Thirsty Concrete: Group Project

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Writing for Engineering, ENGL 21007, D3

Prof. Von Uhl

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1 - Summary

Our proposed program is the use of asphalt thirsty concrete in the use of bus lanes and parking lots. The project will focus on implementing this technology for the Bx15 bus lane, which will be a test for the future implementations for the concrete. The budget we will be working with is $8.7 million, which will cover tools and labor. Also, this will be our first time leading the implementation of any asphalt road. And, the qualifications for workers would be anyone who is 18 years and older, has a D class drivers license, and passes a drug test.

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Introducing Thirsty Asphalt

A Revolutionary Solution for Managing Stormwater Runoff

New York city planners, developers, and environmental advocates can now rejoice with the arrival of Thirsty Asphalt – the world's first permeable asphalt solution that can help manage stormwater runoff. Thirsty Asphalt is composed of high-quality porous asphalt, steel pipes, and an underground water tank, which work in unison to capture, filter, and store stormwater for later use. Compared to traditional asphalt, Thirsty Asphalt can significantly reduce the amount of runoff that flows into storm drains and use the water to cool off roadways on a hot summer day.

“Porous asphalt has been around for a while, but it was never integrated with a system to store and manage the water”, says Anthony, CEO of Thirsty Asphalt Inc. “Thirsty Asphalt is a game-changer because it allows stormwater to naturally store on an underground water tank, preventing it from accumulating on the surface and potentially causing flooding or erosion. The cooling system also allows the asphalt to be more durable against heat.”

Thirsty Asphalt can be installed in both residential and commercial properties, making it an ideal solution for new construction and retrofitting. The installation process and cost of equipment requires a little more labor than a traditional asphalt installation, but the benefits outweigh the cost. Thirsty Asphalt is expected to make a significant impact in the construction industry by providing a more sustainable and eco-friendly option for managing stormwater runoff. With the increasing concern over climate change and the need to protect local bodies of water, Thirsty Asphalt is the solution that many cities have been waiting for.

For more information about Thirsty Asphalt, please visit our website at www.thirsty-asphalt.com.

Introduction

Roadway in New York City

The roadway in New York City are critical for the efficient movement of commuters and goods around the city. However, these lanes are often plagued with dangerous conditions such as wet and icy roads, which can cause accidents and put lives at risk. Additionally, New York City is prone to flooding, which can further exacerbate the problem of wet roads. Finally, the roadway absorbs a lot of heat on a hot day and retains it as it does not have any mechanisms to fight back. To address these issues, the city of New York must take the initiative replacing traditional asphalt with thirsty asphalt.

Flooding Problem

The problems with New York City's drainage system are compounded by the issue of garbage blocking the drainage and causing flooding. The city generates an enormous amount of waste each day, and much of this waste ends up on the streets. When it rains, garbage is washed into the storm drains, clogging them and preventing rainwater from flowing away from the city. This, in turn, can lead to flooded streets, subways, and buildings, creating significant problems for residents and businesses alike.

Garbage filled drainage. Barrameda Tsangarides, A. (2023). [Photograph].

Hurricane Ida

New York City is no stranger to flooding, particularly during severe weather events. In 2021, hurricane Ida caused catastrophic flooding throughout the city. An article from The New York Times states that “At least 43 are dead after Ida causes flooding in four states”, causing an enormous loss for the city and its residents.

Asphalt Heat Problem

Asphalt's heat problem is a significant concern, particularly in urban areas. Asphalt is a common material used in roads, parking lots, and other surfaces, and it absorbs a significant amount of heat from the sun and retains it. This can result in what is known as the "urban heat island effect," where temperatures in urban areas are significantly higher than in surrounding areas. The heat absorbed by asphalt can also lead to other problems, such as increased air conditioning usage, which can strain the power grid and contribute to climate change. Additionally, high temperatures can damage the asphalt itself, leading to cracks and other structural problems.

Thirsty Asphalt

Replacing traditional asphalt with thirsty asphalt is an effective way to mitigate these risks. According to Sarah Noel from Homeguide.com, porous concrete or porous asphalt costs around $ 8 to $ 16 per square inch which is double the normal price of asphalt, however, it does not outweigh the dangers of having only normal asphalt. Fundamentally, porous asphalt is designed to allow water to pass through it, reducing the amount of standing water on the road and decreasing the risk of hydroplaning and the formation of black ice in cold weather. Furthermore, porous asphalt provides more traction in wet conditions, reducing the risk of accidents. Ultimately, by modifying this porous asphalt to store rainwater in an underground water tank, we can use it on a later date to cool the porous asphalt to combat urban heat island effect.

Non-porous asphalt vs porous asphalt

A test section shows how well snow has melted on the porous asphalt Section (center) compared to the crushed rock trail (foreground) and regular asphalt (far left and rear)

Replacing traditional asphalt with thirsty asphalt is also an environmentally friendly option. Traditional asphalt requires extensive drainage systems to manage runoff, which is costly and energy intensive. Thirsty asphalt reduces the need for these systems, making it a more sustainable and environmentally friendly solution.

Proposed Program

With the increased chances of warmer temperatures in 2024 (Shao, 2023), many different cities of the United States, such as New York, will need to take proper measures in order to combat these unfavorable conditions, such as constant precipitation and humidity. Thus, along with the issues of flooding and the urban heat island effect, New York is susceptible to a bunch of climate issues, which is why we have brainstormed an innovative multilayer porous asphalt that is referred to as “Thirsty Concrete,” which can help tackle these problems. In particular, our porous asphalt is composed of various underground layers of rocks that serve different functions in order to provide reliable absorption of rain water. The number of layers can vary depending on the usage and location of the concrete, since some factors like terrain and traffic have to be considered. However, the typical layers include the main porous concrete, a filter/choker layer, and the sub-base reservoir. In addition, we have incorporated an underground tank system that will allow collected water to be pushed back into the surface in order to combat drier conditions and warmer temperatures.

Main Porous Layer

The main porous layer is the uppermost layer located at the surface of the pavement, which is where all the people and vehicles will be traveling across. It will also be the first surface that the rain will touch and land on before it begins to drain down the concrete. Its composition is typically “portland or blended cement, water, and uniformly sized aggregate falling within a narrow gradation.” (PCA, 2020) The aggregate, meaning fragments of rock, is the most vital aspect of the concrete, since the material and size used are the greatest factors in determining the efficiency of the absorption of water by the concrete. Our “thirsty concrete” would consist of a small open-graded aggregate of asphalt that will be around two to four inches in size in order to increase the strength and durability properties of the concrete (Sánchez-Mendieta, 2021). As shown in Figure 1, these aggregates of asphalt will need to be compacted to leave certain gaps, which is referred to as “void space.” The void space of our thirsty concrete will be 20 - 25% of the whole hardened mass (PCA, 2020) in order to have an efficient flow of water go through this first layer. However, we also need to keep in mind that this project is aimed to be used initially for bus lanes, where higher weights for prolonged periods of time may need to be

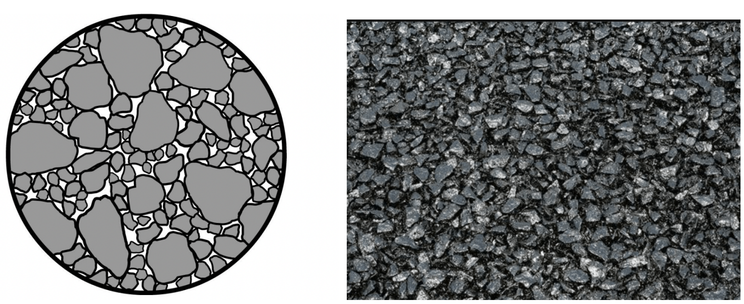


Figure 1. *Aggregates of Asphalt* (2018). From Pavement Initiative

considered. Thus, a smaller or more compact aggregate of asphalt may be used in order to help create a stronger pavement to carry the weight of a bus which can weigh up to approximately

33,000 pounds. (MORR Transportation Consulting Ltd., 2014). This may have a huge impact on how fast the water is absorbed since smaller aggregates may lead to less void space for water to drain through. Nevertheless, we are still aiming to have a fast drainage at a rate of 36,000 millimeters of water an hour (Weller, 2015). Although having an efficient and strong surface of porous concrete is vital, there are a lot more layers that help with the process of the absorption of water.

Choker Layer

Once the initial rainwater travels through the main porous layer, it will immediately traverse through a choker layer, which serves two functions. The first one being that it helps filter the rainwater even more by removing any particles or pollutants that were not removed by the porous layer. As seen in Figure 2, this is facilitated by using bigger aggregates of asphalt allowing there to be less void space or gaps for these unwanted particles to go through. We aim to have these aggregates of asphalt to measure at least six inches in order for the choker layer to efficiently allow only water to go through to the next layer. In addition, this layer is also referred

Figure 2. *Bigger Aggregates of Asphalt for Choker Layer* (2013) From AsphaltPro

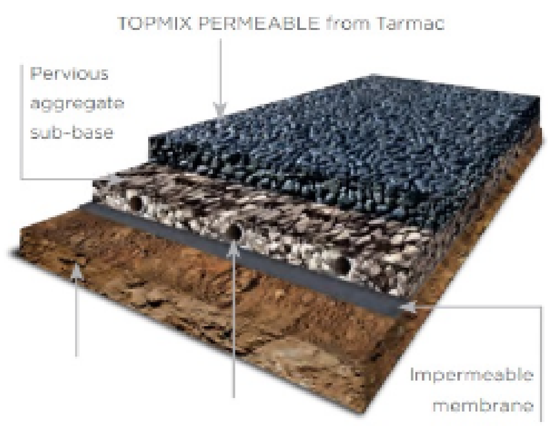
to as a “bedding,” which is a term that refers to the layer underneath the pavement. In other words, the choker layers will be the cushion for the porous layer (which is directly above) in order to prevent it from collapsing or sinking. This will especially be useful when the workforce is evening and flattening out the surface of the pavement. Thus, the choker layer will be very important for the stabilization of the main porous layer.

Sub-Base Reservoir

After the unpolluted water travels through the choker layer, the final destination of that rainfall water needs to be considered. There are typically two main options for where the water can go, which are, being transported into potentially a drainage system or being absorbed into another layer (e.g. soil). This can be done by the sub-base reservoir which is the layer that is directly underneath the choker layer. Its main function is to temporarily store the water that is collected/captured from the rainfall until it can be slowly released into the drainage system or into another layer like soil. The thickness of the reservoir will vary based on the amount of rain that is captured and the rate at which the water will need to be released. Ideally, we would go for a thicker reservoir of around 6 inches in order for water to be captured faster, since it is safer to have bus lanes to be clear of water as soon as possible. In addition, the sub-base reservoir is useful for supporting the other layers that are directly above it, since it is a very thick layer of hard crushed stone. As seen in Figure 3, the layer is mainly composed of bigger pieces of crushed stone that will trap the excess water due to lack of gaos/void space that exist in this layer.

Figure 3. *Crushed Stone for Sub-Base Reservoir* (2020) From Ahmed, Tanveer

Innovations to Porous Asphalt



Topmix permeable layers (2019). From Topmix Permeable - Designing Buildings.

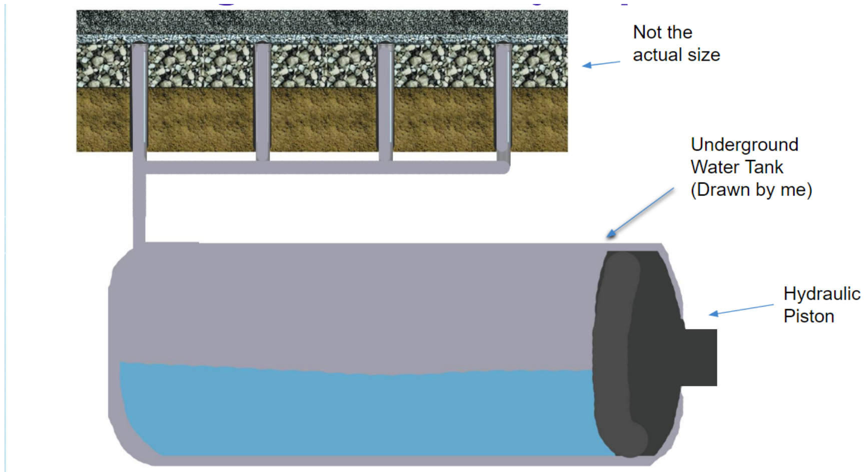
Porous asphalt struggles against heavy loads due to its coarse composition. This prevents it from being fully utilized in busy roads or highways. One innovation planned in order to fix this issue is to make the aggregate base thicker: from 6 inches previously to 12 inches currently. With a thicker support layer beneath the asphalt, heavier loads could be supported, making the material viable for Highways.

Figure 2. *Topmix permeable before and after shot* (2019). From Topmix Permeable - Designing Buildings.

The current applications of porous asphalt under the standard layering are large parking lots and bike lanes as they usually face less pressure compared to that of a highway. During slight to intermediate rainfall, traction along bike routes greatly decreases, causing more accidents. Porous asphalt would easily absorb the water at first contact and help maintain vehicle traction long enough for the bikers to return home safely. Standard layering is also suitable for bus routes such as the Bx11, a path that is prone to delays due to heavy rainfall. Thicker layering is required for highways due to the constant pressure from all the cars and heavy trucks. Each year, "75 percent of weather-related vehicle crashes occur on wet pavement and 47 percent happen during rainfall. Nearly 5,700 people are killed over crashes on wet pavement annually - 3,400 people are killed in crashes during rainfall" (FHWA Road Weather Management, 2023). Having a version of porous asphalt that is suitable for highways is a necessity in order to save more lives. Many modern day vehicles are not equipped with all-wheel drive or all-season tires, making them prone to slip-ups on slippery roads (FHWA Road Weather Management, 2023).

Water Tank

Underneath the porous asphalt roads are a series of steel pipes that lead down to a water tank. These tanks are composed of steel, which provides strength, durability, and corrosion resistance. They are designed to be buried underground, with a cylindrical shape and a capacity of 1000 gallons (or approximately 3785 liters)(NTO Tank, 2023). This specific size was chosen due to the fact that 550 gallons of rainwater can be collected for every 1000 square feet of rain (Drenner, 2013); for every square mile, roughly 27,500 water tanks are needed. The main jobs of the tanks are to allow for better rainwater management. Through an additional network of steel pipes that connect to existing water lines; the water can be pushed out to reservoirs, for water storage; water treatment facilities, for more drinking water; or even back to the surface, to cool down hot roads. These pipes will rest above the water tank, so gravity will prevent them from filling up for the most part. The shape of the tank was chosen to be cylindrical in order to accommodate a piston that will aid in the transportation of floodwater. The very back of the tank is cut out and a seal is placed in the gap between the edges of the tank and the body of the piston. This prevents leakage and contamination; water will be kept within the tank and the pressurized hydraulic fluid, which powers the piston, will be kept out.



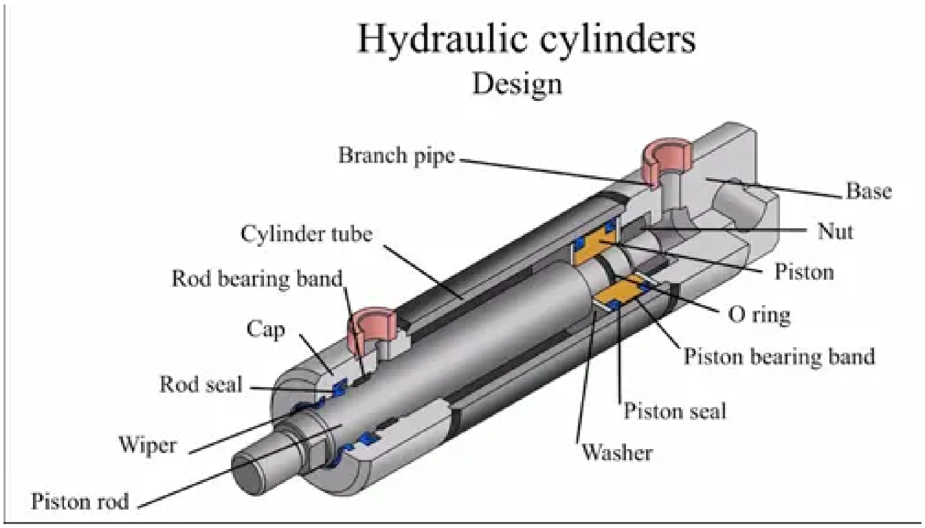
Water tank and piston system. Barrameda Tsangarides, A. (2023). [Diagram].

1000 gallon Norwesco low profile water tank. NTO Tank. Retrieved May 2, 2023, from https://www.ntotank.com/1000gallon-norwesco-1comp-underground-low-profile-septic-tank-x6872503?gclid=Cj0KCQjw6cKiBhD5ARIsAKXUdyZYdHFIddan30u_xXE5g8MRtcU5KMtBh1lX9RQpEDWSmP5RJsItyMYaArIEEALw_wcB

Hydraulic Piston

Hydraulic pistons are mechanical devices that convert hydraulic energy into linear mechanical force and motion. The piston consists of four main components: the cylinder barrel, the piston, the piston rod, and seals/supports. The cylinder barrel is the main exterior of the piston that holds the fluid when deployed and it is made out of cast iron. The piston rod is a long, solid stainless steel pipe that is contained within the cylinder barrel and connects to the piston on the outside. The piston head, itself, is a solid block of cast iron that is cylindrical and spreads across the end of the water tank; this is the part that is in contact with the water and will push it out. Lastly, the seals consist of rubber rings and o-rings; o-rings are thin steel plates that sit between nuts in order to prevent fluid or air from escaping while rubber rings are layers of rubber that sit between both ends of the piston rod and piston head in order to prevent liquids from leaking/mixing.

The piston functions through pressurized hydraulic fluid, which can flow in based on activation: through the flip of a switch, the flip of a lever, or the press of a button. The most popular hydraulic fluids are Petroleum-based oils (also known as mineral oils) and it can reach pressures up to 2500 psi. Hydraulic fluid is pumped in from their own special lines consisting of steel or lead pipes to the main cylinder of the piston. As the fluid enters the piston chamber and builds up, it receives resistance from the piston rod, building up the pressure in the fluid. Once this pressure builds up it releases massive amounts of force on the piston, causing it to move out in one direction (Momentum, 2019). The exact force of the piston can be controlled by an operator, who would manage the exact outflow of the liquids through the pipelines. These pistons are best equipped for this job because “unlike pneumatic cylinders that max out at 250 psi, a top-of-the-line hydraulic pump can produce 4000 psi” (Momentum, 2019).



Piston Diagram. The GrabCAD Community Library. Retrieved May 2, 2023, from

https://grabcad.com/library/hydraulic-piston-14

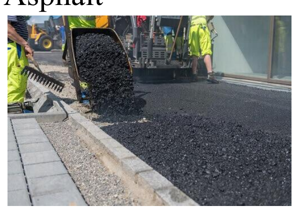
Spec Sheet

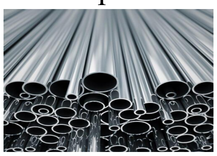
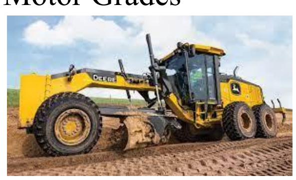
Object	**Dimensions**	**Brief Description of Composition and Function**
Main Porous Layer	4" (Height)	- Aggregates of Asphalt (Two to Four Inches) - Will allow water to drain/pass through upon contact
Choker Layer	2" (Height)	- Bigger aggregates of Asphalt (6+ inches) - Filter any pollutants or small particles - Stabilizes the main porous layer
Sub-Base Reservoir	6-12" (Height)	- Crushed Stone (6+ inches) - Temporarily stores any excess water - Provide support and resistance for the layers above (i.e. main porous layer and choker layer)
Water Tank	127" Length x 60" Width x 51" Height	- 1000 Gallons - Stainless Steel

		- Houses temporary stormwater.
Hydraulic Piston	Piston Head: 12" Length x 60" Width x 51" Height Cylinder Barrel: 109" Length x 30" Width x 25" Height Piston Rod: 100" Length x 12" Width x 12" Height	- Stainless Steel (piston rod) - Cast Iron (Piston Head and Cylinder Barrel) - Pushes water out of the water tank as needed.
Steel Pipes (per)	10" (Diameter) 16" (Length)	- Stainless Steel - Transports water through various sources (i.e. porous asphalt to water tank, water tank to reservoir, water tank to water treatment facility, etc.)

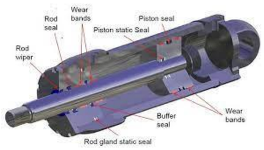
Innovation Process

Materials used

Material	Amount	Cost	Description
Asphalt  “Becky Dunlavey. (2019). *What are the Uses for Asphalt*”	176 tons	$211,200	Petroleum-like material that is made up of binder, filter, and aggregate. Can either have a liquid or granny form.
Steel Tanks	30	$114,000	Holds the water that falls from its connected pipes, and the water at that hydraulic press would

 Highland Equipment Inc *"Stainless Steel Tanks"*			pump back into the surface.
Steel Pipes  Ebay, *"Stainless Steel Round Tube Pipe Many sizes and lengths Metal Bar Rod Strip"*	5,280	$260,832	Transports the water from the choker layer to the steel tank.
Asphalt Compactors  *"Volvo Construction Equipment Global"*(2023)	5	$100,000	Compresses Asphalt until it is flat by its heavy roller, that allows the machine to crush the surface with its weight.
Motor Grades  Ryan Young, (2021, October 13), "*John Deere Motor Graders: Facts, Offerings, & Capabilities"*	5	$50,000	Levels the ground for the addition of other layers, with its forward facing bucket with a blade on the bottom of it.
Road Reclaimers	5	$100,000	Stabilizes the deteriorated roadways, by turning the asphalt layers into

 *Road Reclaimers | Cat | Caterpillar.* (2023)			particles. It does this via a router at the bottom of the machine that crushes the asphalt into pieces.
Cold Planers  *Cold Planers. (2022) "Rise to Meet to Road With Cat Cold Planers"*	5	$85,000	Removes the previous layers of concrete, by its routined drums and cutters at the bottom of the machine.
Roller  *"Caterpillar CB13 Roller at MacAllister CAT"* (2023)	5	$40,000	Provide a stable surface to work on, via its giant roller that flattens the surface. It's similar to the asphalt compactors, but these rollers would only be used for the sub base layers.
Aggregate Stone  *"Round Aggregate Stepping Stone 12". (n.d.). Landscape Shoppe"*	66 tons	$348,480	Made up of Crushed stone, sand, and gravel. This will be used for the aggregate base layer.
Hydraulic Press	30	$15,000	Pumps the water from the water tank into the surface, via its rod wiper pushing the stored water into the

 *"Most Common Seal Used in Hydraulics"*, June 7th, 2021			steel pipes.
Coarse Aggregate  Admin. (2022, August 31). *Coarse Aggregates – the unsung heroes of concrete*.	53 tons	$279,840	Crushed stone from mineral extraction sites, which would be used for the choker layer. This is due to the thickness of the rock being able to filter the water from the asphalt surface, as the polluted particles wouldn't fit through the rocks.

Labor power

Labor Aspect	Description
Exerting lots of power  (2/26/2016 *How to Balance a Physically Demanding Job and Working Out*. (n.d.). Biolayne.	The construction workers would have to shovel the previous layers, carry asphalt materials, and smoothen out layers.

Skilled with hand held tools  *Hand and Power Tool Safety - SafetySkills*. (2018, August 28).	The construction workers would have to work with multiple tools, such as shovels and drills to get to deeper levels.
Driving heavy vehicles  LLC, N. D. (2021, March 23). *Are Construction Workers Entitled to Travel Pay?* Nilges Draher LLC.	Construction workers would also have to drive multiple heavy vehicles that do a variety of things to the terrain. They would also have it park those vehicles correctly for its next use.

Task Schedule

Tasks	Group Member's Names
Summary	Muhammmad Wally
Press Release	Anthony Barrameda Tsangarides
Introduction	Anthony Barrameda Tsangarides
Proposed Program	Kevin Loja, Sahil Musfiq
Innovation Process	Muhammmad Wally

Evaluation Techniques

Work split evenly between all group members. Everyone was responsible for 3 or more pages of their own work as well as helping with the organization of the whole paper. Members discussed every portion of the project through Discord.

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