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Belgian Block Report

Bureau of Planning & Sustainability

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BRANDON SPENCER-HARTLE | CITY PLANNER

LORA LILLARD | SENIOR PLANNER

CASSIE BALLEW | CITY PLANNER

CITY OF PORTLAND

(503) 823-4641

PREPARED BY

PETER MEIJER ARCHITECT, PC

605 NE 21ST AVENUE, SUITE 200

PORTLAND, OR 97232 | (503) 517.0283

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Redeployment of Portland's Belgian Block as road surface is currently broadly determined by two City of Portland policies, historic preservation ordinances monitored by the Portland Historic Landmarks Commission (PHLC) and street surface regulations by Portland Bureau of Transportation (PBOT), that are, at times, in direct conflict with each other regarding best practices.

This report focuses on key components of the two policies including ways to meet the Americans with Disabilities Act (ADA) requirements, means and methods to modify the physical characteristics of the blocks, and linear methods of redeployment meeting historic standards of appropriateness.

Within the Section on Public Right of Way, the technical definitions of flatness and surface tension are discussed in order to better understand concerns of "tripping and slipping" hazards of the block and ways in which ADA requirements could be met. Modifications to the block surface, including physical changes performed in the field, in the yard, or by computer driven stone dressing tools, are also discussed.

The historic ordinances governing the re-deployment of the blocks were written in the mid-1970s. North American case studies and similar regulations from other North American cities are presented as examples to provide ideas on ways to update Portland's existing historic ordinances. Along with the case study examples, applications of surface applied products are presented as alternative means that both meet historic standards and meet anti-slip requirements.

In review of the primary issues raised regarding resistance to redeployment of the Belgian Blocks, the research performed and presented in the Belgian Block Report provide data and ideas by which both the PHLC and PBOT are able to reconsider polices and from which more alignment with similar goals for redeployment may be met.

Based on the research and technical information, it is the opinion of Peter Meijer Architect, PC that:

1. The historic ordinances need to be updated to reflect more deployment options;
2. Design details for deployment are in need of updating and reflect various methodologies:
3. Belgian Blocks can be redeployed as linear elements within the Public Right of Way meeting ADA requirements;
4. Best use of the Blocks within the Right of Way are as vehicular surface material, between rail lines, in plazas combined with smoother pathways;
5. Modification of surface tension and texture are acceptable methods meeting historic standards.

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Background

First introduced to the US in 1850, Belgian Blocks were used as a study paving material in New York. It is the shape of the block, which is narrower at the top than at the base, rather than the material or location that give the block a distinct design and use. Belgian Blocks in the City of Portland are made of basalt, mined at St. Helens, OR, and then at Ridgefield, WA.[1]

Belgian Block

The Belgian Blocks, commonly referred to as cobblestones, were used as a primary paving surface in the City of Portland from the 1885 to 1900's, bridging the gap between mud roads and asphalt pavement. Crosswalks were made of slabs of granite, brought from England or China.[2] When asphalt replaced the blocks as the primary road surface, the asphalt was applied directly over the blocks essentially hiding the blocks from the public domain. During street repair projects, the Belgian Blocks are often rediscovered under the asphalt.

During the 1970's, with renewed interest in saving Portland's historic character, the City of Portland passed ordinances no. 139670 and no. 141548 in 1975 providing guidance for redeployment of Belgian Blocks removed during street repair projects. The ordinances call for both saving and storing the blocks as well as creating a land use process of approval from the Portland Historical Landmarks Commissions for reuse of the blocks.[3,4] At the time of adoption, these ordinances were primarily focused on salvaging characteristics of Portland's original street scape. As a result, the ordinances did not address the practical aspects of re-deployment and could not anticipate the Americans with Disability Act (ADA) requirements mandating accessibility for all citizens.

1 "Portland Oregon, Belgian Block," The Columbian River, A Photographic Journey, September 2016, Accessed May 2021. http://columbiariverimages.com/Regions/Places/portland_belgian_blocks.html

2 "Portland Oregon, Belgian Block," The Columbian River, A Photographic Journey, September 2016, Accessed May 2021. http://columbiariverimages.com/Regions/Places/portland_belgian_blocks.html

3 City of Portland Ordinance no. 139670, Section 17.56 Code of the City of Portland, City Auditor of Portland, OR. March 27th 1975, Accessed May 2021.

4 City of Portland Ordinance no. 141548, Section 17.56.100 Code of the City of Portland, City Auditor of Portland, OR. April 7th 1976, Accessed May 2021.

Stone Petrography

Background information on stone petrography is necessary to understand durability, chemical composition, and other factors affecting use of stone in the built environment. The pacific northwest region has three distinct basalt regions, the Oregon Coastal region, the Cascadia Region, and the Columbia Plateau Region. [5] The two quarries that the Belgian Blocks of Portland originate from are the St. Helens and Ridgefield quarries, located in the Columbia Plateau Region.

Three distinct stratigraphic bedrock subcategories (Yakima, Late Yakima, and Pomona) have been identified, each with a unique characteristic that led to three different flow types of basalts, varying in age and distance from the Columbia Plateau.[6] Based on information collected from the National Register listing for the quarry in Ridgefield, the basalt in this quarry is from the Columbia River Gorge Basalt flow of the Yakima subcategories.[7] Of the flows within the Columbia River Gorge, the Grande Ronde is the largest flow and comprises of 72% of basalts within the Columbia River Gorge.[8]

Yakima-type basalts are high in SiO2 (silcon dioxide or sand) and are Miocene Tholeiitic basalts. The Miocene period ranges from 23.03 million to 5.3 million years ago and Tholeiitic basalts are richer in silica and iron, with a lower concentration of aluminum compared to other basalts. Specifically in northwestern Oregon and southwestern Washington, the Columbia Plateau basalts are high in MgO (magnesium oxide) and CO (calcium oxide).[9]

In 1931, Harold Fisk produced a history and petrography of Oregon basalts, providing microscopic imaging of different basalts. The work that Fisk did resulted in a comprehensive

Ridgefield Quarry, 2011

analysis and categorization of basalt types in Oregon, meaning that comparable basalt types and the locations in Oregon can easily be found and used. [10]

An US Geological survey from 1976 compared the Columbia Plateau basalt flows to the Oregon and Washington coastal basalt flows, giving specific chemical composition of the samples taken.[11]

To further identify the Belgian Block's thru petrographic differences, a report from 1983 tests the characteristics of two different types of stone blocks at Lewis and Clark college. The types are referred to as "Neolite" and "Leathered, " the latter a common name that may have been derived by the supplier of the stone at the time of installation. A description of neolite basalt comes from an article titled A Natural Order of Volcanic Succession by Kenneth Aalto. Neolite refers to the presence of magnesium (Mg) and aluminum (Al), creating flecks of green that is visible to the eye.[12]

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5 Stephen P. Reidel and Terry L. Tolan, "The Grande Ronde Basalt, Columbia River Basalt Group," Special Paper 497, The Geological Society of America, 2013.

6 Parke D. Snavely Jr., Norman S Macleod, and Holly C. Wagner, "Miocene Tholeiitic Basalts of Coastal Oregon and Washington and Their Relations to Coeval Basalts of the Columbia Plateau," Geological Society of America Bulletin US Geological Survey, Menlo Park, CA. v.84, February 1973.

7 Susan M. Saul, National Register of Historic Places Nomination: Basalt Cobblestone Quarries District, Clark County, Washington; Ridgefield, WA: Lower Columbia River National Wildlife Refuge Complex, 1981.

8 Stephen P. Reidel, Victor E, Camp, Terry L. Tolan and Barton S. Martin, "The Columbia River Flood Basalt Province: Stratigraphy, Areal Extent, Volume, and Physical Volcanology," Special Paoer 497, The Geological Society of America, 2013.

9 Parke D. Snavely Jr., Norman S Macleod, and Holly C. Wagner, "Miocene Tholeiitic Basalts of Coastal Oregon and Washington and Their Relations to Coeval Basalts of the Columbia Plateau," Geological Society of America Bulletin. US Geological Survey, Menlo Park, CA. v.84, February 1973.

10 Harold Fisk, "The History and Petrography of the Basalts of Oregon," Masters of Art and Science Diss. (1931), University of Oregon, Eugene, OR. University of Oregon Library, 461. F57.

11 Allan B. Griggs, and Donald A. Swanson, The Columbia River Basalt Group in the Spokane Quadrangle Washington, Idaho, and Montana, with a Section on Petrography, Geological Survey Bulletin 1413, US Geological Survey (1976).

12 Kenneth Aalto and David Oldroyd, "A Natural Order of Volcanic Succession," Earth Sciences History 27, no. 1 (2008): 59-77.

This is similar to Pomona Basalt, noted for its youth in the basalt family and high content of MgO (magnesium oxide) and CaO (calcium oxide). The article Miocene Tholeiitic Basalts of Coastal Oregon and Washington and Their Relations to Coeval Basalts of the Columbia Plateau highlights the connection of "Neolite" Basalt to Pack Sack Basalt, a subcategory of basalt in the Pomona Basalt flow.

Petrography of the Belgian Blocks dictates absorption rates, durability and compressive strength. In Report on Belgian Blocks (1983) by Steven E Thomsen, the absorption rate of Belgian Blocks is 0.4% and the compressive strength for a block at is 4 ½" thick is 10,000 psi. Both of these values are considered very good.[13,14,15]

13 Steve E. Thomsen, Report on Belgian Block Pavement, City of Portland, Bureau of Street and Structural Engineering, April 1983.

14 Water absorption is a measure of the porosity of a stone and can be an indicator of its susceptibility to damage during freezing. A stone that has greater water absorption will also tend to absorb liquid stains more readily. In general, the lowest water absorption is desired. The absorption is expressed as the percent weight change due to absorbed water. The maximum allowable water absorption for each type of stone is prescribed in the standard specifications for that specific stone. The required values range from 0.20% for marble to 12% for low-density limestone.

15 Compressive strength is a measure of the resistance to crushing loads. If one were to build a stone wall, for example, the stone at the bottom would have to withstand the compressive load of the weight of the stones above. A horizontal stone surface must be able to bear the crushing loads of people, traffic, and other objects. The compressive strength is the maximum load per unit area that the stone can bear without crushing. A higher compressive strength indicates that the stone can withstand a higher crushing load. The required values range from 1,800 psi (12.45 MPa) for marble to 19,000 psi (131 MPa) for granite.

Public Right-of-Way Deployment

Re-deployment of Belgian Blocks within the public right-of-way must meet modern building and land use codes like ADA and historic review. As a part of any re-deployment of Belgian blocks in public spaces, understanding how the blocks meet, or could be modified to meet, current accessibility codes are critical. Specifically related to the use as walking and biking surfaces, two primary concerns arise: tripping and slipping.

It is possible through manipulation of the stone surface, use of setting means and methods, and testing to modify the Belgian Blocks to allow for reuse as horizontal surfaces.

Tripping

To avoid tripping, a level surface (defined as having less than ½ inch in surface variation) is required. [16] Achieving a level surface depends on the block surface texture, the sub-base setting of the blocks, the mortar used between the blocks, the joint between units, and the impact of surface movement over time.

Sub-base Setting

Based on the 1983 publication, Report on Belgian Block Paving, City of Portland by Steven E. Thomsen, the Lewis and Clark College Belgian Block pavements had a concrete sub base of 3 ½" and maintained a more level surface than sand set blocks. The pavement had been laid 7 years prior in 1976, and the surface showed only ¼ inch deflection in grade over a four (4) foot length. [17] The report also noted that the surface variation of the stone did not exceed 1/8", meeting Americans with Disabilities Act (ADA) requirements. Both results pass the 2010 ADA guidance of not exceeding ¼" level change.[18]

The 1983 report consulted with a local mason who suggested a Laticrete leveling agent to create a stronger mortar base for the blocks and insure the level of the pavement for a longer period of time. [19]

Lewis and Clark College parking circle

Mortar Joints

The transition from one unit to another can become a tripping hazard, so the ADA sets a guideline of ½" wide mortar joints.[20] The width of any mortar joint will affect total surface area and quantities of materials. The mortar can be made level with the surface of the blocks, creating a continuous smooth, level surface and eliminating a trip hazard.

Block Sizing

In general, a rough inventory of average block face dimensions and overall sizes resulted in an average variation of +/- ½" per face dimension. The variation in sizes results in overall lengths of up to 1" between blocks, with blocks as small as 4" high and as tall as 5".[21] This 1" difference is critical when trying to create a level surface. The difference in block sizes requires specific means and methods to accommodate the changes to achieve ADA compliance. [22]

16 Americans With Disabilities Act of 1990, Public Law 101-336, 108th Congress, 2nd session, July 26, 1990.
17 Steve E. Thomsen, Report on Belgian Block Pavement, City of Portland, Bureau of Street and Structural Engineering, April 1983.
18 Americans With Disabilities Act of 1990, Public Law 101-336, 108th Congress, 2nd session, July 26, 1990.
19 Steve E. Thomsen, Report on Belgian Block Pavement, City of Portland, Bureau of Street and Structural Engineering, April 1983.
20 Americans With Disabilities Act of 1990, Public Law 101-336, 108th Congress, 2nd session, July 26, 1990.
21 Steve E. Thomsen, Report on Belgian Block Pavement, City of Portland, Bureau of Street and Structural Engineering, April 1983.
22 ADA defines level as a maximum of ¼" change in height. A ½" change is allowed if the edge is beveled at a 45O angle

Slipping

Slippery exterior horizontal walking surfaces are a safety hazard; thus, some measure of slip resistance is needed to evaluate suitable material. Traditionally in the stone industry, slip resistance was evaluated by measuring the static coefficient of friction (the force required to initiate slipping divided by the normal force) per the ASTM C1028 method. This test method was withdrawn in 2014 and no replacement method was offered.

Coefficient of Friction

A method in use today for slip resistance is the Coefficient of Friction test. The coefficient of friction is determined by finding the ratio between the forces necessary to move one surface horizontally over another and the pressure between the two surfaces. The coefficient of friction (frictional force over normal force, represented as µ) is a standard used by ADA guidelines. On a level surface, a coefficient of 0.6 µ necessary. On a ramp (1:12), a coefficient of 0.8 µ is necessary.[23]

In *Report on Belgian Block Paving, City of Portland* by Steven E. Thomsen, Neolite stones had a dry coefficient of 0.6 µ and a wet coefficient of 0.56 µ. Neolite stones could meet ADA standards in a level dry environment, but not during rainy weather. Leathered stones have a dry coefficient of 0.47 µ and a wet coefficient of 0.77 µ.[24] The slip resistance between these two types of stones when there are no visual differences between the stone is an indication of the importance of requiring tested coefficients under all deployment scenarios.

More details about mediating slipping are explained in Section 4 with coatings and sealers of the stones helping increase the coefficient of friction without affecting the appearance.

23 *Americans With Disabilities Act of 1990, Public Law 101-336, 108th Congress, 2nd session, July 26, 1990.*
24 *Steve E. Thomsen, Report on Belgian Block Pavement, City of Portland, Bureau of Street and Structural Engineering, April 1983.*

Block Modification

Modifying the physical characteristics of the blocks to meet tripping and slipping standards for re-deployment is possible. Many modification techniques exist for both shop and field modifications. This report focuses on two: cutting and dressing surfaces.

Cutting

Cutting is used to help blocks fit into spaces that are not necessarily regular and to modify exposed surfaces. To increase the quantity of Belgian blocks, block units can be cut and either the smooth surface or the natural surface can be used as the exposed surface. This could double the square footage of Belgian block pavement area as well as provide continuity of material for both rough and smooth surfaces. It is recommended that both cut surface and original surface be tested for coefficient of friction. The primary methods of cutting include hand and machine cutting.

Machine Cutting

Traditional machine cutting is achieved with a diamond tip carbide saw blade and a jet of water. The result is a very measured and precise cut, leaving a smooth surface and employing a process that can be repeated easily. Traditional machine cutting can be accomplished both in a controlled shop environment or in the field. The cut plane reflects the type of blade used to make the cut, but overall, the result is smoother than the original surface. One concern with cutting stone is that a smooth surface decrease surface area which may cause lower bond strength between the stone and mortar and decrease coefficient of friction. Once cut to size, the surface of the stone can be roughened to regain surface area.

Typically, saws can be accessed on sites, allowing workers more freedom in solving design details with custom pieces. The following saws are used to cut stone:

Wire saws spins a wire between two wheels very quickly while a stream of water is poured over the block. The wire is lowered and slices the block. This leaves a very smooth surface after it has been cut. This process can be done quickly but requires special training.

Saw Cutting Belgian Block

Hydraulic Stone Splitter

Hydraulic stone splitters can be used on-site. It splits the block by pinching it between two blades that slowly press into the top and bottom surface of the stone. This snaps the stone in a controlled manner, leaving a natural texture on both pieces. This tool can be rented and requires minimal training.

Thin veneer saws use a diamond blade and extreme amounts of water to cut thin strips of stone on a conveyor belt. The depth of each cut is highly controlled and can be repeated on the same block multiple times. A veneer slice that is 1” thick can be repeated on a block that is 4” thick at least 3 times. This is considering that each cut might have a little variation. Such a process could drastically increase the surface area of the Belgian block inventory very quickly.

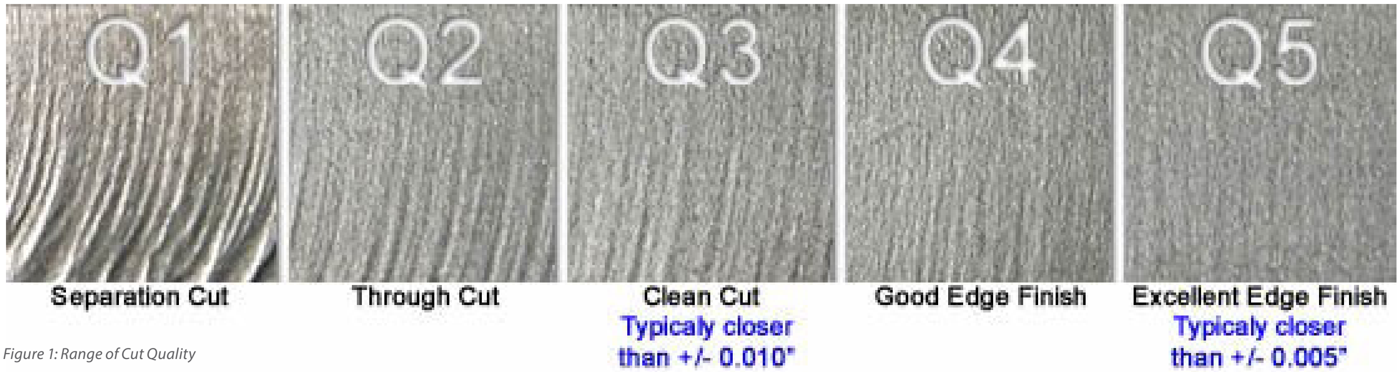


Figure 1: Range of Cut Quality

Advancements in technology have created new methods of cutting stone including robotic laser and water jet techniques and robotic milling of natural stone. These methods are shop only techniques but create great efficiency for large quantities of stone. Blocks can be both cut to size and milled in a single process. Robotic methods are economically viable with large quantity projects.

The water jet, or otherwise known as the Wet Jet, is an industrial machine that uses a high-pressured stream of water to cut a range of metals, stones or glass. The system is highly controlled and uses a computer system to guide a vector through the material. The depth of the cut and how wide the cut is made are controlled by the pressure and size of the nozzle. This means that a through cuts, rough cuts and etching is possible with this machine, creating a potential for artistic uses for Belgian blocks. Figure 1 is representative of the quality of cuts that can be achieved with a wet jet. By using an additive mixed in with the water, a rougher, more natural cut can be made. This would be desirable for maintaining a higher coefficient of friction.

The water jet is hands free, detailed and can work with small pieces of stone, making it a useful tool for block modification. There are 7 companies within 20 miles of Portland that have wet jets, meaning that the operation can remain local, supplying a local business with a contract that would help local projects. Special consideration should be made, however, for on-site problem solving as a water jet must remain in an industrial warehouse setting.

Hand Cutting

Accomplished with a hand tracer (a pointed chisel used by masons) and a hammer to cut the block providing a surface texture similar to the original appearance prior to cutting.[25]

The process takes more skill and requires more understanding of the material and how it naturally breaks. Hand cutting is best implemented in small quantity and for select areas of a project.

Using a hand tracer to cut block

25 *Fabiano Cruz, "How to Cut Belgian Block," Fine Homebuilding, 282 April/May 2019, Accessed May 2021, https://www.finehomebuilding.com/2019/02/27/cut-belgian-block*

Section 4: Block Modification

Cutting Process	Method	Tools Needed	Surface Quality Control	Results
Dry Process				
	Hand Cutting	Hand Tracer, Hammer	Mid control	Hand chiseled look, more natural breakage
	Hydraulic Stone Splitters	Hydraulic Stone Splitters	Low Control	Like a stone snapped in half, very rough, natural surface
Wet Process				
	Wet Jet	Wet Jet CNC	High Control	Varying levels of roughness from "texture" to "smooth"
	Chop Saw Tile Cutter	Diamond blade, constant water flow	High Control	Consistant smooth surface cut
	Wire Saws	Wire saw machine	High Control	Linear grooves parallel to motion of blade, otherwise smooth depending on quality of blade.
	Veneer Saw	Diamond Blade, conveyor belt	High control	Consistant smooth surface cut

Table 1: Tool Table and Process

Redressing

Redressing stone is the act of scoring, grooving, or detailing the stone surface. Redressing maintains a level surface while increasing the coefficient of friction without creating deep tripping surfaces. Redressing roughens the surface of the stone, adding a uniform texture for visual impairment detection or increasing slip resistance. Redressing is approved in Philadelphia and helps with the deployment of cobblestones for reuse.[26]

Knapping, pecking and grinding are other ways that can modify the surface of the stone. These vary in levels of skills and time but can be used to carve the surface of a stone. The act of carving would be more of an aesthetic treatment of the stone, rather than a treatment to prevent slipping or tripping.

Coatings and Sealers

Applications of coatings and sealers are methods for increasing the coefficient of friction. With rapid advancement in the coating industry, new products are increasingly available. Although product literature is available to assist with selection, only field application followed by friction testing using mock-ups will allow for the selection of the most appropriate product. In general, coatings and sealers fall under two broad categories: opaque and clear.

Opaque Coating

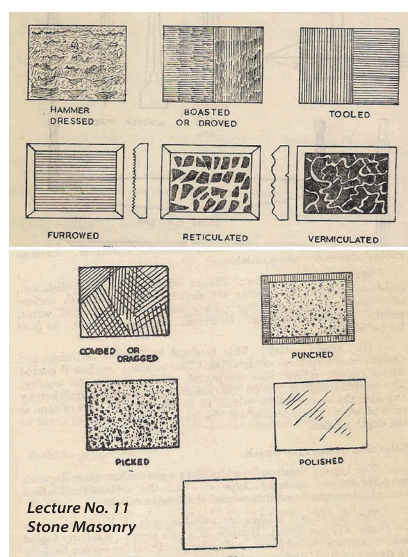
Opaque coatings and sealers are applied directly to the blocks after they have been set. A clean surface is necessary for the coating to completely bond to the block. Drying time for coatings and sealers vary and reapplication also depends on the type of coating, environmental exposure, and surface wearing. Anti-skid additives can be added to either applicant, helping to increase the coefficient of friction.

Absorption characteristics also affect a coating useful life. A low rate of absorption will limit the depth of penetration of the coating and thus result in a thinner application subject to a shorter life expectancy prior to recoating.

Road coatings have high durability and higher texture for slip resistance. Hot tape, applied to asphalt for cross walks, is easy to apply and is designed for high traffic areas. It has an excellent resistance to slipping and long durability.[27]

This coating would be ideal for linear applications rather than whole surfaces. An example of its use would be between traffic as a solid line or on the edge of steps to mediate slipping.

Acetone road coating is for larger surface areas, with more freedom in color, texture and reflection. Additives can be added to create an anti-skid texture.[28] As the coating is a non-heated coating, it can be applied after the paved surface has been set. This coating might need to be reapplied as it will eventually peel. Both hot tape and acetone road coatings coat the natural stone.



Lecture No. 11 Stone Masonry

26 *Philadelphia Complete Street Design Handbook, City of Philadelphia, PA, 2017, Accessed May 2021.*
27 *Tape 101: A Comprehensive Guide to Adhesive Tape Properties and Selection, Budnick Converting, St. Louis, MO.*
28 *"Road Paints for Every Condition," Zimmerman Paint Contractors CO., Accessed May 2021, http://zimmermanpaint.com/html/types-of-road-paints.html*

Clear Coating

Surface applied sealers are the most known clear coating product. Two types of sealers are most common: silane-siloxane and acrylic based. Both types can be mixed with an anti-skid additive that can provide more texture. The silane-siloxane based sealer does not affect the color or appearance of the block. It acts as a densifier and penetrates into the stone. This makes the sealer last longer and need fewer reapplications. Given low absorption rates of Belgian Block, sealers that rely on penetration will need to be tested (cut the block after application and measure the depth of penetration) to determine the long term effectiveness of the application.

Acrylic based sealer is similar to a traditional paint coating in that the sealer imparts a gloss (low, high or "wet look") and needs to be reapplied more often since it does not get absorbed into the stone. Any product that remains on the surface of a stone does not alter the stone as permanently as products that are absorbed into the capillaries of the stone.[29]

Applications & Locations

Belgian blocks have a unique texture and historical context that beautifies the built environment but can also be a visual reference indicting a space that is shared by vehicles, pedestrians and cyclists. The change in visual texture is a safety precaution that helps the user remain aware of their surroundings. In linear applications, the blocks can separate the pedestrians from vehicle use, communicating where it is safe to walk.

This practice is implemented in Ottawa, Canada and on Portland's SE Gideon St. The separation of pedestrian and vehicle lanes increases safety through clear visual and textural communication.

Tactile and textural differences also convey clear pedestrian desired route by being explicitly more difficult to navigate. In Nantucket, MA, a combination of brick, granite blocks and cobblestone form their historic streets.

A clear, primary path across the road is provided to meet ADA standards while the granite serves a visual indicator of a difference between materials. It is also used by visual, mobile, other impaired individuals as a textural indicator, guaranteeing a safe mixed-use environment that can be accessed by everyone.

29 Dale Keese, "Best Paver Sealer (2021): Review & Comparison," Seal with Ease, May 2021, Accessed May 2021, https://sealwithease.com/best-paver-sealer/#our-reviews-of-paver-sealers

Case Studies

Figure 2. Acorn Street., Boston, MA.

Locations with similar climate and demands on their public spaces were considered and how they maintain and deploy their resources were taken into consideration for this report.

Examples of local deployment include Portland's SE Gideon St for the Tri Met connection between Portland and Milwaukie, Lewis and Clark College roads, and in between rails on SW Morrison. The application of Belgian Blocks in a linear, transportation focus has been applied to case studies in this report.

Boston, MA

The City of Boston has a long tradition of maintaining historic fabric throughout their urban built environment and has a similar wet environment as Portland. One of the most robust aspects of Boston's preservation tactics is their maintenance plan for old streets like Acorn Street and Moon Street.

Acorn Street (figure 1) is one of the oldest cobblestone streets in Boston. Acorn is difficult to walk on and has a steep slope. The street is located within a high tourist area of Boston and is subject to a lot of foot traffic. Considered "the most photographed street in America", the City of Boston focused on accessibility and maintenance[30] The sidewalks of Acorn Street are brick but lined with granite block curbs. This is similar to Nantucket's method of textural transition between clearly pedestrian and accessible, and a space that is more commonly dominated by vehicles.

The Boston Complete Street Design Guidelines, a guide with an emphasis on sustainability and historic preservation offered a few key takeaways. Pedestrian conditions should use pavers "so long that it is feasible to achieve and maintain all accessibility requirements" by using as large of pavers as possible. Fewer joints mean an easier maintenance job and fewer tripping hazards. Utilities, trees and man-holes, should be located outside of paved areas. This also decreases the amount of maintenance due to tree roots disrupting the block sub base and damage due to regular city maintenance around utilities.[31]

The guide states that pavers should not be used for crosswalks, and that a "A clear accessible path should be provided across intersections". This, however, can be overturned with approval from the Historic Districts Commission and Public Improvement Commission.[32]

A porous joint between the blocks is suggested, more for sustainability factors rather than maintaining a smooth, level surface. The combination of reusing a resource and using a permeable material and sub base has desirable sustainability implications and is therefore viewed as a priority despite possible increase in maintenance. An annual inspection of all paved conditions is incorporated into the City of Boston maintenance plan.[33]

Starting in 1991, Boston's Department of Public Works (DPW) implemented a 24-year plan to apply ADA standards to all streets and sidewalks in Boston. Areas that were not ADA compliant had concrete replace the paved surface. By 2014, the DPW contacted The Beacon Hill Architectural Commission (BHAC) with plans for replacing historic sidewalks with ADA surfaces. The BHAC voted to reject DPW's plans for accessible sidewalks in a historic district, siting the lack of material consideration and noted that there were alternatives that were ADA compliant but were not being used by DPW. The BHAC did approve a different project that involved replacing a brick sidewalk with "new, wire cut brick that have been found to provide a smoother surface for persons in wheelchairs."[34]

30 Megan Barber, "America's 11 Most Beautiful Streets," Curbed, November 2016, Accessed May 2021, https://archive.curbed.com/2016/11/8/13559970/united-states-beautiful-streets.
31 Boston Complete Streets, Design Guidelines, City of Boston, Department of Transportation, May 2013.
32 City of Boston Ordinance no. 14339, Section 14 Code of the City of Boston, Commissioner of the Department of Public Works, Boston, MA. 1975, Accessed May 2021.
33 Boston Complete Streets, Design Guidelines, City of Boston, Department of Transportation, May 2013.
34 "BHAC Rejects DPW Plan for ADA Accessible Ramps". Beacon Hill Times. Boston, MA. December 31, 2013. Accessed May, 2021. http://beaconhilltimes.com/2013/12/31/bhac-rejects-dpw-plan-for-ada-accessible-ramps/

Ordinance no. 14, 339 (1975, Boston) directs the construction standards of sidewalks composed of "granite or other stone" to the Commissioner of Public Works.[35] Details provided by the DPW set a standard for "Permeable Pavers" and specify its use in a linear application between sidewalks and the curb of the road. Within the Municipal Code of the City of Boston, there are no other mention of sidewalk or materiality of sidewalks.

Nantucket Island, MA

Nantucket case study represents an example of a technical setting method vs. an ADA compliant study.

Nantucket's average rain fall is similar to Portland, OR. Cobblestones in Nantucket reflect the development of the town and are essential to its "historic character". In Preserving Historic Pavement on Nantucket, guidelines describe "how to identify, maintain, and rehabilitate the Island's unusual and increasingly rare historic pavement". It further relates mediating contemporary challenges such as transportation, accessibility, maintenance and sustainability goals.[36]

Community interests have pushed for cobblestones to be set in sand to allow rain to permeate the soil. Concern for flooding stems from the low elevation of the street (Winter Street & Pleasant Street) and the large amount of rain seen in Nantucket. A detail was provided by Preservation Engineering Study on Historic Cobblestone Street Paving by Simpson Gumpertz & Heger Inc. (figure 3).[37]

The size of the joint makes this surface inaccessible, but it relates to the Belgian Blocks in the City of Portland through the setting depth. Simpson Gumpertz & Heger engineers determined that a cobblestone set deeper into a sub base, whether it was concrete or sand, will maintain a level surface better. This detail recommends 6" minimum.[38]

Figure 3. Nantucket pedestrian cross walk with brick on a cobblestone road. Analysis of photo: Pedestrians have the ability to walk anywhere but for accessible paving, a curb and granite boarder is used to distinguish access visually and texturally.

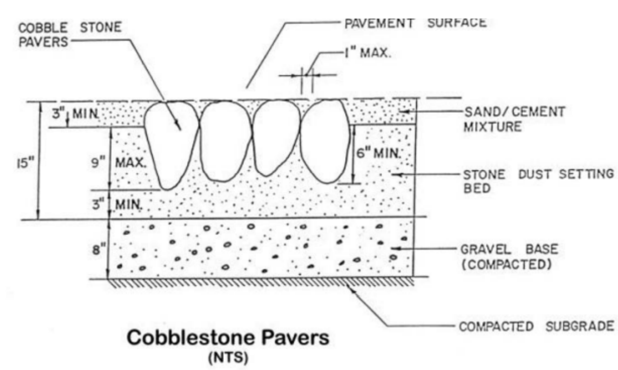


Figure 4. Detail of suggested Cobblestone Pavers in Nantucket, MA.

35 *City of Boston Ordinance no. 14339, Section 14 Code of the City of Boston, Commissioner of the Department of Public Works, Boston, MA. 1975, Accessed May 2021.*
36 *Preserving Historic Pavement on Nantucket Guidelines, The Nantucket Historical Commission, Nantucket, MA (2021).*
37 *Preservation Engineering Study on Historic Cobblestone Street Paving Report, Simpson Gumpertz & Heger Inc. Waltham, MA, September 2020, Accessed May 2021.*
38 *Preservation Engineering Study on Historic Cobblestone Street Paving Report, Simpson Gumpertz & Heger Inc. Waltham, MA, September 2020, Accessed May 2021.*

Section 5: Case Studies

Pittsburgh, PA

In 2017, the City of Pittsburgh created the Department of Mobility and Infrastructure (DOMI) to integrate accessibility and condition management of public resources such as roads, sidewalks and public transportation. There is a focus on repaving streets and repairing concrete sidewalks rather than maintaining previous materials that aren't asphalt or concrete.[39] The main argument is for accessibility purposes but there is no integration to historic materials and ADA compliant surfaces.

Ordinance no. 417.06 (Pittsburgh, PA) refers all power of repairing historic pavement to the DOMI. If 75% of the surrounding area signs a petition in support of repairing a historic surface, the DOMI still can override the petition over concerns of "feasibility and safety."[40]


Historic photo, Pittsburgh


Pittsburgh resetting Belgian Blocks

Philadelphia, PA

The Philadelphia Complete Street Design Handbook of 2017 is a holistic document guiding city and state governments on Executive Order no. 5-09, the establishment of a Complete Street Order (2009).[41] Full consideration for "the safety and convenience of all users of the transportation system, be they pedestrians, bicyclists, public transit users, or motor vehicle drivers" and the "Prioriti[zation of] the safety of those traveling in the public right of way, and in particular the safety of children, the elderly, and persons with disabilities."[42]

In relation to stone blocks, which can be granite blocks, curbs or Belgian blocks in Philadelphia, they are actively reused in decorative purposes and in areas of high pedestrian use. Ordinance 3.1.3.5.3 in the Regulation of the Department of Streets, calls for the "redressing or reheading" the resource to meet a coefficient of friction that satisfies ADA specifications.[43] There is an emphasis on avoiding "materials that are slippery, create tripping hazards, or are difficult for individuals with disabilities to traverse."

Concern over visibility at night time allows the modification of the material with Dura-Therm thermoplastics, with other materials being considered. This thermoplastic paint is slip resistant and is suggested for surfaces that are non-retroreflective.[44]

San Francisco, CA

Ordinance 201,954 (2019) calls for "no granite, cobblestone or brick gutter shall be restored within a pedestrian accessible route (PAR)." This is revision of ordinance no. 178,806. The 201,954 ordinance intends "to establish procedures for salvage and restoration of granite curb, cobblestones, and/or brick of existing curb and gutter."[45] This was a follow-up ordinance to no. 200,369 (2018) which expanded the list of city standard paving materials to include more pavers and reused materials.[46] This ordinance applies to areas throughout the city of San Francisco regardless of historical significance or relation to a historic district.

There is a clear distinction within the City of San Francisco code about major pedestrian accessible route (PAR) and minor PAR. "Large scale pavers must be used for the [major] sidewalk" and smaller pavers can be used for minor PAR. Large pavers are classified as larger than the following dimensions: 6"x36", 12"x18", 12"x36".[47]

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39 "About the Department of Mobility and Infrastructure," Department of Mobility and Infrastructure, Accessed May 2021, https://pittsburghpa.gov/domi/domi-about#:~:text=The%20Department%20of%20Mobility%20and%20Infrastructure%20was%20established,the%20newest%20department%20of%20the%20City%20of%20Pittsburgh.

40 City of Pittsburgh Ordinance no. 417.06, Section 417 Code of the City of Pittsburgh, Department of Mobility and Infrastructure, Pittsburgh, PA ,2018, Accessed May 2021.

41 Philadelphia Complete Street Design Handbook, City of Philadelphia, PA, 2017, Accessed May 2021.

42 Philadelphia Complete Street Design Handbook, City of Philadelphia, PA, 2017, Accessed May 2021.

43 Regulations of the Department of Streets, the City of Philadelphia, PA, 3.1.3.1.5, Accessed May 2021.

44 Philadelphia Complete Street Design Handbook, City of Philadelphia, PA, 2017, Accessed May 2021.

45 City of San Francisco Ordinance no. 201954. Public Ordinance of the City of San Francisco. Department of Public Works, San Francisco, CA. 2019. Accessed May 2021.

46 City of San Francisco Ordinance no. 200369, Public Ordinance of the City of San Francisco, Department of Public Works, San Francisco, CA. 2018, Accessed May 2021.

47 City of San Francisco Ordinance no. 201954. Public Ordinance of the City of San Francisco. Department of Public Works, San Francisco, CA. 2019. Accessed May 2021.

Montreal, Canada

Canada, although working with different accessibility standards to the US (Accessible Canada Act (ACA) as oppose to ADA), the techniques used to reuse stone block resources are similar. The Place D'Youville, located in close to historic downtown Montreal, uses a range of paved surfaces to express the overlapping transportation needs of the space. It is an intersection of vehicles, pedestrians and cyclists that looks like a square but focuses on linear movement. The linear deployment of materials helps the intersection be bike friendly, pedestrian friendly, while providing a safety component. Cars slow down due to the visual indicators.[48]

Figure 5. Aerial of Place D'Youville.

Figure 6. Blocks are one of the materials that were used in this project.

Toronto, Canada

The Distillery District was founded in 1832 in Toronto, Canada. It became the subject of a revitalization project in 2003. The roads that connect the blocks provide a good example of deployment.[49]

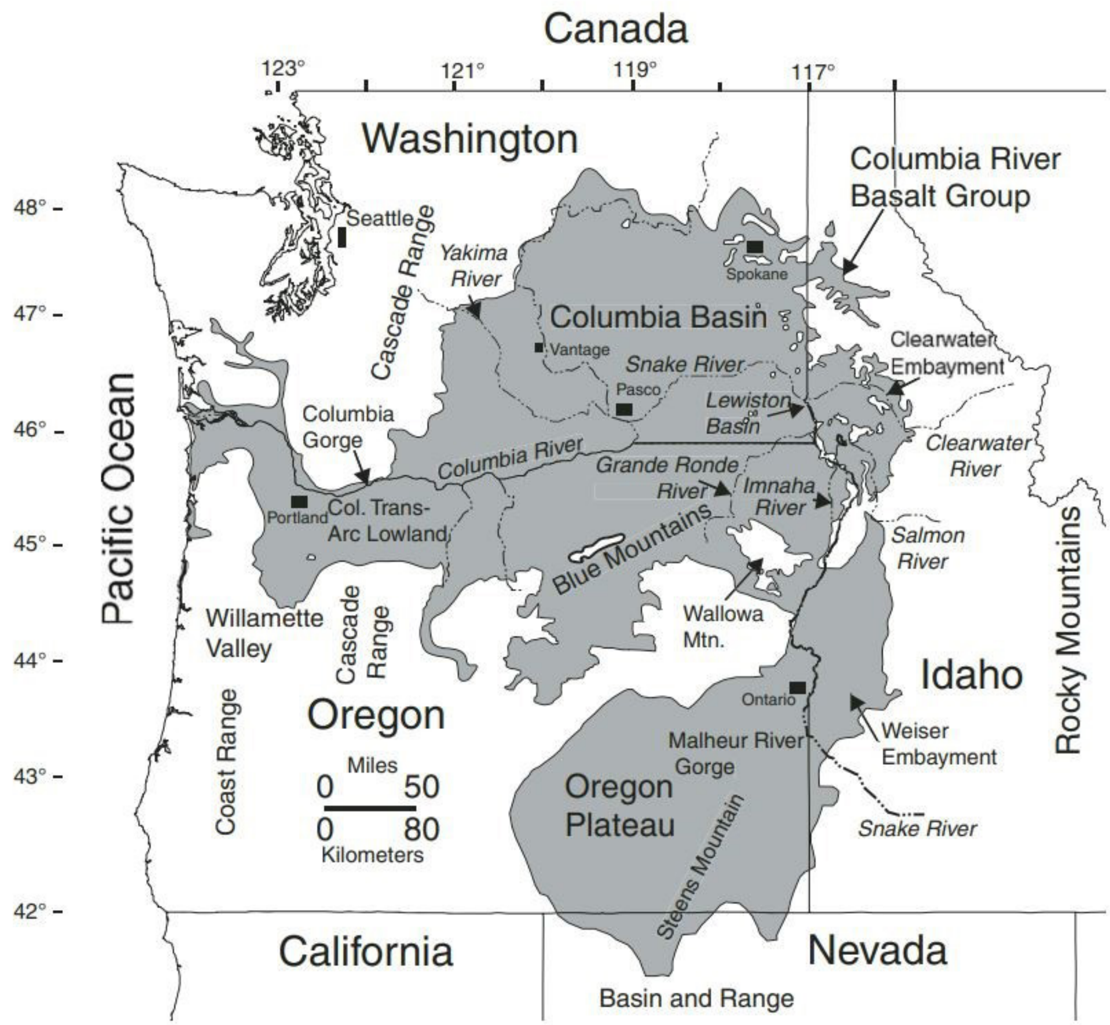
Historic bricks that were original to the site were reset in the district. It is a predominately pedestrian space, with restaurants spilling out into the road (figure 6) and events taking place in the open roads. It can be used for cars, mostly delivery trucks. The brick roads are lined with concrete sidewalks that provide alternative walking surfaces as seen in figure 8.

Figure 7. Blocks are one of the materials that were used in this project.

Figure 8. The brick road is used as a pedestrian space in the Distillery District

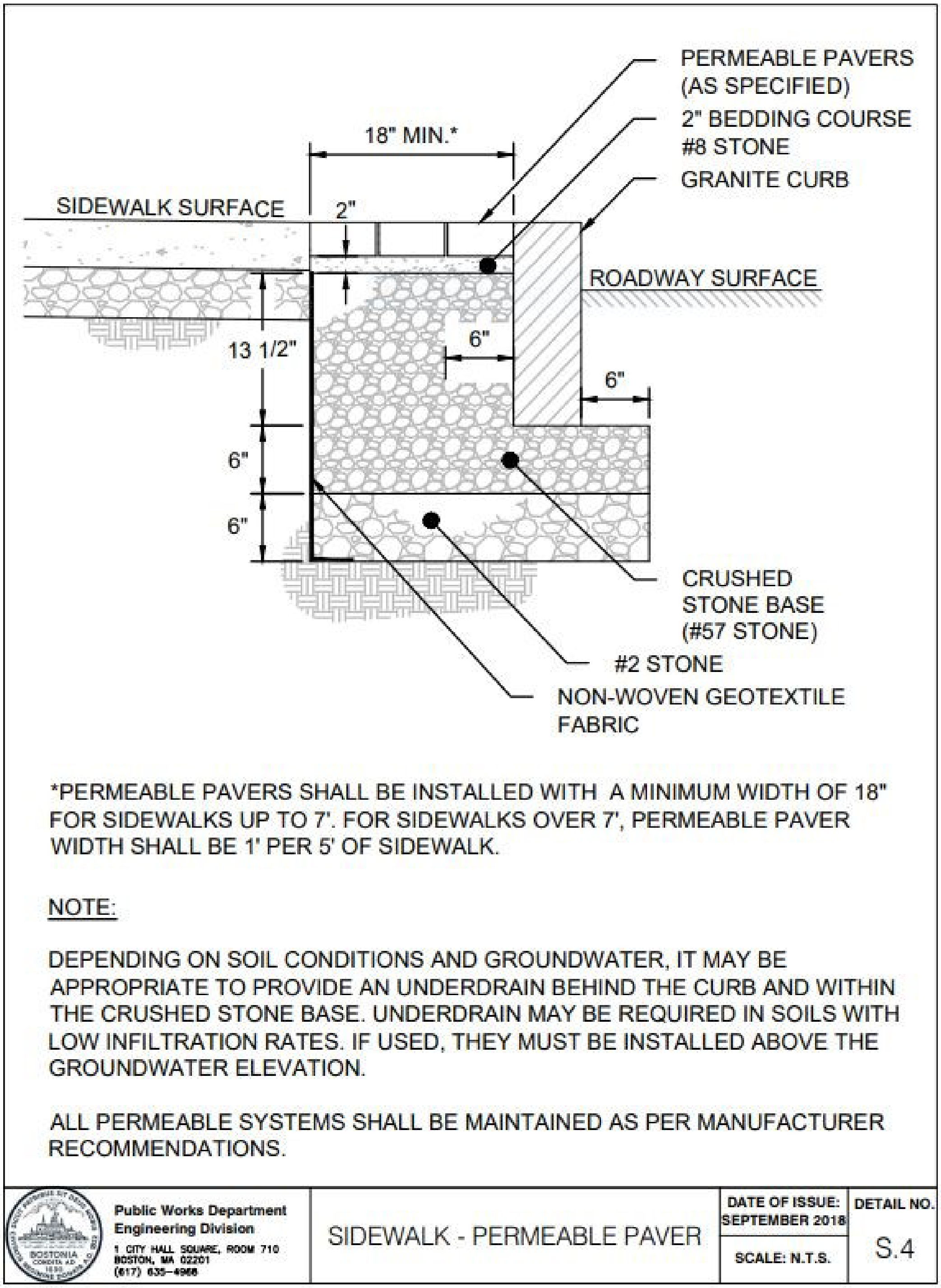
48 "Place D'Youville, Montreal (Quebec), Canada." Claude Cormier + Associes. Accessed May 2021. https://www.claudecormier.com/en/projet/place-dyou-ville/.

49 "About Us," The Distillery District, Accessed May 2021, https://www.thedistillerydistrict.com/about/.



Map 1. Map showing the Columbia River flood basalt province, areal extent of the Columbia River Basalt Group. Shaded area is extent of the Columbia River Basalt Group. Map is from The Geological Society of American Special Paper 497, (2013).

APPENDIX



Detail 1. City of Boston, Public Works Department. Sidewalk - Permeable Paver in a linear application between sidewalks and roads.

Bibliography

Aalto, Kenneth and David Oldroyd. "A Natural Order of Volcanic Succession." *Earth Sciences History* 27, no. 1 (2008): 59-77.

"About the Department of Mobility and Infrastructure," *Department of Mobility and Infrastructure*, Accessed May 2021, https://pittsburghpa.gov/domi/domi-about#:~:text=The%20Department%20of%20Mobility%20and%20Infrastructure%20was%20established,the%20newest%20department%20of%20the%20City%20of%20Pittsburgh.

"About Us." The Distillery District. Accessed May 2021. https://www.thedistillerydistrict.com/about/.

Americans With Disabilities Act of 1990. Public Law 101-336. 108th Congress, 2nd session, July 26, 1990.

Barber, Megan. "America's 11 Most Beautiful Streets." Curbed. November 2016. Accessed May 2021. https://archive.curbed.com/2016/11/8/13559970/united-states-beautiful-streets.

Boston Complete Streets, Design Guidelines. City of Boston, Department of Transportation. May 2013.

"BHAC Rejects DPW Plan for ADA Accessible Ramps". Beacon Hill Times. Boston, MA. December 31, 2013. Accessed May, 2021. http://beaconhilltimes.com/2013/12/31/bhac-rejects-dpw-plan-for-ada-accessible-ramps/

City of Boston Ordinance no. 14339. Chapter 14 Code of the City of Boston. Commissioner of the Department of Public Works, Boston, MA. 1975. Accessed May 2021.

City of Pittsburgh Ordinance no. 417.06. Chapter 417 Code of the City of Pittsburgh. Department of Mobility and Infrastructure, Pittsburgh, PA. 2018. Accessed May 2021.

City of Portland Ordinance no. 139670. Chapter 17.56 Code of the City of Portland. City Auditor of Portland, OR. March 27th, 1975. Accessed May 2021.

City of Portland Ordinance no. 141548. Chapter 17.56.100 Code of the City of Portland. City Auditor of Portland, OR. April 7th, 1976. Accessed May 2021.

City of San Francisco Ordinance no. 201954. Public Ordinance of the City of San Francisco. Department of Public Works, San Francisco, CA. 2019. Accessed May 2021.

City of San Francisco Ordinance no. 200369. Public Ordinance of the City of San Francisco. Department of Public Works, San Francisco, CA. 2018. Accessed May 2021.

Cruz, Fabiano. "How to Cut Belgian Block." Fine Homebuilding, 282. April/May 2019. Accessed May 2021. https://www.finehomebuilding.com/2019/02/27/cut-belgian-block

Fisk, Harold. "The History and Petrography of the Basalts of Oregon." Master's of Art and Science Diss. (1931), University of Oregon, Eugene, OR. University of Oregon Library, 461. F57

Griggs, Allan B. and Donald A. Swanson. *The Columbia River Bsalt Group in the Spokane Quadrangle Washington, Idaho, and Montana, with a Section on Petrography.* Geological Survey Bulletin 1413, US Geological Survey (1976).

BIBLIOGRAPHY

Keese, Dale. "Best Paver Sealer (2021): Review & Comparison." *Seal with Ease.* May 2021. Accessed May 2021. https://sealwith-ease.com/best-paver-sealer/#our-reviews-of-paver-sealers

Office of the Bureau of Development Services, City of Portland, OR. 2014 Landmarks Commission Briefing TriMet Cobblestone Request. City of Portland Achieves. December 14th, 2014.

Philadelphia Complete Street Design Handbook. City of Philadelphia, PA. 2017. Accessed May 2021.

"Place D'Youville, Montreal (Quebec), Canada." Claude Cormier + Associes. Accessed May 2021. https://www.claudecormier.com/en/projet/place-dyouville/.

Preservation Engineering Study on Historic Cobblestone Street Paving Report. Simpson Gumpertz & Heger Inc. Waltham, MA. September 2020.

Preserving Historic Pavement on Nantucket Guidelines. The Nantucket Historical Commission. Nantucket, MA (2021).

"Portland Oregon, Belgian Block." The Columbian River, A Photographic Journey. September 2016. Accessed May 2021. http://columbiariverimages.com/Regions/Places/portland_belgian_blocks.html

Saul, Susan M. *National Register of Historic Places Nomination: Basalt Cobblestone Quarries District, Clark County, Washington.* Ridgefield, WA: Lower Columbia River National Wildlife Refuge Complex, 1981.

"Stone Testing, An Excerpt from the Dimension Stone Design Manual, Version VIII." Marble Institute of America. May 2016. https://pubs.naturalstoneinstitute.org/pub/2c4ec57c-aef5-8a85-16e0-106c5cada13c

Snavely, Parke D. Jr., Norman S Macleod, and Holly C. Wagner. "Miocene Tholeiitic Basalts of Coastal Oregon and Washington and Their Relations to Coeval Basalts of the Columbia Plateau." *Geological Society of America Bulletin.* US Geological Survey, Menlo Park, CA. v.84, February 1973.

Reidel, Stephen P. and Terry L. Tolan. "The Grande Ronde Basalt, Columbia River Basalt Group." *Special Paper 497.* The Geological Society of America, 2013.

"Road Paints for Every Condition." *Zimmerman Paint Contractors CO.*. Accessed May 2021. http://zimmermanpaint.com/html/types-of-road-paints.html

Tape 101: A Comprehensive Guide to Adhesive Tape Properties and Selection. Budnick Converting. St. Louis, MO.

Thomsen, Steve E. Report on Belgian Block Pavement, *City of Portland.* Bureau of Street and Structural Engineering. April 1983

"Testing Frictional Properties of Natural Stone Walking Surfaces." Technical Bulletin. Natural Stone Institute. January 2018.