Effectiveness and Benefits of Calcium Chloride Stabilized Road Base: A Township of Woolwich Study

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ABSTRACT

Different additives (cementitious, bituminous, chemical, mechanical, biological, and proprietary blends) are routinely used to improve material properties of poor soils and aggregates ranging from highly expansive clays to more granular materials. Whereas the benefits of some of these additives are accounted for in pavement design and lifecycle processes; the benefits of Calcium Chloride ($CaCl_2$) – a common chemical soil stabilizer is not considered.
The hygroscopic properties of $CaCl_2$ effectively stabilizes soils through the attraction of moisture and subsequent evaporation resistance, improving compaction during construction which in turn ensures a strong and durable base material. An additional benefit of $CaCl_2$ particularly in cold regions, is its ability to decrease the freezing point of water consequently providing enhanced resistance to frost heaving.
Leaning on the successes and challenges of calcium chloride stabilized road base in Canada, this on-going Township of Woolwich study investigates the effectiveness of a 35% $CaCl_2$ road base application for improving the short and long-term performance of an asphalt surfaced roadway and reducing the overall life-cycle costs. This study employs a monitoring program of Falling Weight Deflectometer (FWD) testing - prior to and after base stabilization, after paving and after one winter cycle - to characterize the short and long-term benefits by comparing the performance of the $CaCl_2$ stabilized and non-stabilized (control) road base sections exhibiting good and poor drainage conditions. This paper presents the short-term findings of using $CaCl_2$ for base stabilization. The economic benefits of incorporating $CaCl_2$ in road base applications is evaluated, and a case for considering the benefits of a $CaCl_2$ stabilized road base during design is further assessed.

KEY WORDS: $CaCl_2$, Stabilization, FWD, Strength and Performance Characterization, Design Criteria, and Economic Benefits.

1. INTRODUCTION

1.1. Background and Problem Statement

Stabilization is a process of blending and mixing materials with a soil or aggregate when the strength, or other properties (i.e. gradation, workability, or plasticity) of the in-place soil do not meet the desired or required levels for a design. Soils can be either modified or stabilized by many methods, including chemical, mechanical, thermal, and electrical [1]. Modification is generally short term and includes benefits such as improvement in workability (expediting construction and saving time and money); while stabilization generally results in a longer term strength gain [2].

Different additives (cementitious, bituminous, chemical, mechanical, biological, and proprietary blends) are routinely used to improve material properties of poor soils and aggregates ranging from highly expansive clays to granular materials. Whereas the benefits of some of these additives are accounted for in pavement design and lifecycle processes, despite some industry guidance, the benefits of Calcium Chloride ($CaCl_2$) is neither considered nor accounted for during design.

Calcium Chloride is a common chemical additive known for its ability to regulate moisture. This capability is derived from its hygroscopic nature which draws moisture from the environment to produce a brine that in turn keeps the road material moist. In addition, its deliquescent property retards surface evaporation during the heat of the day by forming a hygroscopic solution which absorbs moisture until equilibrium is reached between the vapor pressure of the solution and that of the surrounding air [3]. For these reasons, $CaCl_2$ is most commonly utilized for dust suppression in unbound road surfacing (gravel roadways) applications with additional proven benefits of reduced surface aggregate loss, reduced grading maintenance which results in annual material and maintenance savings [4].

The key benefit of the use of $CaCl_2$ is that it allows for optimum aggregate interlock by penetrating into the aggregate structure and coating its particles, improving compaction during construction which is already known to provide cost savings to gravel surfaced roads. When applied to granular base/subbase courses in a roadway, these lifts can also benefit from improved compaction which would result in a more uniform and durable base/subbase material with a higher resilient modulus. An additional benefit of the use of $CaCl_2$, particularly in cold regions, is its ability to decrease the freezing point of water to below the freezing index, consequently providing enhanced resistance to frost heaving in these layers [6, 8].

The Township of Woolwich is a rural township located in Southwestern Ontario in the Waterloo Region. The Township is made up of 10 small communities with a total population of approximately 25000 people as of 2016 [5]. The Township is bounded by the cities of Kitchener, Waterloo and Cambridge and as a result, the typical traffic consists of a large number of commuters. The roadways are also used by heavy equipment from the numerous farmers in the area as well as horse-drawn buggies from the substantial population of Old Order Mennonite families.

The Township of Woolwich has been using $CaCl_2$ for a number of years on its road rehabilitation projects. The Township has noted a number of benefits in the use of $CaCl_2$ on its projects including: better material workability during construction; less use of water for compaction; higher compaction levels; and a general sense of better performing projects. It should be noted however that despite these experiential benefits, there is no consideration given to these benefits in the Township's designs. As a result, the use of $CaCl_2$ is considered to be an additive cost to providing a better performing project.

There has not been a significant amount of research that has been completed on the stabilization of pulverized RAP and granular blended base/subbase material. Evidence provided by the $CaCl_2$ industry suggests that a Granular Base Equivalency of 1.3 can be expected from $CaCl_2$ stabilized roadbase when compared against the use of a standard granular road base material. Another study indicates that a $CaCl_2$ stabilized would be 30 percent stronger and more durable and concludes that $CaCl_2$ stabilized roads will last longer [8].

Although a $CaCl_2$ application rate of 3.6 liters per square meters is recommended by suppliers, research from a gravel road stabilization project in Pelham, Ontario suggests that strength improvements were achieved over a range of the application rates [9]. This study recommended a $CaCl_2$ application rate of 1% by weight combined with thorough mixing with all materials to ensure penetration to the full-depth of the granular material prior to compacting with a smooth drum vibratory compactor. This result was corroborated by a second study which employed non-destructive Falling Weight Deflectometer (FWD) to investigate the effects of $CaCl_2$ with FDR on a low volume roadway in the Town of Caledon, Ontario [3].

1.2. Scope and Objectives

Given the proven ability of $CaCl_2$ to regulate moisture and improve compaction of unbound materials, this on-going study investigates the effectiveness of a 35 percent $CaCl_2$ solution in roadbase stabilization applications for low volume roads. This study is particularly important to Agencies and Municipalities which have experienced the benefits of calcium chloride application to gravel surfaced roadways and are considering the potential of extending these benefits to road pulverization projects. Therefore, the study seeks to quantify the strength benefits as well as advocate the practical need of accounting for the same during pavement design.

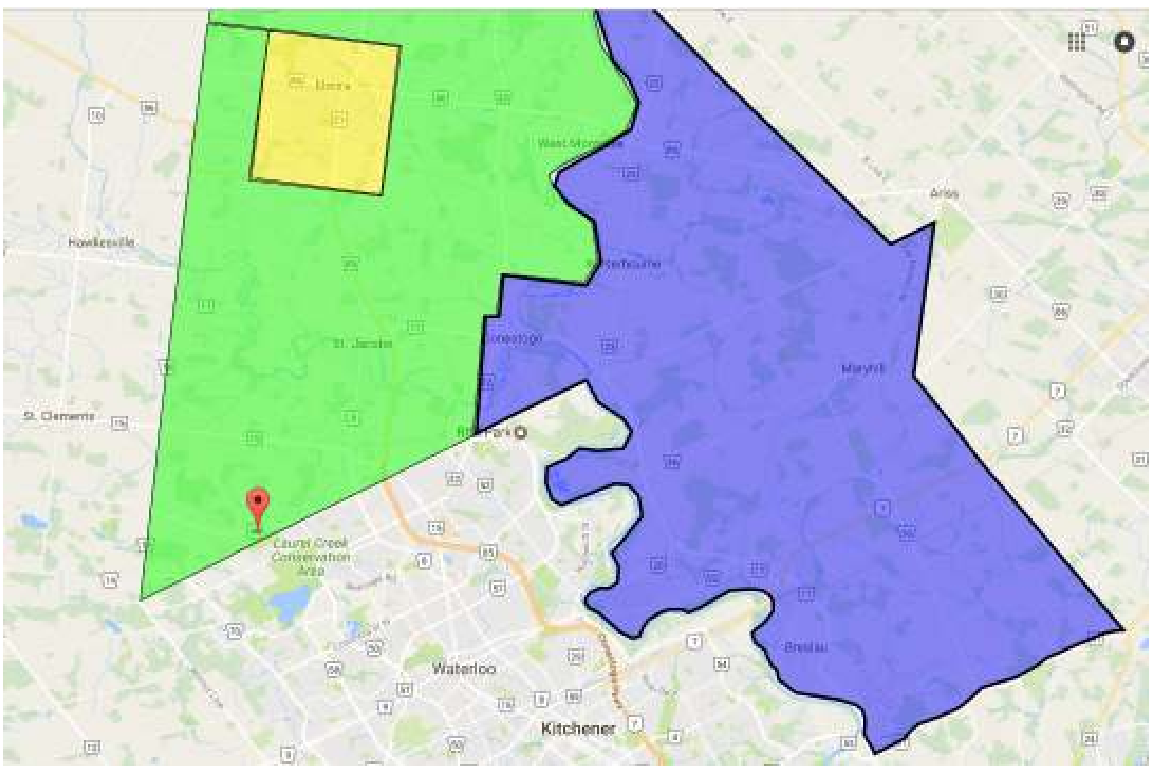
The Township of Woolwich and the calcium chloride industry have claimed a number of benefits to calcium chloride application during full depth reclamation. These benefits include improved moisture retention and compaction during construction resulting in increased in-situ material density having long term benefits to the roadway performance. The objective of this study is validate these benefits with a controlled experiment in order to quantify the potential long term benefits in terms of design benefit or cost benefit.

This paper presents the short-term (2 year) findings of using $CaCl_2$ for stabilization of Benjamin Road in the Township of Woolwich.

2. RESEARCH METHODOLGY AND EXPERIMENTAL DESIGN

Benjamin Road is located in the southwestern corner of the Township near the boundary with the City of Waterloo. The roadway section evaluated in this study is the portion of Benjamin Road between Westmount Road North and Kressler Road. The test site location is shown in Figure 1.

Figure 1 Site Map Showing Woolwich Boundaries and Test Site Location



The Site was first investigated in May of 2015 by Englobe in order to provide recommendations for the most cost effective rehabilitation strategy for the roadway. The investigation consisted of the completion of a semi-automated visual condition survey of the existing pavement sections in order to determine the primary modes of distress as well as a falling-weight deflectometer survey to determine the structural condition of the roadway. This was combined with geotechnical information that was gathered as part of a separate study in order to determine the optimum rehabilitation strategy. After review of a number of different strategies, a full depth reclamation with hot-mix asphalt overlay we selected as the preferred rehabilitation strategy for the entire site. However based on past project experience, the Township requested that calcium chloride stabilization of the pulverized base be included in the work plan. After some discussion, the Township agreed to set up control sections (i.e. sections that were not stabilized with calcium chloride) in order to determine if there was a difference in constructability and life-cycle performance between stabilized and non-stabilized roadway sections.

The visual condition survey noted differences in the surface condition and drainage along the length of the roadway with the eastern portion having fair surface condition and good ditching and the western portion having poor surface condition and relatively shallow ditches. The FWD testing noted a difference in structural capacity between these two sections with the eastern portion having higher moduli and the western portion having lower moduli. Based on the observed results, the roadway was divided into two sections for design purposes. Photographs of the surface condition and summaries of the FWD surface modulus are provided in Figures 2 to 4 respectively.

Figure 2 Photograph of Typical Site Conditions in Both Questions

Section 1 – Showing low severity alligator cracking and low severity transverse cracking with good ditches

Section 2 – Showing medium to high severity alligator cracking and medium severity transverse cracking with poor ditches

Figure 3 FWD Testing Results from Section 1

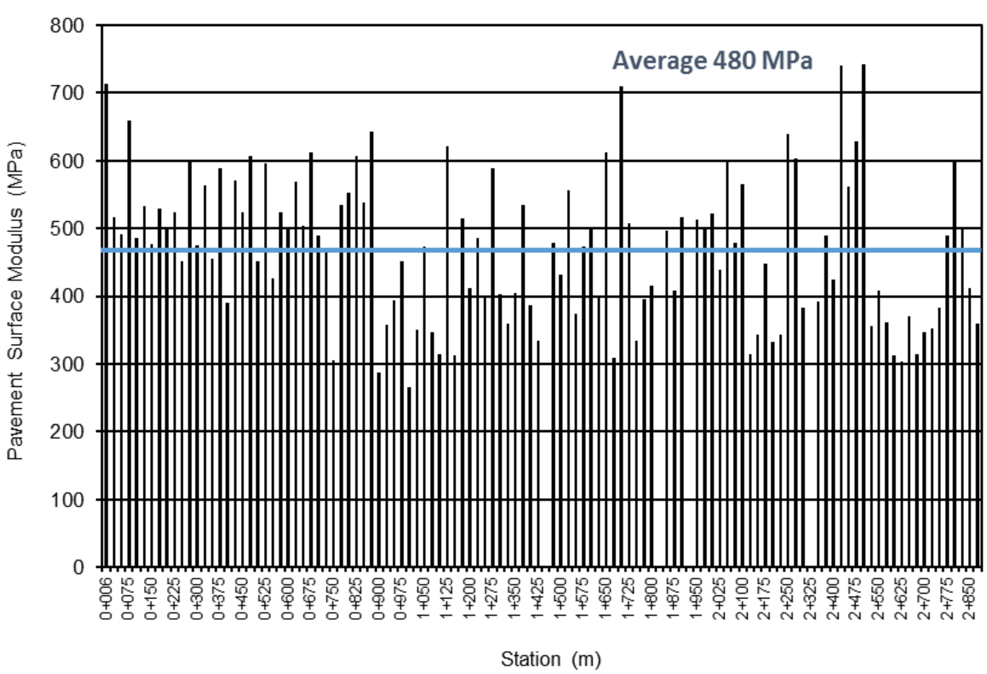
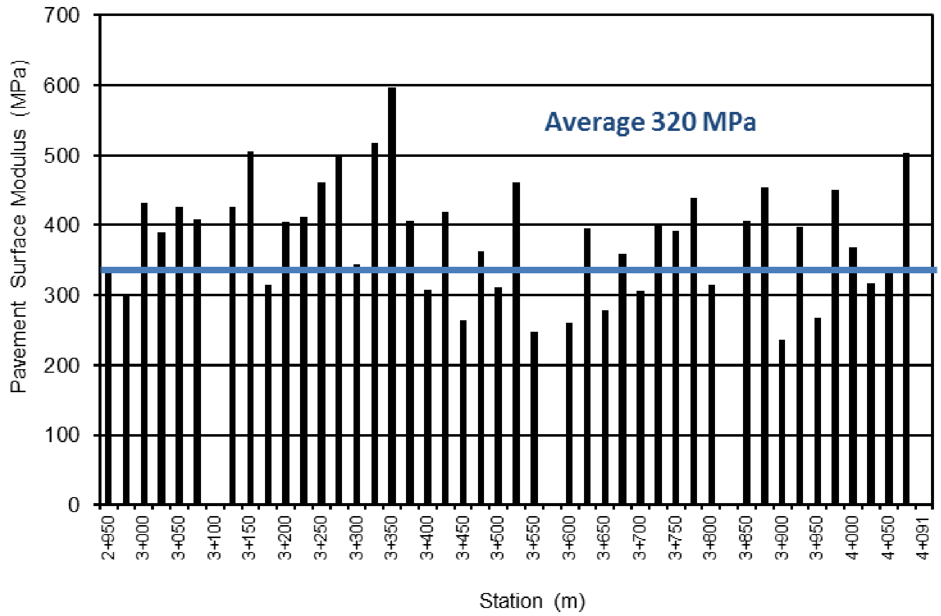


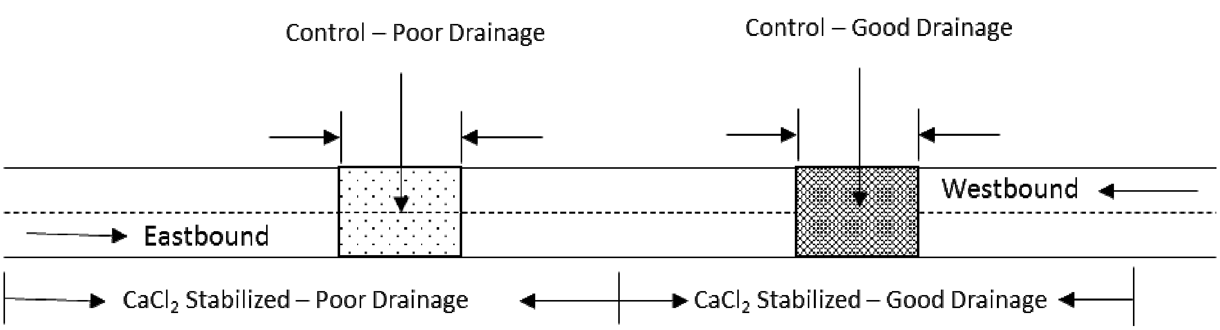
Figure 4 FWD Testing Results from Section 2



Prior to rehabilitation, the general surface condition of segment one (Westmount Road North – Bisch Street, 2.9 km) was observed to be fair with intermittent poor distress areas, and good with intermittent poor drainage conditions. The general surface condition of Segment Two (Bisch Street – Kressler Road, 1.14 km) was observed to have poor and localized very poor surface distresses, and poor drainage conditions. The subgrade on both segments were found to be predominantly clayey silt or clayey silt till. Other subgrade types observed intermittently throughout the site include sand, silty sand, sandy silt and sand, and sand and gravel, and mixtures of all of the above.

As mentioned previously, it was important to the study to be able to quantify the amount of strength gain and long term performance gain between calcium stabilized and non-stabilized materials. Consequently, as part of the study, two 100 m long control sections (one in the area with poor drainage and one in the area with good drainage) were left non-stabilized. An Illustration of the test section layout is provided in Figure 5.

Figure 5 Test Site Layout



Research that has been completed on the use of calcium chloride on gravel surfaced roads has indicated that the effectiveness of calcium chloride could be impeded when used in saturated conditions and/or in the proximity of the water table. The concern is that the calcium chloride solution may be drawn to, or migrated out of the granular material by the water which would eliminate the benefit. The conditions on Benjamin Road provided an opportunity to evaluate this condition which resulted in the development of two control sections, one in the poor drainage area and one in the good drainage area, as outlined in Figure 5.

One of the key reported benefits to the use of calcium chloride for stabilization of granular base/subbase materials is the control of the relative moisture condition in this material and the associated benefits to compaction. In order to evaluate this condition for this study, Englobe completed in-situ density and moisture content testing at an elevated frequency using a nuclear density gauge in both the control and calcium stabilized sections. When using a nuclear density gauge to determine moisture content and in-situ dry density of materials that contain asphalt coated particles (ACP), it is known that the moisture density count will be overestimated because of the presence of hydrogen ions in the ACP. In order to mitigate this effect, in-situ samples of the compacted material were regularly recovered at the location of the nuclear density testing (approximately once per hour) and tested in the laboratory in order to determine the actual moisture content of the material. These values were then used to determine the corrected moisture density and dry density of the field material.

The field performance and strength gain (in terms of the material resilient modulus) was determined using a non-destructive investigation program consisting of Falling Weight Deflectometer (FWD) testing. The FWD testing was completed at 50 m intervals along the site. At each test location, three load levels (approximately 30, 40, and 50 kN) was used to determine the deflection response of the pavement. The FWD testing program was completed at key stages during the construction and during the initial service period in order to evaluate the strength gain over time. The key stages evaluated to date are as follows:

- Before Rehabilitation During Design (BR) – May, 2015;
- During Rehabilitation (After Pulverization and Before Base Stabilization (BBS)) – August, 2015;
- During Rehabilitation (After Base Stabilization and Curing (ABS)) – September 2015;
- After Paving (AP) – September, 2015; and
- After First Winter (AFW) – May, 2016.

Potential short term benefits for the use of calcium chloride for stabilization include increases in density, better material workability and better moisture control (i.e. less watering). The benefits to in-situ density and moisture control were evaluated as part of the nuclear density gauge testing. In order to determine the benefits gained from enhanced workability, Englobe conducted a project debriefing upon completion of construction with the Township inspection staff and the Contractor in order to discuss these benefits and how they compare to other projects. The costs were also discussed in order to evaluate the potential cost benefits of the process.

3. $CaCl_2$ ROAD BASE STABILIZATION PROCEDURE

In order to ensure that a uniform 50/50 blend of RAP and existing granular material was achieved on the site, a detailed pre-milling program was completed in both of the test sections. The pre-milling program consisted of removing localized thick layers of asphalt concrete to provide a consistent 150 mm (or less) thickness along the alignment. The existing remaining asphalt concrete as well as 150 mm of the underlying existing granular base course were then pulverized and blended together to a total depth of 300 mm. Oversized pulverized material (greater than 26.5 mm in size) was removed from the road base surface and either discarded or placed ahead of the pulverizer for reprocessing. The pulverized material was then carefully graded to repair localized transverse and longitudinal profile issues.

The compliance to the blend specification was confirmed during construction by recovering samples of the pulverized material and completing an asphalt coated particles (ACP) test. The ACP testing was completed at an initial frequency of 500 m. If ACP testing results showed high RAP content or an area looked to visually contain high RAP content, then additional sampling was completed in between test locations to more accurately delineate high RAP areas for remediation. Remediation consisted of spreading sufficient additional Granular 'A' base course material to dilute the RAP content to below the 50 percent threshold followed by pulverization and regrading the affected section.

The prepared surface was then sprayed with a 35 percent solution of liquid calcium chloride. The solution was sprayed on the surface at a rate of 3.5 litres per square metre. After the solution was sprayed, the solution was immediately blended to a depth of 300 mm depth through multiple passes of a pulverization machine. The blend was then final graded, shaped and then compacted using a single steel drum vibratory compactor to achieve the required compaction levels.

After compaction was confirmed to have been achieved, the surface of the final product was again sprayed with a 35 percent solution of liquid calcium chloride at a nominal rate of 0.5 litres per square metre in order to seal and bind the surface. The exposed surface was then allowed to stabilize for a period of 2 weeks prior to paving the surface with hot-mix asphalt.

4. RESULTS AND DISCUSSION

4.1. Construction Notes and Observations

The Township staff responsible for the project were surveyed in order to provide their evaluation of the stabilization process. The staff noted that after the stabilization process was completed, but prior to placement of the hot-mix asphalt overlay, the road base sections that were stabilized with calcium chloride appeared firm. After the curing period, the surface required regrading in order to remove any potholes or rutting that had developed due to traffic action. It was noted that the base was easily workable and still very firm and compaction was obtained easily; the steel drum rollers would almost bounce on the granular when compacting. In comparison, the two 100 m control sections that were not stabilized with calcium chloride did not appear not as compact; the surface was described as bulky and was observed to produce a lot of dust.

The surface of the stabilized roadway was inspected by Township staff prior to overlaying with hot-mix asphalt. There were no deficiencies relating to cracking that were observed on either the calcium chloride stabilized sections nor on the control sections prior to placement of the asphalt. The Township did not note any other differences between the two project sections.

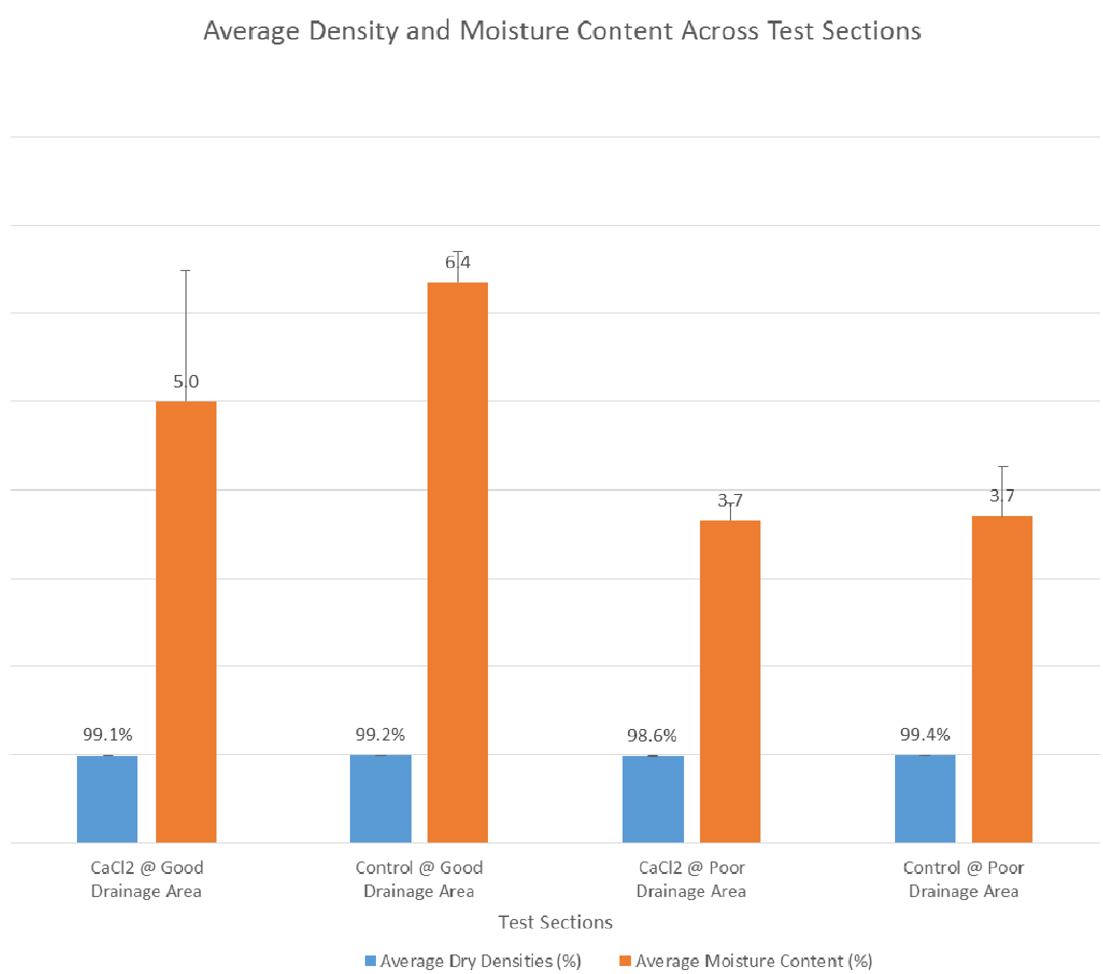
The Township indicated that two week curing period after calcium chloride stabilization that was included as part of the stabilization procedure was, at times, difficult to manage. Township staff reported that motorists were under the impression that they no longer needed to use the detour provided seeing that there were no construction activities occurring during this period. There was no indication that the Township was considering altering this curing period due to the fact that this stabilization procedure has been proved to be successful on past projects.

4.2. Compaction and Moisture Content Testing

The main benefit that is expected to be derived by the use of calcium chloride in road stabilization is an improvement in material density which is developed by maintaining the optimum level of moisture during construction, as well as providing some additional lubricity to the particles during the construction process. For this research, the objective was to evaluate the level of density improvement that calcium chloride would provide in a 50/50 blend of RAP and granular material as compared to control sections that were not stabilized and to evaluate how this density improvement would benefit the material resilient modulus and in-turn how these layers should be designed.

The density of the RAP granular blended material on the project was tested in-situ using a Troxler nuclear density gauge. The in-situ density was measured at 100 m intervals along the job site in both directions of travel. Due to the presence of RAP in the compacted material, the nuclear density gauge could not be used to determine the in-situ moisture content to the reliability level required for this study. As a result, samples of the compacted material were gathered at each nuclear density gauge test point and tested in Englobe's Kitchener laboratory in order to determine the actual moisture content. The average compaction results as well as the average moisture content readings for the two test sections (good and poor drainage areas) as well as the two control sections are summarized in Figure 6.

Figure 6 Average Density and Moisture Content Across Test Sections

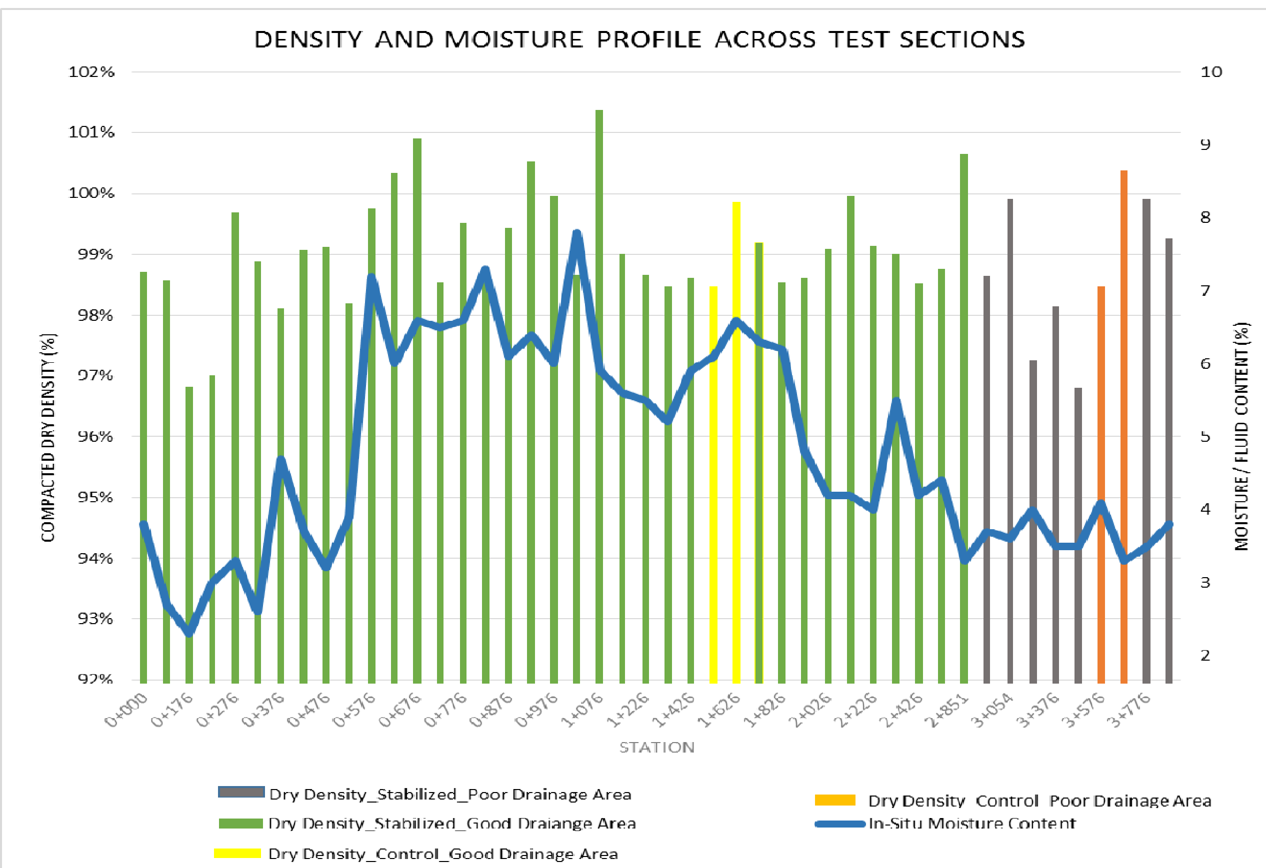


The compaction results that are summarized in Figure 6 indicate a negligible difference in the level of compaction achieved at the time of initial construction between the calcium chloride stabilized portions of the roadway and the control sections. The average compaction in Section 1 (good drainage area) was nearly identical, ranging from 99.1 percent in the calcium stabilized area to 99.2% in the control area. The error bars for the compaction results in the good and poor drainage areas are very small which indicates that the general site compaction results were relatively consistent throughout.

The moisture content testing results summarized in Figure 6 indicate that the moisture content in the calcium chloride stabilized sections was less than or equal to the moisture content observed in the control sections at the time of compaction. In addition, the error bars for the moisture content results in the good and poor areas are quite large indicating variability in the recorded moisture content on the site. These two results would indicate that there was no recorded benefit in the calcium chloride stabilized areas with respect to the level of moisture (i.e. maintaining the moisture level near optimum for compaction), nor in terms of the reliability of the moisture content level across the site.

The effect of the moisture content variability was further evaluated by comparing the compacted density and the moisture content at each point on the site. The results of this comparison are shown graphically in Figure 7. The moisture content profile shows very low (3 to 4 percent) in-situ moisture content values between Stations 0+000 and 0+500. The corresponding compaction results range from 96 to 99 percent. This scenario is repeated in Section 2 (between Stations 3+000 and 4+000) with low in-situ moisture content values corresponding to locally low values of corresponding compaction. The highest compaction values were obtained between Stations 0+500 and 1+100 which corresponded to in-situ moisture content values which were near the optimum moisture content of the pulverized materials.

Figure 7 Average Density and Moisture Content Across the Site



The results of this analysis indicate that the application of calcium chloride in and of itself does not result in a more uniform and homogeneous moisture content level during the construction process. This is an important observation as maintaining an optimum moisture content level is one of the key benefits attributed to the use of calcium chloride for stabilization purposes. Consequently, the level of compaction on the site was observed to vary with the varying level of moisture.

4.3. Non Destructive Testing Results

The purpose of the non-destructive testing program was to evaluate the in-situ performance of the calcium stabilized material in comparison to the identical site materials that were not stabilized in the control sections. The non-destructive testing process allows for a rapid evaluation of both the short and long term material performance. The non-destructive testing program also allows for testing of the materials during different seasons which allows for an evaluation of any potential seasonal benefit to the stabilization process. Once the long term performance of this material is known, then an evaluation of the benefits to the design process can be completed.

The FWD testing on the test site was completed at five different stages: Before Rehabilitation During Design (BR) – May, 2015; During Rehabilitation (After Pulverization and Before Base Stabilization (BBS)) – August, 2015; During Rehabilitation (After Base Stabilization and Curing (ABS)) – September 2015; After Paving (AP) – September, 2015; and After First Winter (AFW) – May, 2016. These testing points were selected to represent key stages in the construction process which would provide an indication of the progression of the deflection response of the material during the construction process as well as the response during different seasons. Additional testing stages are planned in the future in order to better understand the long term performance of this stabilization process for consideration during design.

At each testing stage the deflection response of the FWD testing points was evaluated in order to determine the effective resilient modulus of the pulverized material through the back-calculation process. Englobe utilized the Elmod 6.0 software in our back-calculation analysis which is based on the Boussinesq equations and the method of equivalent thickness [12]. The resilient modulus values that are obtained from the back-calculation process represent the in-situ resilient modulus values which are known to vary from those obtained from laboratory testing, however it is the laboratory testing values that are used for design. This makes it necessary to adjust the back-calculated resilient modulus values by a correction factor in order to make them representative of the laboratory/design values.

The MTO has completed internal research and calibrated Ontario materials to FWD results with the most recent guidance provided in their *publication Ontario's Default Parameters for AASHTOWare Pavement ME Design* [13]. For aggregate base/subbase materials which are evaluated below an HMA layer, the results obtained from backcalculation are multiplied by a factor of 0.62 to obtain equivalent laboratory/design values. Another factor that was considered during our evaluation was that the resilient modulus of a granular material will vary depending on the season. For the three stages tested during construction, the seasons were the same and an adjustment factor was not needed. The AFW stage however was completed in the spring. As a result, the AFW resilient modulus values were adjusted to equivalent values that would have been obtained in the fall season in accordance with MTO guidance [14]. A summary of the backcalculated resilient modulus results from the two sections and the four stages is provided in Figure 8.

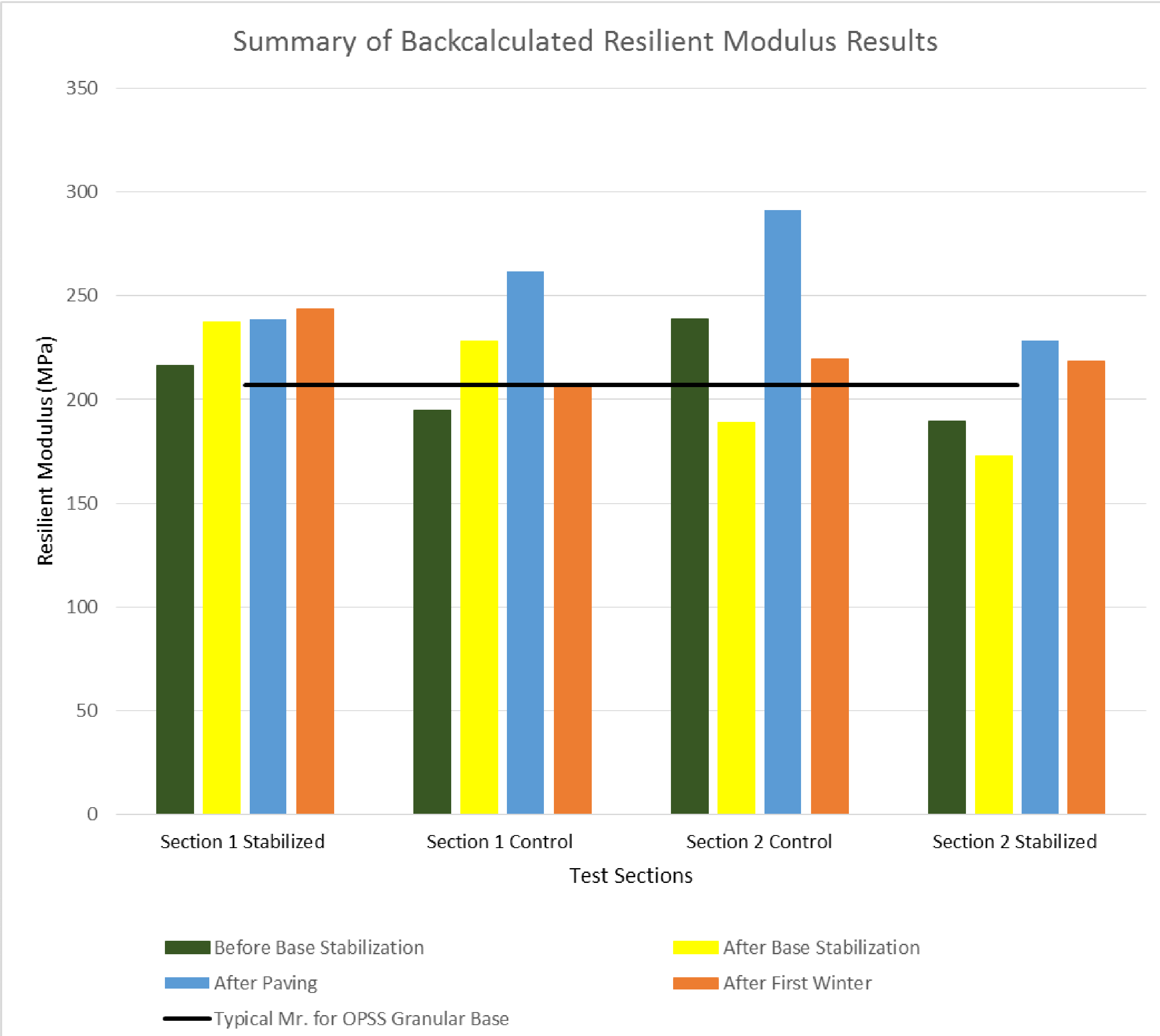
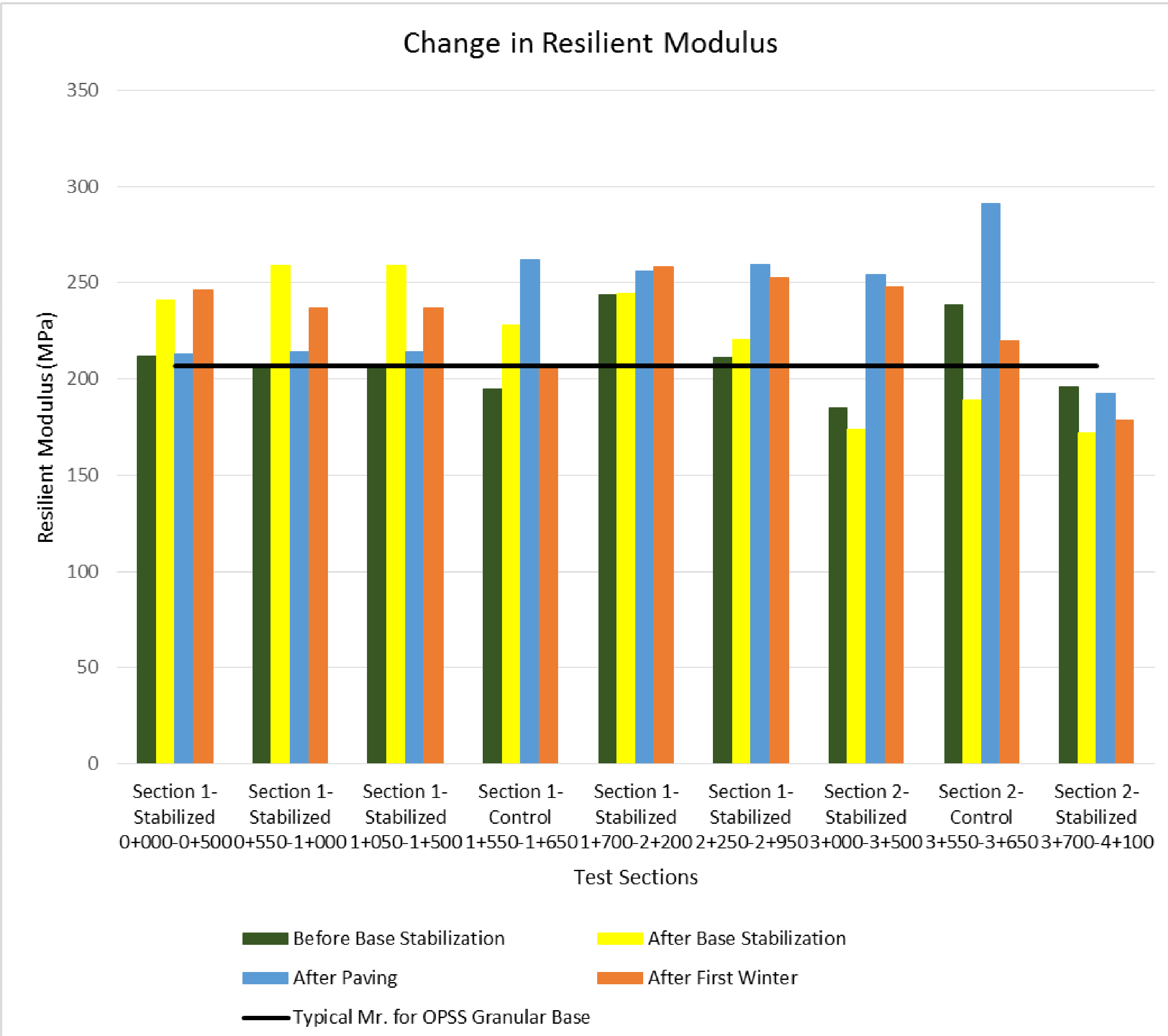


Figure 8 Summary of Backcalculated Resilient Modulus Results

The results in Figure 8 show a general improvement in the resilient modulus before base stabilization and after paving. However the observed improvement is in both the stabilized and control sections with the control sections having more average improvement than the stabilized sections. This result would indicate that the observed improvement in resilient modulus is due to other factors and not directly related to the calcium chloride stabilization process.

Considering the results of the density and moisture content testing showed that the in-situ density of the pulverized material varied across the site, the non destructive testing data was evaluated in order to determine if the increase in resilient modulus could be attributed to additional densification of the granular material. The resilient modulus results were summarized based on 500 metre segments along the site. The output of this evaluation is provided in Figure 9.

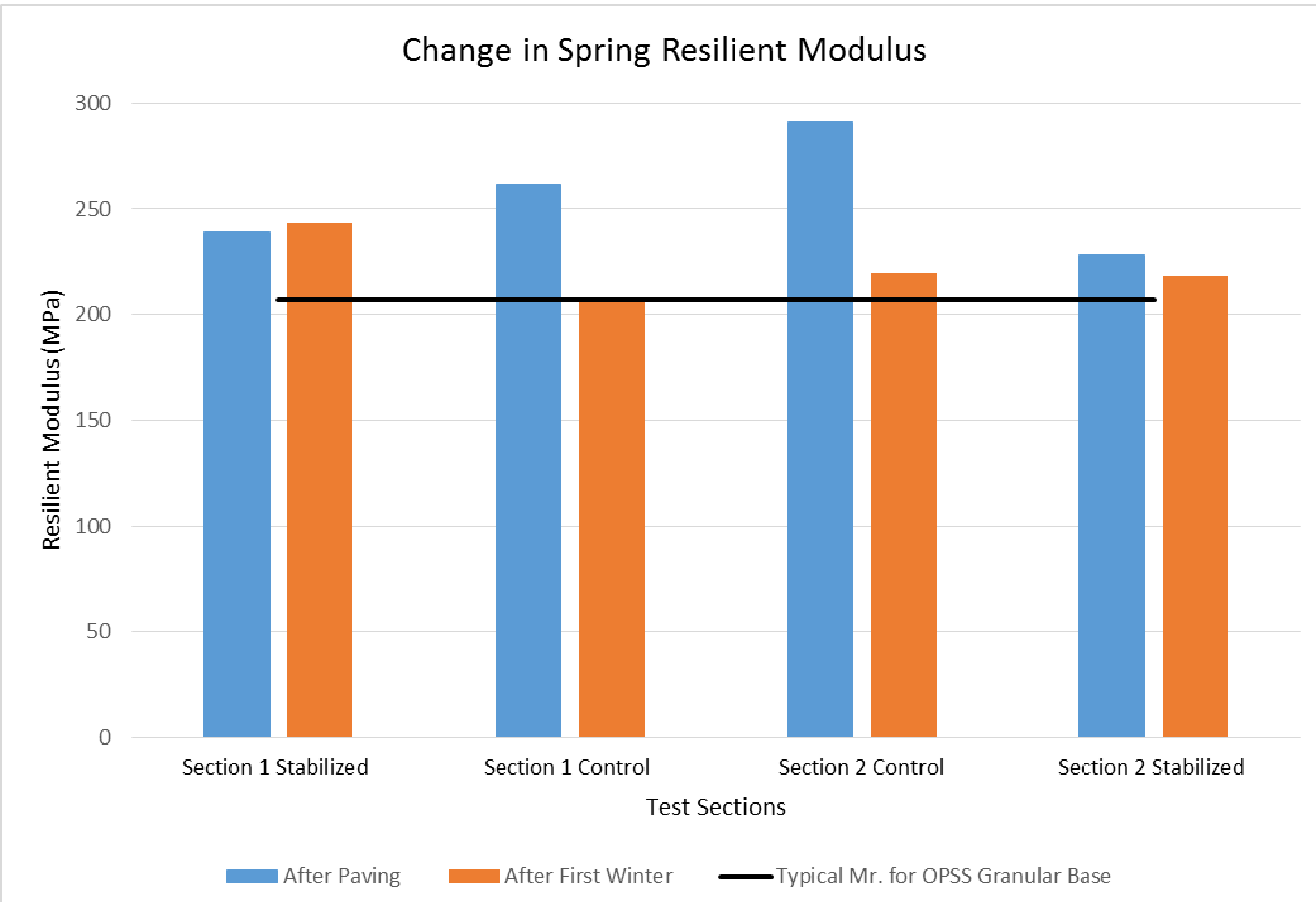
Figure 9 Summary of Backcalculated Resilient Modulus Results – 500 m Segments



The results in Figure 9 show that the improvement in resilient modulus appears to be independent of the level of compaction prior to paving. For instance, there were three distinct levels of compaction in Section 1 between Stations 0+000 and 1+500, however the improvement in the resilient modulus between these stations is nearly identical. Conversely, the two control sections which had greater than 99 percent compaction prior to paving both had large improvements in their resilient modulus over time. This would appear to indicate that the gain in resilient modulus is not predominantly related to either the level of compaction or the calcium chloride stabilization process.

One result that can be noted in Figures 8 and 9 is that there is an interesting change in resilient modulus in the control sections from the testing completed after paving to the testing completed in the following spring. This drop in resilient modulus is not noted in the calcium chloride stabilized sections. This is despite the fact that the AFW results were normalized to equivalent fall values. This result appears to indicate some benefit being derived in the granular materials from the stabilization process which reduces the level of spring modulus reduction. This is potentially an important benefit to the pavement as the loss of pavement support in the spring typically results in a more rapid consumption of pavement life than in the other seasons. As expected, it is also noted that the reduction in spring modulus in the control sections is more pronounced in the area with poor drainage (Section 2) however the reduction in resilient modulus appears to have been mitigated in the area of calcium chloride stabilization. A summary of the loss of resilient modulus in the spring is provided in Figure 10.

Figure 10 Evaluation of Loss of Support in the Spring



The non-destructive testing program for this site is ongoing and will be updated in the future in order to evaluate any long term benefits with the use of calcium chloride as a granular base stabilization product.

5. ECONOMIC BENEFITS OF CALCIUM CHLORIDE USAGE FOR BASE STABILIZATION

Although usage of calciuim chloride for road base stabilization adds cost to initial construction, it is considered an inexpensive chemical whose cost-savings benefits easily outweigh its cost. Previous research and field tests suggests that adding calciuim chloride to road base in proper amounts of 0.5 – 1 percent by weight results in greater density in the aggregate than would be achieved by use of water alone since the solution has a stronger moisture film which enhances the lubrication effect with less moisture [8]. This is particularly beneficial when used in good drainage conditions since less compactive effort will be required to achieve specified densities.

Records from the project as well as interviews with the Contractor after construction were completed in order to try and quantify the cost-savings derived from construction efficiencies. While anecdotal evidence was provided which indicated that compaction was achieved more readily, there was no information readily available in the records which could be used to quantify the anecdotal evidence.

The non-destructive testing data was reviewed in conjunction with the AASHTO 93 design method in order to determine the potential cost benefit derived from an increase in resilient modulus of the pulverized granular base material. In the AASHTO 93 method, an improvement in the resilient modulus will provide two benefits to the design: reduce the minimum HMA thickness required to meet the terminal fatigue criteria; and reduce the total pavement structure thicknesses required to withstand structural rutting. For the case of a low volume roadway such as Benjamin Road, the revised design resilient modulus value would result in a decrease in the required HMA thickness of 5 mm as well as a reduction in the GBC thickness of 30 mm. Combined, this would result in a cost savings of approximately $2.57 per square metre which is far less than the cost to complete the calcium stabilization. The analysis is summarized in Table 1.

Table 11 Cost Benefit of Modulus Increase in GBC

Test Section	Design Benefit Based on AASHTO 93		Savings $/m^2$
	Reduction in HMA Thickness	Reduction in GBC Thickness	
Stabilized Section	5 mm	30 mm	$ 2.57

Assumed HMA Cost of $100/tonne and 2.5 t/m^3
Assumed GBC Cost of $20/tonne and 2.2t/m3

It should be noted that the economic analysis presented is based on the short term improvement in resilient modulus after one winter and may not be indicative of the benefits gained over the design life of the pavement. A thorough analysis of the economic benefits will be completed once more performance data is gathered.

6. CONCLUSIONS AND NEXT STEP

The primary objective of this study is to evaluate the short and long-term benefits of using calcium chloride in road base stabilization applications. The calcium chloride industry claims a number of benefits to the use of this product during construction including moisture and density control during construction; enhanced lubricity and compaction of granular material; and better freeze thaw performance. The study employed a monitoring program during construction including field and laboratory testing of in-situ density and moisture content as well as a program of Falling Weight Deflectometer (FWD) testing to determine the structural response of the stabilized product over time.

The evaluation of the moisture and density control was completed during construction and consisted of an evaluation of how these two parameters varied within the test sections and in comparison to the control sections. The analysis did not reveal any benefit to moisture control on the site with the in-situ moisture content observed to vary widely across the site. This in turn had a detrimental effect on the density control which was observed to vary with the varying moisture content levels. When compared to the results from the control sections which were not stabilized, there was no observable benefit to the calcium chloride stabilization process. The benefit to moisture and density control was also evaluated between the poor and good drainage areas however there was no observable additional benefit to either of these areas.

A two week curing period was included as part of the calcium chloride stabilization process which is standard practice by the Township when using this product. The evaluation of the resilient modulus did not identify any strength gain over this period therefore it is not known what benefit this curing period is providing. This curing period was not considered when developing the initial research program and as a result the moisture content and in-situ density was not evaluated after this curing period to determine if there is any benefit gained in these aspects of the construction. Future research into the calcium chloride stabilization process should evaluate these benefits and the applicability of the curing period.

An evaluation of the in-situ resilient modulus was completed using a falling weight deflectometer (FWD) at four different points during construction and the early performance period. It was theorized that the calcium chloride stabilization process would increase in-situ density resulting in higher early resilient modulus values than the unstabilized control sections. This case was not observed and is likely due to the fact that there was no improvement in density in the stabilized sections at the time of construction.

The analysis of the non-destructive testing results indicated an observable strength gain between the time of construction and the first spring. The gain in resilient modulus was approximately 20 percent which is similar to previous reports which noted a 30 percent strength gain [3]. However an equivalent strength gain was also noted in the control sections. The results of this test section indicate that while short term strength gain is observed in the calcium chloride stabilized material, the same strength gain is naturally occurring in the non-stabilized material. There was no significant difference in the strength gain between the poor and good drainage sections.

One benefit of the calcium stabilization process which was observed in this study but had not been previously reported is the mitigation of loss of support during the spring. In the calcium stabilized areas, there was little if any reduction in resilient modulus in the granular materials based on the testing completed during the first spring. Conversely, there was a significant reduction in the resilient modulus of the non-stabilized granular materials in the spring period. The control section which had poor overall drainage (Control Section 2) was observed to be affected more than the control section with good drainage which was an expected result. This is potentially an important benefit to the pavement as the loss of pavement support in the spring typically results in a more rapid consumption of pavement life than in the other seasons. Further research is recommended in order determine the mechanism which is providing this benefit. In addition, this benefit will be evaluated in future spring seasons in order to determine if there is a long-term benefit to the pavement.

Given that the long-term benefits of calcium chloride application in road base applications is yet to be determined, a case for considering the benefits of a calcium chloride stabilized road base in pavement design cannot be assessed at this time. The test sections will be regularly monitored to determine the long-term performance benefits. It is recommended that soil and test-pit samples are collected for laboratory testing as a basis of further assessment in this study.

Calcium chloride is a relatively inexpensive product to use during construction which provides known benefits to dust mitigation, density and moisture control. This research however indicates that the process is not ‘fool proof’ and these benefits can only be gained through additional moisture evaluation and control during construction. When compared to control sections, it is not clear that this stabilization process provides immediate benefit to construction, however a long-term evaluation will be completed in order to determine if the benefits can be considered during design.

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