

BLUFFDALE CITY LIGHT POLE STANDARDS
PROJECT ID: CEEN_CPST_002

by

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A Capstone Project Final Report

Submitted to

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Executive Summary

PROJECT TITLE: BLUFFDALE CITY LIGHT PROJECT
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The city has a streetlight luminaire standard that specifies lumens, poles etc. Some vendors are suggesting the use of varied materials or pole types and luminaires with some claims that the current City standards are not adequate. The project's objectives are to:

1. Research different streetlight pole material types (i.e., steel, aluminum, thermoplastic) to understand the short- and long-term performance of such materials.
2. Study the coating/paint types that are on the market to understand the properties and performance of such coatings for protecting the pole hardware.
3. Study the LED luminaires typically used to describe their performance for illuminating the streets.
4. Study light color temperature (typically described in Kelvin) that would best provide for street illumination.
5. Research the principles of "Dark Sky" to understand what is needed and required to reduce light pollution from streetlights.

ASCE, Elsevier, and professional websites were used to find research on these topics. After doing the research, the City of Bluffdale was given recommendations on the appropriate standards to be followed by our research. These recommendations will give the city advice on any need to change their lighting standards. The recommendations are to use powder coating, directional lighting with a warm light, and if corrosion is excessive on industry standard bases, then switching to an elastomer base is a sound option.

Table of Contents

Bluffdale City Light Pole Standards..... 1

Executive Summary 2

List of Figures..... 4

List of Tables 4

Introduction 5

Schedule 6

Assumptions & Limitations..... 7

Research & Analysis 8

 Light Pole Base 8

 Elastomer 9

 Aluminum 12

 Paint Coating..... 13

 Lighting Components..... 17

Related Issues..... 20

Lessons Learned..... 22

Conclusions and Recommendations..... 23

References 25

Appendix A..... 28

List of Figures

Figure 1: Capstone Schedule.....	6
Figure 2: Damaged Light Pole in Chicago (Rusty, 2019)	9
Figure 3: Polyurethane Market Share (Das, 2020).....	11
Figure 4: Common Light Pole 1 Figure 5: Common Light Pole 2	14
Figure 6: Mass Loss per Sample type (Rossi, 2013)	16
Figure 7: Light Types Comparison by Spectral Power (Luginbuhl, 2014).....	18
Figure 8: Scotopic Ratio Comparison to LPS (Luginbuhl, 2014).....	18
Figure 9: Light Cover Type Affect (DarkSky.org).....	19

List of Tables

Table 1: Aluminum Test Results (Schoukens, 2017)	12
Table 2: Specimen type and mass loss (Garcia-Ruiz, 2018)	15

Introduction

Streetlight pole specifications are a critical specification for the safety of towns. The type and design can affect the sight distance of vehicle operators, comfort of pedestrians, natural environment, and the intrusive nature of the street lighting. Maintaining a high quality for street lighting is crucial to the confidence of the public towards the city officials and engineers. The main concerns with light poles are the structural integrity, the lighting mechanism, and the look of the light pole overtime.

The structural integrity is especially important to the public because light poles are placed around high travel areas of pedestrians and vehicles. The likelihood of a light pole hitting a pedestrian while walking past it is incredibly low, but if it did happen that would be devastating because what can be done to prevent its failure. The falling of a light pole in front of vehicles would economically affect people with increased travel time, and if the light pole hit the car could cause the driver thousands in repairs.

The lighting of the light poles is a safety concern for both pedestrians and vehicles. Vehicles need proper lighting so they can have better sight distance down the corridor. Pedestrians, especially women need lighted areas to feel safe while walking along roads and trails (Boomsma, 2014). The importance of minimizing light pollution is also an issue with light poles, as we do not want to destroy the beautiful night sky.

The coating on light poles affects the longevity of the poles. The poles need to have the proper coating to keep the pole from rusting and maintain its appearance. There are many different coatings in the industry, but which one performs the best is important to know as you decide what to put in your city.

The final deliverable for the capstone project is to address Bluffdale City's concerns on the quality of the materials and light, and to summarize the information in this report. The City of Bluffdale will then be able to make an informed decision on what to change or keep for their current light standards.

Schedule

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Task 1 Sturdevant City Light Spec Research		Task 2 Light Pole Material Research		Task 3 Paint Research	Task 4 LED Luminaire Research	Task 5 Light Color Research	Task 6 Dark Sky/ Light Pollution Research		Task 7 Complete Report	

Figure 1: Capstone Schedule

Assumptions & Limitations

The major assumption that we had to make during our project was that the research we found and did could be applied to our specific project. Much of the research that was found was not related to our project due to its specific nature.

The major limitation we faced in the project was our ability to reproduce the data found in the research used to complete our project. We were not able to run any physical tests ourselves on the elastomer bases, powder coating, or light fixtures. We did receive a base from Northwest Standards, but due to the type of testing machinery we could access at Brigham Young University we were unable to run any tests on the base. Due to this we had to make sure we found reputable sources that could be trusted and presented to our client, Bluffdale City.

Another limitation we found was not being able to compare pricing of materials. We had asked the local vendor for quotes and pricing but were never given anything. So, as a part of our research and analysis, we were not able to do any cost analysis for the project.

During our research we were originally under the assumption that Mountain State Lighting was the company that built the light poles and bases. We found that Northwest Standard is the company that produces the bases and poles of interest, and Mountain State Lighting is the vendor. Mountain State Lighting sells products for multiple companies and not just Northwest Standards. This caused limitations in communication, because we were not speaking with Northwest Standard resulting in our information coming from the vendor and not the manufacturer.

Research & Analysis

In this research and analysis section, a summary of the information gathered is given and analyzed. The information in this section covers research done on paint, light design, and shroud material that is used in public streetlights. The information gathered is to give educated recommendations to Bluffdale City regarding their city specifications and to provide trustworthy information about the selection of streetlight components.

Light Pole Base

The purpose of the light pole base section of this study was the recent desire to use an elastomer base material for the City of Bluffdale light poles. The base serves as a decoration and protection for the light pole and does not have a structural role. The importance of the base in construction is to make the light poles esthetically pleasing and protect the base of the pole from the elements. The two different bases researched are elastomer-and aluminum decorative covers.

Image 1 shows a light pole that had broken and fallen to the ground because of rust to the main light pole. Image 1 is from a report in Chicago called “Rusty, Corroded Light Poles Continue to Be Problem Across City” (Rusty, 2019). The report says “... Covers might have looked pretty at first, but their design has created a danger. They trap ‘water...” (Rusty, 2019) Water was trapped between the decorative base and the pole base creating a wet environment which corroded the base material and caused light poles to fall (Rusty, 2019).



Figure 2: Damaged Light Pole in Chicago (Rusty, 2019)

The report is surprising, because the initial assumption was that sealing off the base would protect the light pole from corrosion, but Chicago did have rusting issues (Rusty, 2019). The bases were sealing the moisture between the pole and decorative base causing rusting of the structural pole (Rusty, 2019). While our Capstone team toured Northwest Standard Corporation, they talked about the importance of having a base that allows air flow through it to keep the structural pole dry and rust-free.

Elastomer

Northwest Standards use a polyurethane plastic material to construct their bases. The focus of research will be the longevity of the base over time when exposed to the elements. Elastomer bases are not widely used, and Northwest Standard is the only known producer. Northwest Standard took the capstone team on a tour of their plant to introduce the elastomer bases and explain why they use them. The reasons they started using elastomer bases are:

1. They buy their elastomer from a local company out of Nephi, Utah.
2. They have more flexibility with the elastomer.
3. They can customize the bases easily.
4. They are cheaper to replace.

5. They are made of non-corrosive material.

While touring Mountain State Lighting the capstone team learned that the problems associated with developing and creating their elastomer bases are:

1. Making the infrastructure to create the bases.
2. Shrinking of the polyurethane while hardening after forming the bases
3. Bolting the bases together and keeping a durable connection
4. Bases flex away from each other when it gets warm while on light pole.

They have improved their products by trial and error over time and have always said that “If it’s their fault they will fix it at no cost.” However, they complain that some cities do not communicate problems and have subsequently lost interest after one base had problems. They showed the team some of their new base engineering designs with a modern design of bolting the two pieces together and using a hardening plastic foam inside their large bases to keep them from flexing away from each other.

The research found is as follows “Polyurethane is a general term used for a class of polymers derived from the condensation of polyisocyanates and polyalcohol’s” (Howard, 2002). In a research paper titled “A brief discussion on advances in polyurethane applications” it talks about some of the benefits of plastic (Das, 2020). It states, “The main advantages of polyurethane have been the durability, toughness, and excellent chemical resistance” (Das, 2020) Graph 1 shows the market share in 2012 of Polyurethane taken from the study.

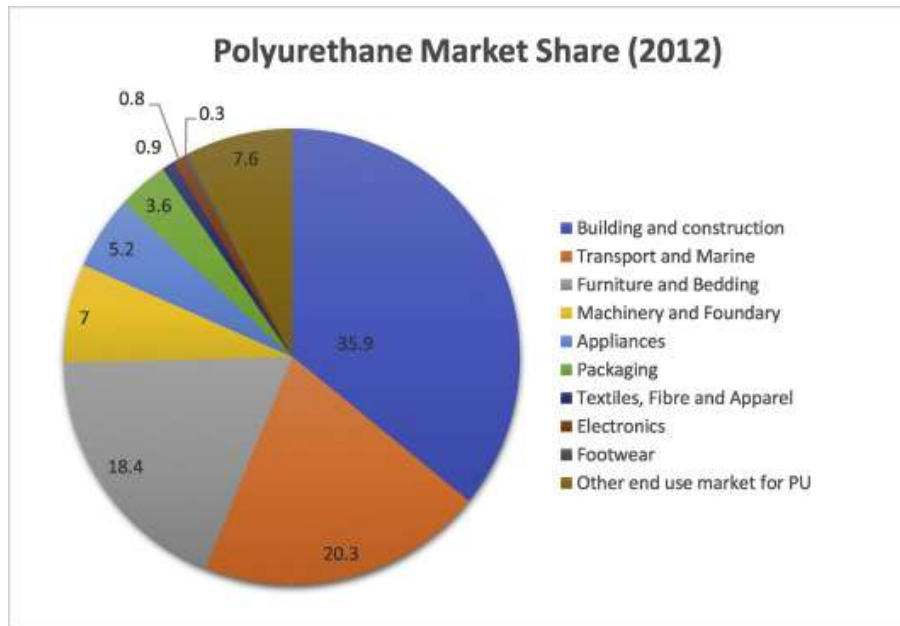


Figure 3: Polyurethane Market Share (Das, 2020)

A research paper called “Long-Term Weathering Effects on Aromatic Polyurethane-Coated Pipe” (Croll, 2014). The report talks about the worries of using polyurethane for long term uses, because of its degradation from sunlight and the elements (Croll, 2014). In the report it says, “Aromatic polyurethanes can however be susceptible to surface degradation from ultraviolet rays and can chalk or discolor when left in the sun for long periods” (Croll, 2014). This is a downside of the elastomer bases in that over time they will discolor, and the exposed plastic will weaken. However, the report also mentions that the remaining depth of polyurethane not exposed to the sun keeps its strength (Croll, 2014).

The elastomer mostly keeps its strength, but over time the base will be sun bleached on the outside. The elastomer will keep a lot of its structural integrity, but the surface will weaken due to the sunlight. These are the two disadvantages of the elastomer base, but elastomer is still a good option because it still serves the main purpose of protecting the light pole.

Aluminum

Aluminum is a versatile metal and is used in many different industries. A research paper says that “Aluminum has high strength to weight ratio... thermal conductivity and good corrosion resistance” (Ashkenazi, 2019). This has made aluminum a great resource in many areas such as the car industry, marine industry, and packaging industry (Ashkenazi, 2019). When aluminum is used in light pole bases it does not necessarily have all the advantages it has in other applications, but it is more corrosion resistant than other metals, and is light in weight which decreases the cost of transporting the bases to their destinations (Ashkenazi, 2019).

Aluminum’s resistance to corrosion does not mean it cannot rust, but that it can resist rust better than other metals. In a report called “Influence of de-icing salt chemistry on the corrosion behavior of AA6016” it talks about the effects of road salt on aluminum parts in cars. In the experiment the aluminum was exposed to “sodium chloride (3 wt%), calcium chloride (3 wt%), magnesium chloride (3 wt%), sodium chloride + magnesium chloride (5:1) mixture (3 wt%), and a 3 wt% solution of a commercially available de-icing salt” (Schoukens, 2017). The results from testing the 5 salt conditions are shown below in Figure 2.

Table 1. Corrosion potential and corrosion activity of AA6016-T4 in the different salts

Salt	Corrosion potential (V vs. Ag/AgCl)	Corrosion activity (A/cm ²)
NaCl	-0.670	4.3 10 ⁻⁴
CaCl ₂	-0.669	3.1 10 ⁻⁴
MgCl ₂	-0.689	3.1 10 ⁻⁵
NaCl + MgCl ₂ (5:1)	-0.667	8.6 10 ⁻⁴
Commercial	-0.662	9.4 10 ⁻⁴

Table 1: Aluminum Test Results (Schoukens, 2017)

From the research, the commercial salt and the mix of salt and magnesium ($\text{NaCl}+\text{MgCl}_2$) is two times more corrosive than table salt (NaCl) and calcium chloride (CaCl). (Schoukens, 2017) Corrosion activity numbers are read as “If the corrosion potential changes negatively then this is due to an increase in the corrosion rate” (Ropital, 2011). This is not a problem if the paint covering the aluminum is still on the decorative base, but if the protective layer is taken off the aluminum it can rust. This appearance would give the public the concern of an unsafe base, even if the structural pole is fine. Over time after the rusting gets worse the structural pole could be exposed to road salt and elements causing excess rust. This will lower the structural integrity of the pole and cause it to be unsafe for the public.

Paint Coating

In researching the various specifications for coating materials from the surrounding cities, it was found that every city that has stated a requirement for coating uses powder-coated finishing. There are many reasons why powder coating is the industry standard. Some of these reasons include efficiency and durability.

While touring Northwest Standard’s plant, they demonstrated their powder coating process. This process includes heating the metal poles to a hot temperature in a large oven-like structure, then removing the poles and applying the paint. The paint is applied through a sprayer and is in the form of a fine dust. When the chemical dust encounters the hot metal surface of the light pole, it bonds to it electrostatically and creates a film over the surface of the material. This was explained by Rany Orban, the owner of Northwest Standard, which does powder coating for light poles in the Salt Lake region.

After the coating is applied to the light pole’s surface, it needs to cure. Curing is the process of the powder baking itself to the pole and then cooling down to the ambient air temperature. This whole curing process takes around thirty minutes. This is according to Northwest Standard’s owner.



Figure 4: Common Light Pole 1



Figure 5: Common Light Pole 2

The images above show two light poles, both coated with a powder-coated finish. The photographs were taken (left to right) along 2200 W, South Jordan and the roundabout of 14400 S and 2200 W, Bluffdale City. Note that as the powder-coated pole is exposed to weathering, such as temperature, sunlight, dust, and so on, it loses its gloss but can still provide protection to the metal pole (Rossi, 2013).

This curing time is the major time saver when compared to a wet paint finish. While wet paints can take hours to days to properly dry before being used, once a powder-coated product cools to the ambient air temperature it is ready to use in its designed environment. This much smaller production time allows for manufacturers to produce larger numbers of light poles in less time and decrease per-pole labor costs.

In a study done by researchers at Ohio University, they found polymeric coating, powder coating, to be the most durable type of metal coating out of multiple coating methods tested (Garcia-Ruiz, 2018). They determined this by doing an abrasion test using aggregate material to act as an abrasion element (Garcia-Ruiz, 2018). In another study done at the University of Trento, in Trento, Italy, researchers again found that powder coating a metal surface resulted in the least amount of mass lost during an abrasion test. (Rossi, 2013).

Table 1. Specimen masses and mass losses at each stage of the test for all coating materials tested.

Coating	Specimen	Initial		500,000 revolutions				1,000,000 revolutions			
		Mass Weight		Mass Weight		Mass	Mass loss	Mass Weight		Mass	Mass loss
		(g)	(lb)	(g)	(lb)	(%)	(%)	(g)	(lb)	(%)	(%)
Polymeric	1	731.5	1.6127	729.5	1.6083	99.73%	0.27%	728.5	1.6061	99.59%	0.41%
	2	749	1.6513	747	1.6469	99.73%	0.27%	746	1.6446	99.60%	0.40%
	3	753.5	1.6612	752	1.6579	99.80%	0.20%	751	1.6557	99.67%	0.33%
	Avg.	744.7	1.6417	742.8	1.6377	99.75%	0.25%	741.8	1.6355	99.62%	0.38%
	Std. Dev.	11.6	0.0256	11.8	0.0260	0.04%	0.04%	11.8	0.0260	0.04%	0.04%
Bituminous	1	941.5	2.0757	939	2.0701	99.73%	0.27%	936.5	2.0646	99.47%	0.53%
	2	935	2.0613	932	2.0547	99.68%	0.32%	928	2.0459	99.25%	0.75%
	3	902.5	1.9897	900.5	1.9853	99.78%	0.22%	899	1.9820	99.61%	0.39%
	Avg.	926.3	2.0422	923.8	2.0367	99.73%	0.27%	921.2	2.0308	99.44%	0.56%
	Std. Dev.	20.9	0.0461	20.5	0.0452	0.05%	0.05%	19.7	0.0433	0.18%	0.18%
Aluminized	1	681.5	1.5025	673.5	1.4848	98.83%	1.17%	669	1.4749	98.17%	1.83%
	2	683	1.5058	675	1.4881	98.83%	1.17%	669	1.4749	97.95%	2.05%
	3	686.5	1.5135	681	1.5013	99.20%	0.80%	677	1.4925	98.62%	1.38%
	Avg.	683.7	1.5072	676.5	1.4914	98.95%	1.05%	671.7	1.4808	98.24%	1.76%
	Std. Dev.	2.6	0.0057	4.0	0.0087	0.21%	0.21%	4.6	0.0102	0.34%	0.34%
Galvanized	1	716	1.5785	708.5	1.5620	98.95%	1.05%	704	1.5521	98.32%	1.68%
	2	724	1.5961	711.5	1.5686	98.27%	1.73%	699.5	1.5421	96.62%	3.38%
	3	717.5	1.5818	703	1.5498	97.98%	2.02%	688	1.5168	95.89%	4.11%
	Avg.	719.2	1.5855	707.7	1.5601	98.40%	1.60%	697.2	1.5370	96.94%	3.06%
	Std. Dev.	4.3	0.0094	4.3	0.0095	0.50%	0.50%	8.3	0.0182	1.25%	1.25%

Table 2: Specimen type and mass loss (Garcia-Ruiz, 2018)

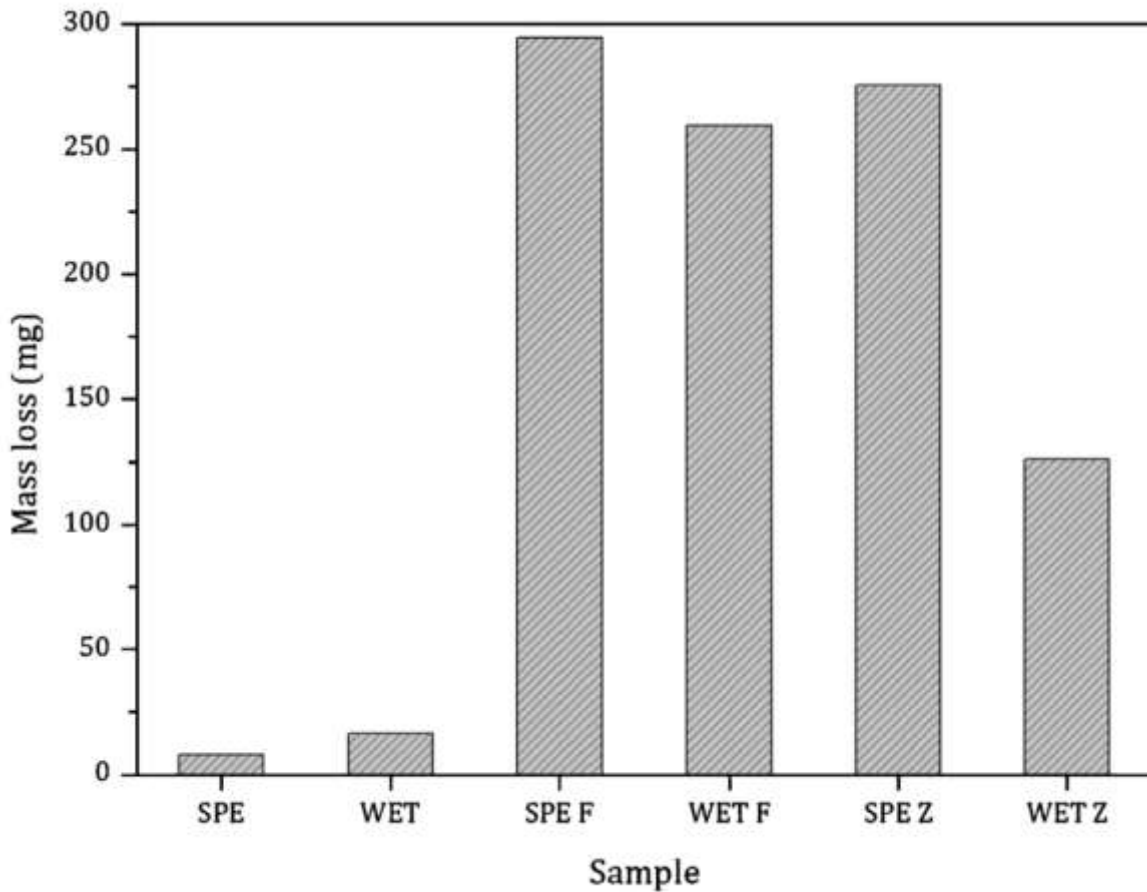


Fig. 15. Mass loss after Taber test.

Figure 6: Mass Loss per Sample type (Rossi, 2013)

The table above from “Accelerated Degradation Test on Coating Materials for Steel Pipes,” the study done at Ohio University, shows the initial mass and weight of each specimen tested. It also shows the mass and weight halfway through the test and at the end of the test (Garcia-Ruiz, 2018). The polymeric coating (powder coating) experiences a much smaller average mass loss and standard deviation of mass loss than the other coatings tests (Garcia-Ruiz, 2018). In the figure from “Evaluation of the abrasion resistance of enamel coatings,” by Stefano Rossi, and Erica Scrinzi the mass loss of powder-coated samples versus other samples tested is shown (Rossi, 2013). The

powder-coated samples are labeled with and “SPE” refer to different type of powder-coating blends, and samples labeled with a “WET” refer to wet coating blends.

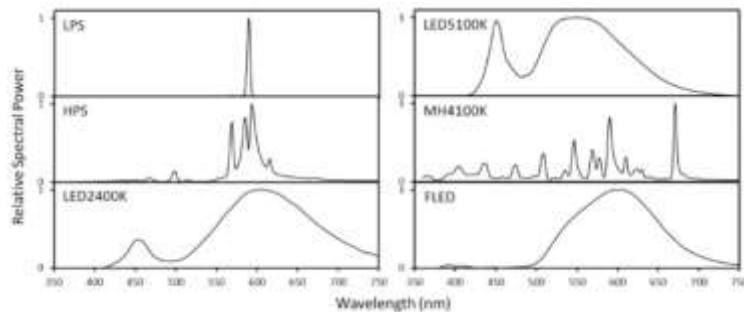
Lighting Components

The way streets are lit is important to the drivability of any city or town and has externalities that pose other concerns. These concerns can include cost, dark sky, and impacts on the environment.

In a study done by the American Council for an Energy-Efficiency Economy (ACEEE), a case study of LED lights being used in Vermont streetlights was used to understand the impact of using LED. The study claims that Vermont cities were able to reduce 10% to 40% of their streetlights and therefore able to lower costs for the city and light pollution in general. However, according to this study the setbacks to LEDs are their initial cost of installation and their higher technology cost compared to traditional lights (Arnold, 2012). LED would be a viable option depending on a city’s installation budget.

According to the Flagstaff Dark Skies Coalition, it is important to consider light color and lumen to lumen ratios when addressing light pollution. Lumen to lumen ratio refers to the difference in brightness between light types even when they emit the same number of lumens. “LED light – with no increase in the amount of light (in lumens, footcandles or lux) – would obscure almost half of the stars in the night sky” (Lamp Spectrum and Light Pollution). Based on accredited published studies, the recommendation is for the use of “warm” yellow-white lighting to reduce the intrusion on night sky and to compare the scotopic ratio of the light. Scotopic ratio is the amount of light emitted from a source useful to the eye. “The brightness of the night sky when observed by humans under naturally dark conditions, and even in urban areas of moderate sizes, is primarily a scotopic response. Thus, sources richer in short wavelengths are more effective in stimulating vision, producing an artificial sky luminance that appears brighter.” (Luginbuhl, 2014).

This study shows that Low-Pressure Sodium lights have the lowest scotopic ratio and therefore give off the lowest sky glow. Distance also contributes to scotopic ratio, therefore the spacing of light poles paired with their spectral characteristics, characteristics such as lumens and light color, can influence visibility. The following graphs from the study show the comparison between Low Pressure Sodium (LPS) lights and other common light types.



a

Figure 7: Light Types Comparison by Spectral Power (Luginbuhl, 2014)

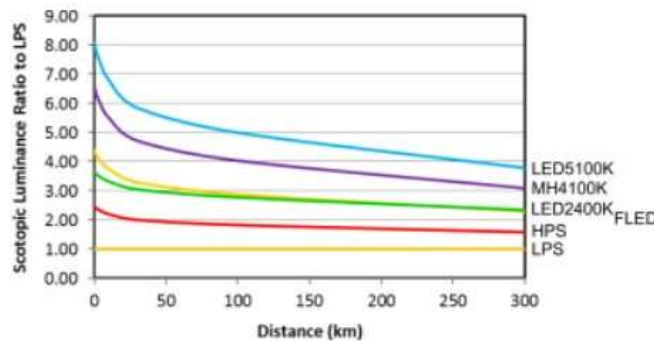


Figure 8: Scotopic Ratio Comparison to LPS (Luginbuhl, 2014)

According to these graphs, it can be assumed that greater wavelength and spectral power results in a brighter perceived light. Spectral power is the area under the wavelength curve. A light with a greater frequency therefore has more spectral power. For example, the LED5100k light has a high relative spectral power over greater

wavelengths and is the brightest perceived light, shown by having the highest scotopic ratio. This paired with light warmth gives an educated judgment of what light type to use. For higher scotopic ratio lights, a warm light tone and greater spacing will reduce glare and allow for visibility, but LPS lights will still give the darkest sky potential. LED lights by comparison give off a greater amount of sky glow. However, the color type and spacing LED light poles farther apart can make them a more viable option when dark sky is an important consideration.

Another key component to lighting without polluting is the cover type. A fully covered light that directs all light downward, will result in less light intrusion on the sky, homes, and businesses.



Figure 9: Light Cover Type Affect (DarkSky.org)

This image from DarkSky.org shows how the cover type can reduce the amount the light puts glare on the surrounding. Many of the cities surrounding Bluffdale City have little or even no direction addressing light pollution in their specifications. Each specification does show the light cover types that are acceptable to the city, and many of

the diverse types accepted for each city do not follow the advice of this image. Specifying the cover type can significantly address the glare on the night sky.

Related Issues

The attitude of public health is important for developing a city. A city will grow when it has healthy economic, social, and environmental structures. Light poles might seem like a small thing, but they could impact all three of these areas. If the light poles are unsafe or do not exist this could affect your economic growth. Trucking routes bring economic growth to those areas as it is easier to get supplies, but if the roads are not maintained and appropriate lighting does not exist then trucks might take another route to their destination and hurt your economic growth.

Socially, having appropriate lighting on your streets helps everyone feel safe when using them. When you have good lighting people have a better understanding of their surroundings. When you understand what is around you, you will have a greater sense of safety. In a study done at BYU (Brigham Young University), they examined the different behavior between women and men in areas that do not have appropriate lighting (Chaney, 2024). The study showed that women and men sense their surroundings differently (Chaney, 2024). The women looked around a lot more as they fear sexual harassment from males, but the males would only look at the road (Chaney, 2024). It is important to have appropriate lighting to keep the citizens safe from walking to their destination.

Respecting the city's natural environment is important as this is part of what draws people to the city. The light poles cause light pollution in the sky which does not allow residents to see the full beauty of the sky under which they live. Citizens and engineers are responsible for ensuring lights minimize pollution in the sky.

Having functioning lights is crucial to the safety of vehicle operators and pedestrians. For a streetlight to function in the manner it is meant to, it must be maintained and adjusted properly. The material used is important because each material will have different strengths pertaining to fatigue and corrosion. That is why having specifications that describe materials that will last long enough, and function well will increase the safety of light poles. The paint coating may increase the life span of the material and therefore the pole. Having all the parts of the pole working and the light designed properly will give sight to help drivers see better, keeping them safer. It will also allow pedestrians to move about at night and feel safe from cars and others in their surroundings.

The effects of our recommendations below will be a culture of safety around light poles. Light poles are used and seen by everyone in your city. When you have light poles that look good and are safe people will know that the city has a culture of safety. Understanding the right specification for light poles will help city engineers and city officials know what is important about light poles. It is a lot easier to keep the confidence of the citizens than to try to repair confidence, so taking time now to study the light poles will help the city keep their attitude towards safety.

Implementing dark sky in cities can be a great social benefit for citizens. Light pollution has decreased the number of stars that are visible in the night sky. The sky we view each night is significantly different than the sky most of history has been able to view. Being able to bring back even a portion of the starry sky that truly exists would socially and emotionally benefit people. Returning to a natural view that is technically right would have a positive effect on the minds of people (Kumar, 2019).

City engineers have the important task of designing elements of the city so that citizens are supported in their daily lives. An aspect of this task though is to reduce the cost of their plans and city designs because the same citizens pay for the plans. Designing specifications that allow for high functionality but are also affordable for the members of the community is therefore important.

Lessons Learned

The challenges we encountered during our capstone project are as follows:

Trying to understand our project and how to research the issue was one of the major problems we encountered. As engineering students, we are not necessarily used to doing a major literature review. To overcome this challenge, we had to ask a lot of questions to our sponsor to make sure we were researching the correct topics. We also reached out to various faculty members to use the correct materials and databases to find adequate resources to review.

Another challenge we encountered was our ability to test the elastomer. We received a base from Northwest Standards, the company that makes them, but because of the equipment in BYU's material testing lab we could not test the elastomer. We let our client know that the elastomer could not be tested and instead of finding the data ourselves we found research that spoke of the same type of data and information we were looking for.

We also found that communication plays a key role in any project. Even more importantly, a lack of communication can make any project extremely difficult to complete properly. Throughout our project we decided to work with Mountain State Lighting and Northwest Standard, because they are the two companies that sell and make the light poles in question. We did this also because there was no research we could find on elastomer as a light pole base. This was not the easiest line of communication to maintain. To get the information we needed we had to keep constant and frequent communication with them. We learned it is important to maintain communication lines with clients and others, essential to completing a project.

Conclusions and Recommendations

The use of both aluminum and elastomer are great options for a decorative base. They will both give longevity and purpose to your decorative base. The elastomer base will experience discolor and lose a little strength on the outer portion of the base. The aluminum can rust if the paint coating is taken off the aluminum base. Elastomer gives you the assurance that you will not have any rusting, which could be a huge positive. The aluminum decorative base is industry standard and is not being pioneered so you know you are getting a quality product for your city.

After choosing a material to use for your decorative base, here are some things to consider before approving the placement of the light pole. Is the base a structural component of the light pole? Does the base allow for the area between the base and pole to be ventilated to minimize creating a rusting environment? What type of paint are they using on the decorative base? We did not research these questions extensively, but while researching and touring Northwest Standard it seemed apparent that these are other important questions to ask when it comes to decorative bases.

Appropriate coatings are an essential part of a light pole's durability. There are many ways to coat a light pole, but research shows that the most effective in protecting the metal is powder coating. Therefore, the recommendation is to continue to use powder-coated poles, as per the existing city standards.

Proper street lighting is crucial to the safety of any city, allowing drivers and pedestrians to navigate safely and comfortably. However, in an ever-modernizing world the amount of light we produce has created a less starry night sky. Limiting the amount of light that intrudes on the night sky is possible through the cover type and the light type that is used. The design of the light cover can vary and tends to be chosen mostly for aesthetics, but this can lead to more light pollution. A cover that fully covers the light from the top and therefore directs the light downward is the best option for dark sky. The more light is allowed out to the side or up, the lighter glare in the sky will occur.

The color of the light is also important to the effects of glare on the sky. Low-Pressure Sodium (LSP) lights are considered the most effective within the industry at having small glares on the sky. Many other lights have been compared to LSP lights through research and each have increasing levels of glare. The best way to compare lights is through their scotopic ratios. These are terms that describe the visibility of light. When choosing a light type, deciding based on these ratios will lead to choosing a light that is less intrusive. LED lights are an increasingly common choice; however, they tend to have much higher scotopic ratios. In addition to the glare strength of a light, the color of light also affects its intrusiveness. In the end, the recommendation is to choose covers that completely direct light downward and a warmer color with lower scotopic ratios.

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Appendix A

Isaac Pacheco

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EXPERIENCE

Itafos, Soda Springs, ID — Mining Engineer Intern

MAY 2023 - AUGUST 2023

- Designed necessary structures for the mine
- Gained experience in open pit mining
- Assisted in project management
- Emphasized work in mine support, such as designing roads, ramps, and water containment ponds.

R Cherrington Enterprises, Springville, Ut — Intern

MAY 2021 - AUG 2021

- Scheduled surveys for construction jobs
- Assisted in pre-construction tasks, such as obtaining quotes
- Worked with and around heavy equipment
- Accomplished jobs both in a team and as an individual

The Church of Jesus Christ of Latter-day Saints, Dallas, TX — Full-time Volunteer

AUG 2017 - AUG 2019

- Gained experience leading large teams of individuals
- Organized and led meetings for over one hundred employees
- Developed communication skills by interacting with a variety of individuals

EDUCATION

Brigham Young University, Provo, UT — BS Civil Engineering

AUG 2019 - DEC 2024

- Emphasis in Geotechnical Engineering
- GPA 3.1

SKILLS

AutoCad Civil, Carlson
Mining, Word, Excel

AWARDS

Eagle Scout, National Honor
Society

Garred Blanthorn

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linkedin.com/in/garred-blanthorn-108189198

EDUCATION

Brigham Young University Sep 2019 – December 2024
Bachelor of Science in Civil Engineering Provo, UT
Collegiate GPA: 3.40/4.00

- ✦ BYU Institute of Transportation Engineering (ITE) Student Officer
- ✦ BYU American Society of Civil Engineering (ASCE) Student Officer
- ✦ Former Collegiate Athlete; Member of the BYU Football Team
- ✦ Member of Phi-Eta-Sigma at Brigham Young University

EXPERIENCE

LEI Engineering September 2023 – Present
Surface Water Intern Spanish Fork, UT

- ✦ Land Development gradation, utilities, storm water, road, stripping, easement and holding tank analysis
- ✦ Detailed analysis of sheets to make sure all plans meet code for sewer, irrigation, water, and storm water

Kimley-Horn May 2023 – August 2023
Roadway Intern Salt Lake, UT

- ✦ Performed daily tasks under project managers mainly in OpenRoads, SignCAD, and some Civil3D
- ✦ Understanding UDOT standards, UDOT QC process, and UDOT drawings

Brigham Young University Sep 2022 – June 2023
201 Sustainable Infrastructure Provo, UT

- ✦ Teaching principles of sustainability, economics, and time value of money through TA office hours
- ✦ Opportunity to be able to lead a class discussion about globalization and lead them through a workshop

Utah Department of Transportation (UDOT) April 2022 – August 2022
Materials Lab Technician Spanish Fork, UT

- ✦ Performed daily rice, gradation, oil, and proctor test on asphalt for quality control
- ✦ Performed in-field samples on soils and oils by using different sample methods

VOLUNTEER SERVICE

The Church of Jesus Christ of Latter-day Saints Jun 2017 – Jul 2019
Volunteer Representative Milwaukee, WI

- ✦ Monitored productivity and wellness of fellow volunteers in a leadership position over 6+ volunteers
- ✦ Developed presentation skills to clearly communicate challenging subjects to small and large groups

AWARDS, SKILLS, & INTERESTS

- ✦ **Technical Skills:** Proficient in Excel, Civil 3D, GIS, OpenRoads, SignCAD
- ✦ **Awards:** First Team All-State (Football), Academic All State (Football), Eagle Scout-BSA America, Recipient of the "National Football Foundation Scholar, Leader, Athlete Scholarship"
- ✦ **Interests:** Skiing, College Football, Hiking, Traveling, Rugby

Joseph Pacheco

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EXPERIENCE

CMT: Engineering Services, Vineyard, UT-Engineer Intern May 2023-Present

- Performing the most common ASTM and AASHTO soil classification tests
- In-field investigations, logging soil classifications and depth
- Acting as a drill helper

American Engineering and Testing, Williston, ND-Engineer Intern May 2022-August 2022

- Performed soil tests
- In-field investigations, logged soil classifications and depth
- Acted as a driller helper

Teacher's Assistant CCE 103 Statics & CE 341 Soils August 2022-

- Educating and communicating with fellow students

Anderson Engineering, Saratoga, UT-Engineer Intern

January 2022- April 2021

- Worked in CAD and CIVIL 3D
- Improved technical communication skills

ND Department of Transportation, Williston, ND-Engineer Intern May 2021-August 2021

- Acted as a project inspector
- Soils lab experience
- Project management training

HireQuest, Williston, ND — Temporary Worker

June 2020 - August 2020

- Construction experience

EDUCATION

Brigham Young University, Provo, UT

August 2020

- GPA 3.43

Career Skills

ACI Concrete Testing
Certification

Lab and Field Soils and
Materials Testing

CIVIL 3D and CAD design

Construction Inspection
Experience

Plan Reading

Excel Based Information
Systems

HIVE RC Inspections

AWARDS

Eagle Scout, Boy Scouts of
America

High School Honor Student

National Honor Society

LANGUAGES

English, Spanish

Extracurriculars

BYU Wrestling Club