BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

BLUFFDALE CITY ALTERNATE PAVEMENT METHODS
Project ID: CEEn_CPST_003

by

Team International
Michael Lorows
Hyeonbin Gil
Daniel Saunders
Santiago Vega

A Capstone Project Final Report

Submitted to

Addison Mitton
City of Bluffdale

Department of Civil and Construction Engineering
Brigham Young University
April 17, 2024

Executive Summary

PROJECT TITLE: Bluffdale City alternate pavement methods
PROJECT ID: CEEn_CPST_003
PROJECT SPONSOR: City of Bluffdale
TEAM NAME: Team International

This report explores alternative pavement preservation and rehabilitation methods beyond industry standards within Bluffdale City. It aims to assess the performance and cost-effectiveness of various techniques, including fiber-reinforced asphalt, asphalt overlay fabrics, full-depth reclamation (with cement), high-density mineral bonds, and microsurfacing. Collaborating closely with Bluffdale City, our team identified three locations requiring pavement improvement or preservation. Through comprehensive research and analysis, we recommend the most efficient pavement treatment option for each site. Site 1, which consists of a new asphalt overlay along 13800 S in Bluffdale, should be treated with either a Type I slurry seal or with a high density mineral bond within the next 3 years to protect against sun damage. Site 2, which is a residential road at 4000 W, is recommended to receive a full depth reclamation with cement slurry, followed by an asphalt overlay. Site 3, a portion of 2950 W adjacent to North Star Elementary, requires a full depth removal and replacement of the asphalt.

Table of Contents

Introduction

In response to the evolving needs of Bluffdale City's infrastructure, the engineering department is exploring advanced pavement preservation and rehabilitation methods to implement on City roads. While traditional industry standard techniques have historically served the City well, there's a need to find newer, more effective techniques that could further optimize pavement longevity and performance.

This engineering report presents an effort to evaluate and recommend innovative pavement rehabilitation techniques. This project's main objectives are to research the performance and relative costs of various remediation methods, with a focus on identifying the most efficient treatment options for specific locations in the City.

The client provided three specific sites to be analyzed. These sites were categorized by the client as follows:

1. Road with great pavement quality, recently redone, or part of new development: 13800 South (3600 West to 4000 West).
2. Roads with fair pavement quality that will require redoing within a few years: 2950 West (13800 South to 14000 South).
3. Roads with poor pavement quality, in desperate need of rehabilitation: 4000 West (south of 13800 South).

In alignment with the project's objectives, site visits were conducted to the three specific locations designated by the client. These visits played a vital role in providing a hands-on assessment of the pavement conditions, enabling a more accurate and tailored analysis.

During the evaluation of the sites, the Pavement Surface Evaluation and Rating (PASER) method was employed at a network level. The utilization of the PASER method allowed for the categorization of pavement deterioration in a standardized manner, facilitating a comparative analysis across different locations.

The combination of this evaluation provided a comprehensive understanding of each site's unique requirements. This formed the foundation for the subsequent findings and recommendations, ensuring that the proposed pavement rehabilitation techniques are both effective and precisely tailored to the specific conditions of each site within Bluffdale City.

In subsequent sections of this report, the detailed methodology, findings, and recommendations derived from collaborative efforts with Bluffdale City will be discussed.

Schedule

October
- Capstone Dinner with Project Sponsor.
- Receive Project Proposal.

November
- Meeting with Mentor concerning Statement of Work, adjusted project proposal.
- Statement of Work Submission.

January
- In-depth research of Alternate Pavement Methods.
- Weather non-cooperative for site visits.
- Difficulty aligning our schedule with Addison to meet regularly.

February
- Addison provides Provo Engineer Contacts concerning HA5 pavement.
- Contacting the City of Provo, City of Orem, and Holbrook concerning HA5.
- Project mentor provides Master Theses and site locations of methods.
- Weather non-cooperative for site visits.

March
- Bluffdale Site Visit and PASER Roadway Condition Analysis.
- Site visits in Provo, Orem, Spanish Fork, etc.

April
- Completion of Poster and Final Report complete.
- Present Poster in Civil Engineering Seminar.
- Report and Powerpoint Presentation to Addison of Bluffdale City.

Assumptions & Limitations

In evaluating Bluffdale City's pavement conditions and determining the most appropriate rehabilitation techniques, the analysis was mainly conducted at a network level. This approach, while broad and informative, inherently carries certain limitations and assumptions that could influence the depth and specificity of the findings. One significant assumption is the homogeneity of pavement conditions within each designated site category—ranging from great to poor quality. This assumption limits the ability to capture nuanced variations within each site, potentially overlooking site-specific conditions that could affect the choice and effectiveness of rehabilitation techniques.

Furthermore, the reliance on network-level analysis restricts the scope to a surface-level evaluation, utilizing the Pavement Surface Evaluation and Rating (PASER) method. While PASER provides a standardized framework for assessing pavement deterioration and categorizing pavement quality, it does not offer the detailed insights that a full Pavement Condition Index (PCI) analysis would. The absence of a full PCI analysis, due to resource and time constraints, means that the recommendations provided might lack the precision needed for targeted remediation efforts. This limitation underscores the necessity for a more detailed project-level analysis, incorporating specific measurements and assessments to tailor the rehabilitation recommendations accurately to each road's unique conditions.

Given these constraints, it is imperative to acknowledge that while the findings and recommendations aim to enhance pavement longevity and performance across Bluffdale City, they are based on a high-level evaluation. To achieve a clear, concise, and accurate set of recommendations, further in-depth analysis at the project level is recommended. This would involve a comprehensive examination of each road segment, considering factors such as traffic patterns, subsurface conditions, and existing pavement distresses, to inform a more precise and effective pavement rehabilitation strategy.

Design, Analysis & Results

1 Alternate Pavement Methods

1.1 Fiber-reinforced asphalt

Fiber-reinforced asphalt refers to asphalt embedded with fibrous materials to increase resistance to cracking, rutting, and fatigue. The fibers can be synthetic or natural materials, such as polyester, polypropylene, aramid, cellulose, or glass. Although there are many possible fiber materials and lengths, the most implemented fibers are polypropylene and aramid. Fiber-reinforced asphalt is implemented because it adds tensile strength which improves the asphalt mix design.
Figure 1.1.1 depicts fibrous materials that are embedded in asphalt pavement.

Figure 1.1.1: Aramid and polypropylene fibers (GeoSolutions)

The cost of fiber-reinforced asphalt can be calculated based on the type and amount of fiber added to asphalt per square foot. Due to a wide variability in materials, it is difficult to identify a single cost for materials and installation.

According to Idaho Transportation Department test results, fiber reinforced asphalt did not have a significant impact on the resistance to cracking at thermal temperatures despite three different fibers and volumes being tested (Bayomy, 2016).

The added tensile strength of asphalt pavements with fiber reinforcement has an added design life. Fatigue life at "600 and 900 με (peak-to-peak strain)" increased 90% and 200% respectively. However, no increased fatigue life was noted at "intermediate strain levels (300 and 400 με)" (Mateos, 2019).

Typical fiber reinforced asphalt takes longer to install than a traditional roadway since it is required to add fibrous materials. Modern techniques involve blending myriad polymerbased fibers with asphalt pavement during batching, resulting in a three-dimensional reinforcement matrix within the asphalt layer. Issues with installation include clumping of fibers and uneven distribution of material throughout the asphalt, directly affecting the asphalts performance.

Pavements with fiber-reinforced asphalt can be treated with other seals and pavements methods. However, due to the fibers being embedded in the asphalt, it becomes difficult to recycle and reuse the pavement once it has exceeded its lifespan.
Figures 1.1.2 and 1.1.3 illustrates a parking lot at 200 N and 900 E in Springville, UT.

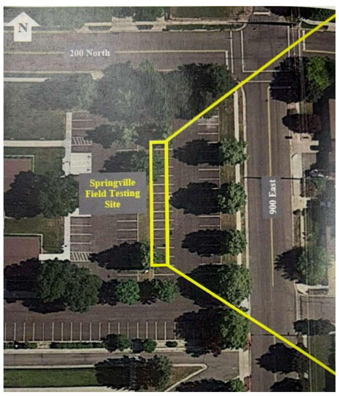

Figure 1.1.2: Aerial View

Figure 1.1.3: Site distresses

In 2014 this fiber reinforced asphalt was installed in Springville, Utah in a church parking lot. As pictured, the asphalt is experiencing extreme discoloration and longitudinal cracking, as is to be expected for a pavement in its tenth year. Seals have been applied to the pavement in order to extend its lifespan.

1.2 Fabric Overlay

Fabric asphalt overlay, also known as paving fabric or asphalt overlay geotextile, is a fabric material placed between layers of asphalt pavements. Its primary function is to bond the new asphalt overlay to the existing pavement, facilitated by its capacity to hold, and stabilize the asphaltic cement tack coat.
Figure 1.2.1 depicts a cross-section of an asphalt overlay pavement, demonstrating the layered composition from the new asphalt surface to the original subgrade.

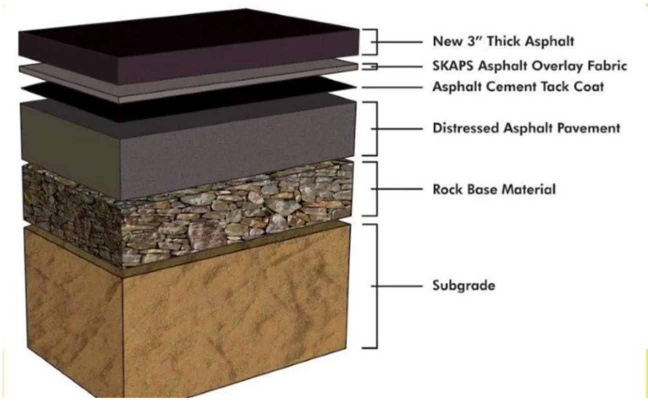

Figure 1.2.1. Asphalt overlay pavement structure (SKAPS Industries, n.d.)

The overlay serves as a moisture barrier, minimizing water infiltration into the base and reducing reflective cracking. It also enhances pavement flexibility, improving the lifespan and performance of the pavement (US Fabrics Inc., n.d.).

The expenditure associated with asphalt fabric overlay is contingent upon the product type and specifications. For example, Mirafi MPV400 and MPV600 (two common types of geotextile overlays) are priced at approximately $0.32 and $0.36 per square foot, respectively (Paramount Materials, n.d.). Price range is reflective of varying dimensions and area coverage of the overlay fabrics.

At low temperatures, asphalt becomes more brittle, losing its inherent flexibility. This brittleness increases the risk of cracking under traffic loads or due to the natural contraction and expansion of the pavement. The rigidity induced by colder climates can lead to the formation of cracks in the overlay, which may propagate to the surface, diminishing the overlay's effectiveness (Tan Q, n.d.).

In cold weather, the performance of asphalt overlays is adversely impacted in several ways. The tack coat, crucial for bonding the overlay to the pavement, might not achieve adequate tackiness or take longer to set, leading to weaker bonding and risks of delamination or slipping. Rapid cooling in colder conditions also hinders proper compaction of the asphalt mix, increasing its susceptibility to moisture penetration and wear, and potentially reducing its density, thus compromising strength and longevity. Moreover, low temperatures allow moisture to infiltrate between asphalt layers, which can freeze and expand, exacerbating cracks and weakening the overlay's integrity. Additionally, thermal cracking can occur due to the contraction of pavement in cold temperatures, challenging the overlay's protective capabilities if not designed to handle such stress. Low temperatures pose significant challenges to the effectiveness of asphalt overlays, affecting their bonding, compaction, moisture resistance, and overall structural integrity, which directly impacts the overlays durability and performance.

The lifespan of a fabric asphalt overlay is generally estimated to be between 8 to 15 years, influenced by factors such as traffic volume, environmental conditions, and maintenance practices. Heavy traffic, particularly from large trucks, and extreme weather, including freeze-thaw cycles, can significantly reduce this lifespan. The quality of the base pavement and the thickness of the asphalt overlay are also key factors in its longevity (EBPave; Mid Atlantic Asphalt; Century Paving).

The time to install a fabric asphalt overlay typically includes site preparation, application of the overlay, and curing time. For an average-sized project, the actual laying of the overlay can often be completed within a day. However, the total project duration, including preparation and curing, might extend over several days.

The repair process of an asphalt fabric overlay begins with a thorough cleaning of the existing surface to remove any debris, vegetation, or moisture, preparing it for the overlay. Large cracks and low areas are then addressed by filling them with hot-mixed asphalt, ensuring a uniform surface. Following this, hot oil is applied to the surface, which plays a crucial role in forming a waterproof barrier. The next step involves laying down the fabric, a non-woven, petroleum-based geotextile, saturated with an asphalt cement tack coat. This fabric acts as a critical moisture-resistant barrier, reducing the risk of reflective and fatigue cracking. A new layer of hot mixed asphalt is added over the fabric and compacted, with the heat and pressure causing the oil to permeate the fabric, creating a waterproof membrane that effectively binds the new and old asphalt layers (Oliver Mahon Asphalt, 2024; Statewide Parking Lot Services, Inc., 2024).

1.3 Full-Depth Reclamation with Cement

Full-depth reclamation of asphalt pavement, also referred to as FDR, is a rehabilitation method that involves recycling an existing asphalt pavement and its underlying layer(s) into a new base layer. As shown in Figure 1.3.1, the FDR process begins with using a road reclaimer to pulverize an existing asphalt pavement and a portion of the underlying base, subbase, and/or subgrade (National Concrete Pavement Technology Center, 2016). The pulverized material is uniformly blended with an additional stabilizing material such as portland cement to provide an upgraded, homogeneous material. Finally, the stabilized material is compacted in place with rollers. The result is a stiff, stabilized base that is

ready for a new rigid or flexible surface course. Pavements that are potential candidates for FDR typically fall within a PCI range of 0 to 55.
Figure 1.3.1 depicts the process related to full depth reclamation.

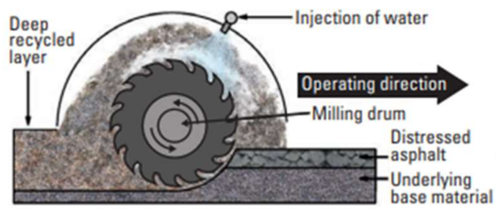

Figure 1.3.1 Full depth reclamation diagram (National Concrete Pavement Technology Center, 2016)

Recent bid analyses demonstrate FDR to be 20 to 30 percent cheaper than traditional methods, with costs typically ranging from $17 to $20 per square yard (Sounart, 2021). As reclaimers and equipment advance, prices are expected to decrease further, making FDR more viable. Additional savings stem from reduced equipment and material usage, fewer personnel, and increased pavement longevity.

Field performance studies have indicated that FDR with cement bases has performed well in harsh climatic conditions. Syed (2007) reviewed actual field performance of FDR with cement projects in eight states throughout the country. Of the 79 projects, more than 50 sections were in areas with moderate to severe winter weather. FDR with cement layers have a permeability that is similar to compacted clay. Low permeability of the mix will improve resistance to freeze-thaw damage and provide improved load support compared to a saturated, unstabilized granular base (NCP Tech. Center, 2016). The mixture for an FDR layer must be designed to limit moisture intrusion.
Figure 1.3.2 highlights a roadway that has been treated with full depth reclamation.

Figure 1.3.2: Redwood Drive in Salt Lake City

Figure 1.3.2 highlights a roadway that has been treated with full depth reclamation.

Figure 1.3.3: 200 North in American Fork

The two sites, displayed in figures 1.3.2 and 1.3.3, are two locations that have had FDR with cement installed. The site on Redwood Dr. was installed in 2008 and the site on 200 North was installed in 2020. Both roads are in incredible shape, and the bases are still displaying healthy strength. No information was procured concerning any overlays or treatments that have been done on Redwood Drive since the FDR with cement installation. However, the road has not had to undergo any major reconstruction. The site on 200 N is still in its prime years, displaying no fatigue, cracking, or external wear.

Typically, FDR with cement bases tend to have a life expectancy of 7 to 10 years when paired with a thin surface course like chip seal or seal coat, and 15 to 20 years when an asphalt surface course is applied (NCP Tech. Center, 2016). It's worth noting that the main factor limiting the service life of pavements constructed on FDR bases is usually the surface course material rather than the FDR base itself.

FDR significantly shortens construction time with minimal disruption to users, typically taking one-third of the time compared to traditional methods (Sounart, 2021). The Portland Cement Association (PCA) estimates agencies that use the FDR process save between 30 to 60 percent in costs over alternative reconstruction methods such as complete removal and replacement of existing pavement (NCP Tech. Center, 2016).

1.4 High Density Mineral Bonds

High density mineral bonds, commonly referred to as HA5, are a pavement preservation method in which mineral bonds formed between the asphalt binder and aggregate particles work to prevent moisture seepage and damage from UV radiation. HA5 is most effective when applied to roads that are still relatively new and without major structural damage. The preferred installation of HA5 is on residential roads with lower design speeds and traffic flows.

Figure 1.4.1 illustrates the proposed benefits of a high density mineral bond.

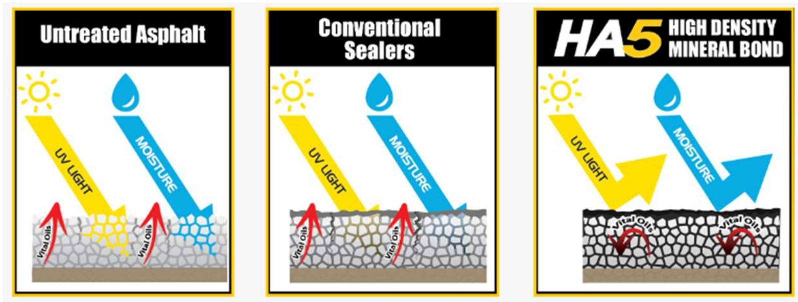

Figure 1.4.1: HA5 mineral bond (Holbrook Asphalt)

Consultations with Holbrook Asphalt in Utah indicated that current materials cost for HA5 are approximately $0.35 per square foot. Additional cost and budgeting is required for equipment, labor, and installation costs.

Asphalt companies performing HDMB treatments claim that the mineral bonds can extend pavement life by 8-10 years (Shatnawi, 2020). This claim is based on a report that is not officially published. Multiple asphalt installation companies refer to Shatnawi's 2020 report to prove the effectiveness of HA5; however, it must be noted that this is an extremely biased source. HA5 theoretically prevents water from infiltrating asphalt and cracking during freeze thaw. There are also no formal studies to prove this claim.

Installation time is dependent upon the size of roadway, thickness of layer, and installation method.

HA5, like other pavement surfaces, can be treated with crack seal and other preventative methods once wear begins. After the HA5 lifespan has been exceeded, if the surface is still intact and without major cracking, it can be treated again with HA5. However, if there is excessive structural damage or cracking, those issues must be resolved before a secondary HA5 treatment is applied.

As HA5 is a more modern approach to pavement maintenance, there are fewer studies proving its reliability. However, several cities in Utah and Salt Lake Valleys have implemented the treatment within the past several years. For instance, Mapleton has used HA5 on several residential roads as presented in Figure 1.4.2.

Figure 1.4.2 provides an example of a roadway recently treated with HA5 in Mapleton, UT.

Figure 1.4.2: 700 N 800 W in Mapleton, UT treated with HA5

700 N 800 W. This new construction road was treated with HA5 in 2023 by Holbrook Asphalt. It is a residential road and cul-de-sac, meaning that there is no through traffic. These factors, along with the HA5 have led to virtually no wear on the road. No other treatments have been applied to this segment. According to HA5 claims, this road should have around 7 years left before other pavement treatment methods are required.
Figure 1.4.3 shows an HA5 application on 700 W.

Figure 1.4.3: 700 W in Mapleton, UT treated with HA5

700 W South of 1200 N. This site was treated with HA5 by Holbrook Asphalt in 2021. It is a residential road with limited through traffic. At the intersection, it was clear that the HA5 treated road segment has maintained its color better than the road to the south (1000 N). In the wheel path, there is beginning to be some discoloration and graying. The road is fully operational with no seals or other pavement treatments being visible on the road's surface, except for seals regarding fiber or cable installation (pictured right). Some longitudinal cracking below the surface can be seen. The asphalt has not fully cracked, but it seems there is structural damage to the road.

Figure 1.4.4 depicts an HA5 treatment on Fallen Leaf Drive.

Figure 1.4.4: Fallen Leaf Drive in Mapleton, UT treated with HA5

Fallen Leaf Drive between 600 W and Mountain View Lane. This residential road was outfitted with HA5 in 2015 by Holbrook Asphalt. The road experiences limited through traffic. The pavement has been treated with a crack seal treatment in several spots. Most treated areas are experiencing transverse cracking. As with other segments assessed, several of the areas are experiencing damage because of sawcuts used to install underground utilities. The pavement surface requires a new treatment, either HA5 or a different prevention method.

1.5 Microsurfacing

Microsurfacing is a pavement preservation method that employs a mixture of water, asphalt emulsion, fine crushed rock, and chemical additives. This blend is designed to set quickly without the need for external heat, making it ideal for use in various environmental conditions, including areas with high traffic or limited sunlight. This technique is notable for extending pavement life, improving road safety, and minimizing environmental impact.

Microsurfacing is recognized for its "economic advantages as a more cost-effective alternative compared to traditional road reconstruction methods" (Van Kirk, 2000), despite having "higher initial costs compared to slurry seal" (Broughton, 2012). Notably, the specific cost per square foot for microsurfacing, at approximately $0.74, when compared to slurry seal at $0.48, underscores its financial viability over time. This comparison highlights that "microsurfacing provides significant long-term savings by extending pavement life and reducing the frequency of repairs" (Shatnawi, 2008), effectively balancing its upfront cost with substantial durability and performance benefits in the long term.

Microsurfacing has proven to be an effective method for extending the lifespan of asphalt pavements, contingent on the initial condition of the pavement, traffic intensity, and the local climate. It can maintain a Pavement Condition Index (PCI) of fair to satisfactory for 3 to 7 years, indicating its capacity to significantly prolong pavement usability (Wilson, 2012). However, pavements with extensive pre-existing issues might degrade to a poor rating within a similar timeframe, emphasizing the importance of careful pre-application assessments to select appropriate surfaces for treatment. This underscores the necessity of meticulous planning and the selection of suitable pavements to ensure the longevity and effectiveness of microsurfacing treatments.

The average lifespan of a microsurfacing treatment is typically between 5 to 7 years. Treatments on pavements in relatively good condition can last from 7 to 10 years (Wilson, 2012). Factors such as the stability of the microsurfacing, traffic levels, and the condition of the underlying pavement primarily influence these variances. The main mechanism of failure is identified as wear, where "the surface oxidizes and is abraded over time" (Broughton, 2012). It is recommended that microsurfacing not be applied on surfaces that are "highly deflecting, cracked, pavements with base failures, or on dirty or poorly prepared surfaces (resulting in delamination)," as these conditions can lead to diminished effectiveness of the treatment (Broughton, 2012).

Microsurfacing is distinguished by its ability to "harden quickly without relying on the sun or heat, thanks to chemical additives in the asphalt emulsion" (Broughton, 2012). This characteristic ensures it can be efficiently applied in a variety of conditions, including shaded areas or locations with high traffic volumes, where minimizing downtime is crucial.

Embracing a proactive maintenance strategy is fundamental, highlighting the necessity of routine evaluations and timely actions to mitigate wear. This approach is instrumental in prolonging the lifespan of microsurfaced pavements and leveraging the full spectrum of economic and safety advantages offered by microsurfacing. Through vigilant monitoring of pavement conditions and prompt responses to early signs of wear or damage, minor issues can be addressed before escalating into significant concerns, thereby maintaining the high quality and functionality of microsurfaced roads over time.

Moreover, the criticality of conducting comprehensive pre-treatment assessments of pavements cannot be overlooked. Pavements exhibiting considerable pre-existing damage or wear might not fare as well with microsurfacing treatments, accentuating the need for selective treatment application to achieve optimal outcomes.

In Orem, the application of microsurfacing treatments over recent years offers valuable insights into the practical performance of this pavement maintenance method. The comparison between roads treated in 2016, which have shown visible signs of deterioration requiring patching (Figure 1.5.1), and those treated more recently, where only minor patching and crack sealing were needed (Figures 1.5.2 and 1.5.3), illustrates the range of durability and effectiveness microsurfacing can achieve.

Through detailed analysis, it's evident that "when used as a preventive maintenance treatment on pavements in relatively good condition, microsurfacing may last 7 to 10 years," (Van Kirk, 2000) though there are cases where this longevity has been exceeded. It's also noted that "the life expectancy of a microsurfacing treatment is on average 5 to 7 years" (Shatnawi, 2008). This variability in lifespan depends on several critical factors, such as the stability of the treatment, traffic intensity, and the underlying pavement condition. Oxidation and abrasion over time are identified as key factors leading to wear, highlighting the importance of strategic planning in the application of microsurfacing to ensure it is deployed under appropriate conditions for maximum benefit.
Figure 1.5.1 depicts a microsurfaced roadway, treated in 2016 in Orem, UT.

Figure 1.5.1: 800 E to 1000 S- 2016

Figure 1.5.2 depicts a microsurfaced roadway, treated in 2020 in Orem, UT.

Figure 1.5.2: 1200 N 800 E to 1200 W 400 E- 2020

Figure 1.5.3 depicts a microsurfaced roadway, treated in 2023 in Orem, UT.

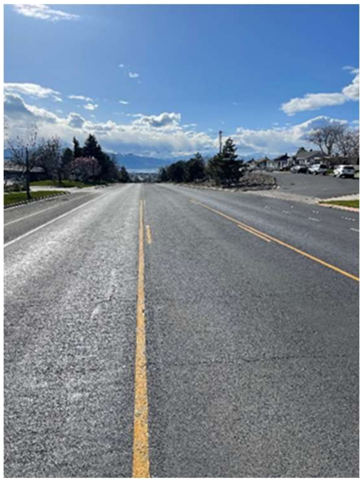

Figure 1.5.3: 1200 W 400 N to 800 N- 2023

2. Site Analysis

2.1 SITE 1 Analysis: W 13800 S

The roadway at W13800 S resides in a low-traffic residential area, presenting an excellent condition with a PASER grade of 9. This denotes a surface with no imperfections such as cracks, raveling, or any form of distress, indicating a recent successful overlay. However, to mitigate future deterioration predominantly caused by sun exposure, proactive pavement preservation measures are essential.
Figures 2.1.1 and 2.1.2 show Site 1 (13800 S) in Bluffdale City.

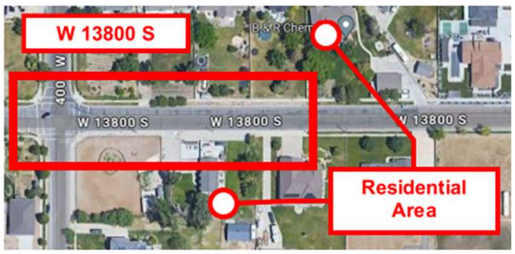

Figure 2.1.1: Aerial View

Figure 2.1.2: Site distresses

13800 S could benefit from either a Type I Slurry Seal or an HA5 treatment.

Type I Slurry Seal: Recognized for its cost-effectiveness and quick set times, Slurry Seal is identified as a suitable maintenance measure for areas like W13800 S, where traffic intensity is minimal. Its ability to be applied in thin layers allows for maintaining surface integrity without altering existing road grades or drainage. In Utah, the average cost for Slurry Seal application stands at approximately $0.48 per square foot, underscoring its budget-friendly nature.

High-Density Mineral Bond (HA5): HA5 is distinguished by its superior composition and durability, aimed at protecting against oxidation and weathering. Its efficacy in preventing water infiltration makes it particularly valuable in climates prone to heavy rain or freeze-thaw cycles, potentially applicable to the study area.

Microsurfacing: While offering increased durability and longevity, particularly under conditions of heavy traffic, Microsurfacing is deemed not viable for W13800 S primarily due to its higher cost ($0.74 per square foot in Utah) and the site's low-traffic conditions. Its application requirements and cost do not align with the preservation needs and economic considerations of the site.

2.2 SITE 2 Analysis: W 13800 S 4000 W

The roadway at W13800 S and 4000 W is in a low-traffic residential area. The roadway has multiple driveways and residential roads intersecting the segment. The main concerns with this segment are its extensive cracking and distortion, closely spaced longitudinal and transverse cracks, raveling, and significant surface wear.

Figures 2.2.1 and 2.2.2 show Site 2 (13800 S 4000 W) in Bluffdale City.

Figure 2.2.1: Aerial view

Figure 2.2.2: Site distresses

The site was assigned a Paser 3 category (poor) due to its deteriorated conditions, closely spaced transverse cracks often showing raveling and crack erosion. Extensive alligator cracking (more than 25% of surface) with patches in fair condition. Moderate rutting or distortion (1” or 2” deep). More than 25% of the surface exhibited alligator cracking, indicative of extensive distress. The extensive transverse cracking can be a high concern as it may result in base layer failures. At a network level, road segment W13800 S 4000 W is due for at least a milling of asphalt overlay. If no further damage is found to subgrade, the roadway can be repaved for further use. If cracks are found further into subgrade, further testing and analysis will be needed to determine best options for the roadway segment.

Considering observed extensive fatigue cracking and the extensive use of crack seal, full depth reclamation with cement (FDR), followed by edge milling to maintain the existing elevation along the lip of a gutter. This approach is suitable for extensive structural repair, and a project-level analysis should be undertaken to ascertain if a more comprehensive solution such as complete asphalt removal and reconstruction is warranted.

2.3 SITE 3 Analysis: 13800 S 2950 W

Within the suburban crossroads of 13800 S and 2950 W, the study focuses on a segment highlighted by several key developments. Adjacent to the east of 2950 W is an active construction site, indicative of development efforts that could influence local traffic patterns and community structure. The west side introduces a new residential development. Further south lies an educational institution.

Figure 2.3.1 presents an aerial view of the studied section.

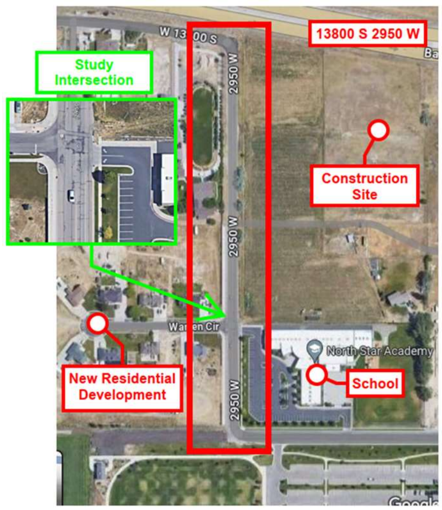

Figure 2.3.1: Aerial view of 13800 S 2950 W

The site, classified as Paser 2 (very poor), shows significant road deterioration, posing substantial risks to road users. Over 25% of the surface features alligator cracking and severe distortions deeper than 2 inches, which undermine the road's structural integrity. Poorly patched areas and potholes are prevalent, especially around a centrally located manhole. These conditions, worsened by nearby construction and proximity to a school, severely affect traffic flow and increase accident risks. Figure 2.3.2 illustrates the road's poor condition with images of the extensive damage.

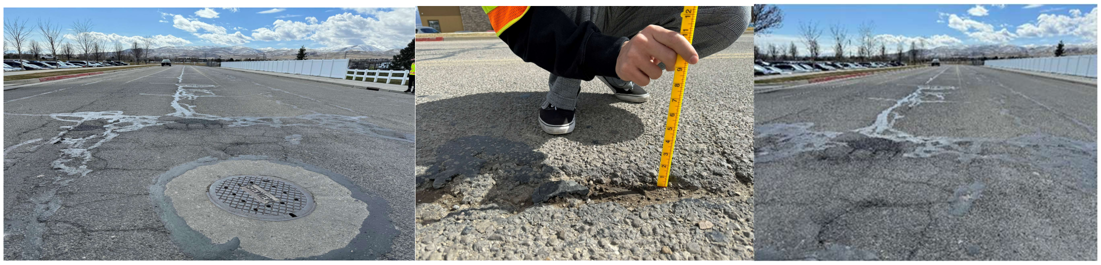

Figure 2.3.2: Road distresses

Given the extensive damage observed at Site 3, a full depth removal process is recommended. This method entails the excavation of the existing pavement down to the base, ensuring the removal of all damaged materials. Subsequently, the area is reconstructed with new base materials and surfaced with fresh asphalt. Although this approach incurs higher costs, it is essential for ensuring long-term durability and safety. This strategy is crucial for addressing the underlying structural issues comprehensively.

Related Issues

The multifaceted impacts of the proposed advanced pavement preservation and rehabilitation project in Bluffdale City are summarized as follows:

Public Health: Improved road conditions are expected to enhance public health by reducing vehicular emissions and minimizing air pollutants like dust and particulate matter, contributing to better respiratory health.

Safety: The project significantly boosts safety by addressing road hazards like uneven surfaces and potholes, particularly benefiting cyclists and pedestrians.

Welfare: Enhanced roads improve welfare by facilitating easier access to services and amenities, thereby improving the overall quality of life for residents.

Global and Environmental Factors: The use of sustainable materials and practices in road rehabilitation contributes to global sustainability efforts and minimizes environmental impact.

Cultural and Social Factors: Well-maintained roads reflect positively on the City's cultural values and promote social equity by providing quality infrastructure across all neighborhoods.

Economic Impact: The project is anticipated to stimulate local economies and reduce vehicle maintenance costs, though initial investment in advanced techniques should be balanced against these long-term benefits.

Overall, the implementation of innovative pavement technologies in Bluffdale City is poised to bring about comprehensive improvements in public health, safety, welfare, and environmental sustainability, while also contributing positively to the City's cultural, social, and economic fabric.

Lessons Learned

Throughout the evaluation of pavement rehabilitation techniques for Bluffdale City, the project illuminated several critical lessons, emphasizing the complexity of engineering research and the importance of strategic communication and resource evaluation. It highlighted the challenges posed by limited resources and the need to sift through real versus biased information sources. The research phase revealed a landscape riddled with resources tied to companies promoting specific pavement rehabilitation methods, highlighting the difficulty of finding unbiased, empirical data to inform our recommendations. This experience stressed the importance of critical evaluation skills in distinguishing between objective information and biased content, which could potentially influence the project's outcome. Additionally, the project's journey highlighted the significance of clear and open communication, particularly when initial project expectations—aiming for a project-level analysis—were beyond the team's capacity due to time and resource constraints. Engaging in discussions with mentors and stakeholders was crucial in realigning the project scope to a more achievable objective, demonstrating the necessity of managing expectations and maintaining flexibility. This adaptive approach, coupled with a diligent search for unbiased, reliable sources, ensured the development of informed and impartial recommendations for Bluffdale City's pavement rehabilitation needs.

The overarching lessons learned from this project extend beyond technical insights into pavement preservation methods. They encompass the critical importance of navigating project limitations, the challenge of ensuring research integrity in the face of biased information, and the vital role of communication in aligning project goals with practical realities. These lessons not only enhanced the project's outcomes but also provided invaluable skills in project management, stakeholder engagement, and the ethical considerations of engineering research, underscoring the multifaceted nature of developing effective and unbiased solutions in the field of civil engineering.

Conclusions

Concluding this comprehensive engineering report, which aimed to address the pavement preservation needs of Bluffdale City, it's evident that a strategic and informed approach to pavement rehabilitation is crucial for optimizing infrastructure longevity and performance. The evaluation of three distinct sites within the City—each presenting unique challenges and conditions—has facilitated a deep understanding of the practical applications and implications of various pavement preservation techniques. This project not only underscored the importance of a methodical assessment process, employing the Pavement Surface Evaluation and Rating (PASER) method, but also highlighted the necessity of considering traffic patterns, environmental conditions, and the specific needs of each site to formulate effective and efficient rehabilitation strategies.

For Site 1 (W 13800 S), the analysis suggests that either a Type I Slurry Seal or High-Density Mineral Bond (HA5) would be effective in maintaining the road's condition, with a decision hinged on further project-level analysis to determine the most cost-effective and durable option. Site 2 (13800 S 4000 W) requires a more intensive approach, with recommendations leaning towards full depth reclamation with cement (FDR) to address the extensive structural damage observed. Finally, for Site 3 (13800 S 2950 W), a full depth removal is recommended. This involves excavating the existing pavement down to the base and removing all damaged material to address the need for significant structural improvements. This method is crucial for restoring the long-term durability and safety of the roadway, given its extensively deteriorated condition.

Throughout the project, several key lessons emerged, notably the challenge of distinguishing between unbiased and biased information sources during the research phase, and the critical role of clear and open communication in aligning project expectations with achievable outcomes. These insights underscore the multifaceted nature of engineering projects, where technical knowledge must be complemented by effective project management, stakeholder engagement, and ethical considerations to develop solutions that are not only technically sound but also practically feasible and aligned with community needs.

In conclusion, this report, through its detailed analysis and recommendations, contributes to the ongoing efforts of Bluffdale City to enhance its pavement infrastructure. By adopting the suggested pavement preservation techniques, the City can ensure the longevity and safety of its roads, thereby supporting the well-being of its community and the efficiency of its transportation network.

Recommendations

This report has comprehensively analyzed the pavement preservation needs for three distinct sites: W 13800 S, 13800 S 4000 W, and 13800 S 2950 W. The following paragraphs synthesize our findings and provide tailored recommendations for each location.

Site 1: W 13800 S

Given the low traffic intensity and environmental considerations, the implementation of a Type I Slurry Seal or HA5 treatment is recommended within the next three years. The decision between these two methods should be based on a detailed project-level analysis, with Type I Slurry Seal offering cost-effectiveness and HA5 providing superior durability and protection against environmental factors. Consideration of potential issues such as thermal coefficient-related cracking in HA5 is crucial.

Site 2: 13800 S 4000 W

Considering observed extensive fatigue cracking, the report recommends full depth reclamation (FDR), followed by recompaction as an effective remediation strategy. Edge milling may need to be performed, especially to maintain the existing elevation along the lip of a gutter. This approach is suitable for extensive structural repair, and a project-level analysis should be undertaken to ascertain if a more comprehensive solution such as complete asphalt removal and reconstruction is warranted.

Site 3: 13800 S 2950 W

The recommended course of action for Site 3 (13800 S 2950 W) is a full depth removal, involving the excavation of the existing pavement down to the base and the removal of all damaged material, to then replace the asphalt with a new base and fresh asphalt layers. This process is crucial for significant structural improvements and restoring the long-term durability and safety of the roadway, given its extensively deteriorated condition. While more costly, this comprehensive approach addresses the underlying issues effectively, ensuring the stability and longevity of the pavement.

This engineering report, aligned with Bluffdale City's commitment to infrastructure advancement, has evaluated and recommended specific pavement preservation techniques for the designated sites. The combination of site-specific assessments, employing the PASER method, and a comprehensive analysis of various rehabilitation methods have yielded tailored recommendations aimed at optimizing pavement longevity and performance.

Appendix A- References

Bayomy, F., Muftah, A., Wen, H., & Bahadori. A. (2016). Evaluation of Fiber-Reinforced Asphalt Pavements: Laboratory Study. *Idaho Transportation Department.*

Broughton, B., Lee, S.-J., & Kim, Y.-J. (2012). 30 years of Microsurfacing: A Review. *ISRN Civil Engineering*, *2012*, 1–7. https://doi.org/10.5402/2012/279643

CostOwl. (n.d.). How Much Does Asphalt Overlay Cost?.

Eosso Brothers Paving. (n.d.). A Handy FAQ on Pavement Resurfacing and Reconstruction.

GeoSolutions. (2024). Pavement Fibers.

Hunsucker, D. Q., Allen, D. L., & Graves, R. C. (2017). In-Place Recycling and Reclamation of Asphaltic Concrete Pavements in Kentucky. *University of Kentucky.*

Jarvis, R. (2023). The Road Ahead: Understanding the Lifespan of Asphalt Pavement. *Century Paving*.

Luhr, D. R., W. S. Adaska, and G. E. Halsted. (2005). Guide to full-depth reclamation (FDR) with cement. *Portland Cement Association*.

Mateos, A. & Harvey, J. (2019). Laboratory Evaluations of the Mechanical Properties of Asphalt Concrete Reinforced with Aramid Synthetic Fibers. *University of California Pavement Research Center.*

McDivitt, P. M. (2023) Long-Term Modulus of Microcracked Cement-Treated Base Layers, *Brigham Young University.*

Mid Atlantic Asphalt. (2017). Overlay VS. Mill & Overlay. When Do You Need Them?

Oliver Mahon Asphalt. (2024). Fabric Overlay.

Paramount Materials. (n.d.). *Asphalt Overlay Fabric*.

Shatnawi, S. (2008). Maintenance Technical Advisory Guide Volume I: Flexible Pavement Preservation (2nd ed.). Sacramento, CA, USA: Caltrans Division of Maintenance.

Shatnawi, S. (2020). Effectiveness of High Density Mineral Bond (HA5) in Preserving and Extending Pavement Service Life.

SKAPS Industries. (n.d.). Asphalt overlay pavement illustration

Statewide Parking Lot Services, Inc. (2024). Fabric Overlay

Syed, I. M. (2007) Full-Depth Reclamation using Portland Cement: A Study of Long Term Performance. *SR016.01. Portland Cement Association, Skokie, IL*

Tan, Q., Zhu, H., Zhao, H., Zhao, N., Yang, S., & Yang, X. (2024). Innovative Treatment of Crack Defects and Skid Resistant Deficiencies in Old Asphalt Pavement Using a Prefabricated Flexible Ultrathin Overlay. *Journal of Materials in Civil Engineering*, 36(5), 04024053. American Society of Civil Engineers. https://doi.org/10.1061/JMCEE7.MTENG-17027

Van Kirk, J. (2000). Long lasting slurry pavements. In Proceedings of the International Slurry Seal Association Conference. Amelia Island, FL, USA.

US Fabrics. (n.d.). Asphalt overlay. *US Fabrics*.

Wilson , B. T., & Guthrie , W. S. (2012). *Performance Evaluation of Microsurfacing in Utah and Analysis of Performance-Reduction Factors* , 1–17.

Appendix B- PASER Method

Rating system

Surface rating	Visible distress*	General condition/ treatment measures
10 Excellent	None.	New construction.
9 Excellent	None.	Recent overlay. Like new.
8 Very Good	No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40' or greater). All cracks sealed or tight (open less than 1/4").	Recent sealcoat or new cold mix. Little or no maintenance required.
7 Good	Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open 1/4") due to reflection or paving joints. Transverse cracks (open 1/4") spaced 10' or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging. Maintain with routine crack filling.
6 Good	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open 1/4"–1/2"), some spaced less than 10'. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition.	Shows signs of aging. Sound structural condition. Could extend life with sealcoat.
5 Fair	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open 1/2") show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition. Needs sealcoat or thin non-structural overlay (less than 2")
4 Fair	Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (1/2" deep or less).	Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2" or more).
3 Poor	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (1" or 2" deep). Occasional potholes.	Needs patching and repair prior to major overlay. Milling and removal of deterioration extends the life of overlay.
2 Very Poor	Alligator cracking (over 25% of surface). Severe distortions (over 2" deep) Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair. Pulverization of old pavement is effective.
1 Failed	Severe distress with extensive loss of surface integrity.	Failed. Needs total reconstruction.

** Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types.*

Michael Lorows

(385) 314-2204 · michaelsmail7498@gmail.com · linkedin.com/in/Michael-Lorows

EDUCATION

Brigham Young University Apr 2024
BS Civil and Environmental Engineering Provo, UT

- ASCE member (since 2020)
- BYUSA volunteer

PROJECTS

Olympia Development July 2022-Present
Engineer in Training Herriman, UT

- Create and label plan sets for city submittal, encompassing several phases of project area (over 10 acres).
- Develop storm drain and sewer pipe networks according to city code and ordinance.
- Design future road extensions and intersections that comply with UDOT and MUTCD standards and striping.
- Respond to city comments to ensure infrastructure and plans are properly prepared.

EXPERIENCE

Ensign Engineering May 2022-Present
Civil Engineer Intern Sandy, UT

- Assist in project completion from preliminary to final submissions.
- Coordinate with clients, architects, and other engineering agencies to fulfill project responsibilities.
- Establish solutions to grading, drainage, sanitary sewer, and water distribution problems through Civil 3D.

Google April 2021-May 2022
Sales Representative Salt Lake City, UT

- Generated over $150,000 dollars of revenue through personal efforts.
- Implemented consultative selling skills to identify opportunities, overcome objections, and close sales.
- Consulted with clients after sales to resolve concerns and provide ongoing support.

Alder Home Security Feb 2020-April 2021
Routing Specialist Orem, UT

- Maintained high level of on-time arrival,reliable service, and performance for product maintenance.
- Oversaw daily workings of nationwide service technicians by coordinating personnel and supervising schedules.
- Managed quality assurance program, including on-site evaluations, internal audits, and customer surveys.

RELEVANT COURSEWORK

Hydraulics

- Created water network for a small community and confirmed viability of network through appropriate water calculations.

Intro to Transportation

- Learned grading requirements for roadways, which were later implemented at Ensign Engineering.

ENGINEERING SKILLS

- Spanish fluency (reading, writing, and speaking)
- Expertise in AutoCAD Civil 3D
- Geographic Information Systems: ArcGIS Pro
- Computer Programming: VBA and Python
- Familiarity with APWA standards

Daniel E. Saunders

6320 Treestead Rd., Fort Collins, CO | (970) 889-7828 | danielsndrs7@gmail.com
linkedin.com/in/danielsaunders7

Objective: Seeking full-time work at civil engineering firm

ENGINEERING EXPERIENCE

Engineering Assistant and Lab Technician | Engineering Analytics Inc. **Apr. 2023 - Aug. 2023**

- Located onsite with a team of four members in a mobile lab at the Ambrosia Lake disposal site
- Achieved certification of WAQTC and 24-hr HAZWOPER training
- Examined radioactive soil samples in controlled environment
- Conducted hundreds of soil tests according to ASTM standards

Engineering Assistant and Lab Technician | Engineering Analytics Inc. **Apr. 2022 - Aug. 2021**

- Collected soil samples and performed dozens of soil tests according to ASTM standards
- Compiled raw data and completed lab reports for managing engineers
- Completed certification to transport and operate Nuclear Densitometry

Unpaved Road Inspector | Larimer County **Apr. 2021 - Aug. 2021**

- Surveyed and inspected 400+ miles of unpaved roads in Larimer County
- Recorded sample road deformities and damages per mile and transferred information into Paver software

EDUCATION

Fulton College of Engineering, Brigham Young University, BS, Civil Engineering **Apr. 2024**

- 3.56 GPA
- Recipient of Caleb Tanner Scholarship - College of Engineering
- Minor in Mathematics

OTHER EMPLOYMENT AND VOLUNTEER EXPERIENCE

- Ski Shop Manager | BYU Outdoors Unlimited, Provo UT Sept. 2019 - Present
- President BYU Freeride Ski Club | Brigham Young University Jun. 2022 - Present
- Mountain Biking Teaching Assistant | Brigham Young University Sept. 2021 - Present
- Seasonal Grounds Crew | Harmony Club Golf Course, Timnath CO Apr. 2019 - Aug 2020
- Service Volunteer | Church of Jesus Christ of Latter-Day Saints, Novosibirsk, Russia Jun. 2017 - June 2019
- Eagle Scout Rank | Boy Scouts of America Sept. 2014

Hyeonbin Gil

389 S State St. Apt 23, Provo, UT 84606, (804) 928-5658, https://www.linkedin.com/in/bin-gil/

Professional Summary

A results-driven Civil Engineer with a robust background in structural analysis and project management, poised to bring a unique perspective to the field of architecture. With a strong foundation in engineering principles and a proven ability to collaborate effectively, excelling in delivering meticulously designed projects. Passionate about blending the precision of civil engineering with architectural creativity, aiming to innovate and elevate projects with an understanding of structural integrity, while aspiring to create architectures that embody and represent individual identities and stories.

EDUCATION

BS Civil Engineering, 04/2024
Brigham Young University – Provo, UT
GPA: 3.2

SKILLS

- Licensed in Microsoft PowerPoint, Excel, and Word
- Experienced in AutoCAD, Bluebeam, Revit, and VBA Primer
- Achieved 9th global ranking in Tetris, showcasing analytical prowess and strategic thinking.

RELEVANT EXPERIENCE

HR General Manager, 04/2023 to Present
Commercial Building Management Inc- Richmond, VA

- Developed and implemented human resources strategies and policies, fostering a positive workplace culture and aligning with organizational goals..
- Collaborated closely with senior leadership to ensure operational strategies were in sync with overarching business objectives.

Vector Engineers Solar Panel Team, 11/2021 to 01/2024
Vector Structural Engineers- Draper, UT

- Expertly managed solar energy system projects, adapting to diverse city-specific building standards across the USA, showcasing compliance expertise and versatility.
- Conducted thorough site analyses, integrating structural and electrical engineering knowledge into architectural design, informed by extensive research on regional standards.
- Demonstrated proficiency in navigating and applying a variety of building standards nationwide, ensuring accuracy and relevance in architectural planning and design.

Structural Analysis and Design, 09/2021 to 09/2023
Brigham Young University- Provo, UT

- Revit-Based Structural Modeling: Expertise in modeling truss systems like Howe Gabled and Scissor Truss using Revit, ensuring precise structural representation.
- Load Analysis and Building Codes Compliance: Skilled in comprehensive load analysis (dead, live, snow, wind) adhering to building codes, and applying LRFD methodology for design safety.

Computational Structural Engineering, 09/2021 to 09/2023
Brigham Young University- Provo, UT

- Python Scripting and SAP2000 Applications: Developed efficient Python tools for structural load evaluation and used SAP2000 for advanced analysis, including indeterminacy effects and beam theory applications.

Engineering Analysis and Comparative Studies, 09/2021 to 09/2023
Brigham Young University- Provo, UT

- Comparative Structural Studies: Conducted studies comparing truss designs, material use, load capacity, and aesthetics, assessing structural performance for optimal design selection.
- Wind Load Analysis and Structural Behavior: Performed detailed wind load analysis using ASCE 7-16 standards and analyzed shear and bending moment diagrams for purlins under varied conditions.

Santiago Vega

(801) 472 4698 · santiagovega9@gmail.com · www.linkedin.com/in/santiago-vega

EDUCATION

Brigham Young University Apr 2024

Bachelor of Science: Civil Engineering, Emphasis in Structures *Provo, UT*

- Ira A. Fulton College of Engineering Scholarship
- Society for the Advancement of Materials and Process Engineering

PROJECTS

Balsa Wood Bridge Dec 2019

Bridge Designer *Provo, UT*

- Applied engineering principles to design a scale balsa wood bridge capable of holding 740 pounds.
- Placed second in competition.
- Aided group in brainstorming and problem solving for simplest design.

PROFESSIONAL EXPERIENCE

Missionary Training Center Sep 2021-Dec 2022

Maintenance Worker *Provo, UT*

- Delegated daily tasks to employees to manage resources and meet deadlines.
- Analyzed and identified equipment failure root causes and initiated correction actions.
- Diagnosed equipment malfunctions and completed repairs to restore equipment and maintain uptime.

Dictuc – Pontificia Universidad Católica de Chile May 2023-July 2023

Research Assistant *Santiago, Chile*

- Participate in the comprehensive redesign of the "Los Portales de Buin" housing complex, orchestrating a multifaceted effort to bring the structures in line with the stringent structural requirements mandated by Chilean law.
- Collaborated closely with structural engineers to develop innovative solutions that not only met legal standards but also enhanced the complex's overall safety, longevity, and aesthetics.
- Conducted extensive field trips to evaluate the structural integrity of houses within the complex.
- Employed a combination of visual analysis and equipment assessments, to meticulously inspect and document the condition of each structure.

Calder Richards Consulting Engineers July 2023-Present

Civil Engineer Intern *Santiago, Chile*

- Determined seismic bracing locations for HVAC, electrical, and pipe systems, adhering to ASCE 16 and ASCE 16 standards.
- Conducted load calculations for mechanical equipment to optimize bracing designs.
- Collaborated with interdisciplinary teams and ensured compliance with local codes.
- Consistently met project deadlines and budgets while emphasizing safety and quality.

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-Day Saints Jun 2016-Jul 2018

Full-Time Representative *Mendoza, Argentina*

- Led groups of 8 to 20 volunteers and conducted training meetings to enhance volunteer efficiency.
- Created goals and weekly progress reports to increase productivity of the volunteer work.
- Develop team leadership skills.

Regional Hospital Diego Paroissien Sep 2016

Paint and Restoration *Mendoza, Argentina*

- Collaborated with 8 volunteers on the restoration of the pediatric unit of the hospital.
- Provided training to said group of volunteers.