Rammer: Wt. 5.5 lb. Drop 12 in.
Type: manual
Layers: No. three Blows per 25
Mold Size: 0.03333 cu. ft.
Test Performed on Material
Passing: #4 Sieve

% #4 2 % < No. 200 71
Atterberg (D 4318): LL 35 PL 26
NM (D 2216) Sp. G. (D 854) 2.65
USCS (D 2487) CL
AASHTO (M 145) A-6(15)
Date: Sampled 6/12/19
Received 6/12/19
Tested 6/14/19
Tested By: RK

COMPACCIÓN TESTING DATA
ASTM D 698-12 Method A Standard

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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>WM</td>
<td>3969.5</td>
<td>4050.0</td>
<td>4037.5</td>
<td>4008.1</td>
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<td>WM</td>
<td>2180.3</td>
<td>2180.3</td>
<td>2180.3</td>
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<td>WM + T #1</td>
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<tr>
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<tr>
<td>TARE #2</td>
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</tbody>
</table>

TEST RESULTS

Maximum dry density = 106.0 pcf
Optimum moisture = 17.9%

Project No. 19-3-157 Client: Town of Bennett
Project: Bennett Public Works Building
Location: B1 - B4 Depth: 1' - 5' Sample Number: 2209

SIEVE TEST RESULTS
ASTM D 422 ASTM D 1140

<table>
<thead>
<tr>
<th>Opening Size</th>
<th>% Passing</th>
<th>Spec.</th>
</tr>
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<tbody>
<tr>
<td>1&quot;</td>
<td>100</td>
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</tr>
<tr>
<td>3/4&quot;</td>
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<td>3/8&quot;</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>98</td>
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<tr>
<td>#8</td>
<td>97</td>
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<td>#30</td>
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<tr>
<td>#50</td>
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<td>#100</td>
<td>77</td>
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<tr>
<td>#200</td>
<td>71</td>
<td></td>
</tr>
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</table>

Material Description
Sandy Lean Clay (CL)

Remarks:
These test results apply only to the samples which were tested; the testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Moisture/density relationships performed in accordance with ASTM D698. All Atterberg tests performed in accordance with ASTM D4318. Sieve analyses performed in accordance with ASTM D422, 19140.

Checked by: JG
Title: MOISTURE-DENSITY RELATIONSHIPS
Fig. 7
# Summary of Laboratory Test Results

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Natural Moisture Content (%)</th>
<th>Natural Dry Density (pcf)</th>
<th>Gradation</th>
<th>Percent Passing No. 200 Sieve</th>
<th>Atterberg Limits</th>
<th>Water Soluble Sulfates (%)</th>
<th>AASHTO Classification (Group Index)</th>
<th>Soil or Bedrock Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.1</td>
<td>116.8</td>
<td>0</td>
<td>33</td>
<td>67</td>
<td>44</td>
<td>33</td>
<td>Sandy Lean Clay (CL)</td>
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<tr>
<td>2</td>
<td>3.1</td>
<td>127.8</td>
<td>0</td>
<td>74</td>
<td>26</td>
<td>21</td>
<td>9</td>
<td>Clayey Sand (SC)</td>
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<td>3</td>
<td>14.6</td>
<td>115.7</td>
<td>0</td>
<td>42</td>
<td>58</td>
<td>36</td>
<td>24</td>
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<tr>
<td>4</td>
<td>15.9</td>
<td>112.4</td>
<td>0</td>
<td>36</td>
<td>64</td>
<td>39</td>
<td>28 0.03</td>
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<tr>
<td>P-1</td>
<td>12.0</td>
<td>115.5</td>
<td>0</td>
<td>24</td>
<td>76</td>
<td>44</td>
<td>20</td>
<td>A-7-6 (15) Lean Clay with Sand (CL)</td>
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<tr>
<td>P-2</td>
<td>8.5</td>
<td>101.8</td>
<td>0</td>
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<td>78</td>
<td>35</td>
<td>22</td>
<td>A-6 (15) Lean Clay with Sand (CL)</td>
</tr>
<tr>
<td>1 to 4</td>
<td>17.9*</td>
<td>106.0*</td>
<td>2</td>
<td>27</td>
<td>71</td>
<td>35</td>
<td>26</td>
<td>A-6 (15) Lean Clay with Sand (CL)</td>
</tr>
</tbody>
</table>

* - Optimum moisture content and maximum dry density as determined by standard Proctor (ASTM D 698)