REPORT ON

BELGIAN BLOCK PAVING

CITY OF PORTLAND, OREGON

Bureau of Street & Structural Engineering

April 1983

Steven E. Thomsen

INDEX

I. PURPOSE OF STUDY

The Banfield Light Rail project is currently in its design phase and scheduled to be in operation by 1986. Tri-Met and their architects (ZGF) are proposing the use of Belgian blocks, also called cobblestones, as a surface paving material in the public right-of-way. Since the City does not have a current standard for installation of Belgian blocks, this study has been compiled to look at the feasibility of using Belgian blocks as a paving material in the public right-of-way. If stone block paving is successfully used on the light rail project, it will set a precedence for such an expansive use of this unique paving material in the public right-of-way.

II. HISTORY

Following is an interesting excerpt from the National Register of Historic Places, Inventory -- Nomination Form, that explains historical uses and sources of Belgian blocks.

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CONTINUATION SHEET ITEM NUMBER 6 PAGE one

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Date: September 1975

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Seven basalt cobblestone rock quarries lie on the floodplain of the Columbia River approximately two miles north of Ridgefield, Washington. The floodplain here exhibits a rolling topography, characterized by basalt knolls surrounded by low areas of alluvial silt which are seasonally flooded. The quarries are located in the sides of these knolls, and a rock road of the same material connects the quarries with Lake River. The only visible remains of the quarry operations are the quarries and their associated piles of tailings, and the two sections of rock haul road. The walls of several of the quarries have fallen in, and they are overgrown with trees and brush.

One quarry and part of the rock haul road have been inventoried on an Archaeological Site Survey Record as 45-CL-113. This site is an extensive quarry located at the northeast end of a large meadow. A rock road runs across the meadow from the quarry to Lake River.

The water level of this area is directly dependent on that of the Columbia River. During the spring "freshet", snow melt in the mountains swells the Columbia and the rising river decreases the flow gradient of Gee Creek, which flows through the area and enters the Columbia just below the mouth of Lake River. Water backs up the creek and spreads out into the low areas to a corresponding level. The water does not recede until the water level of the Columbia drops.

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The Basalt Cobblestone Quarries represent a significant technological period in the development of Portland, Oregon and other American cities, and a turn of the century industry in Ridgefield, Washington.

As Portland grew from a frontier village into an urban and commercial center in the second half of the Nineteenth Century, some sort of street improvements quickly became imperative. The rainy winter climate of Portland turned dirt streets into impassable muddy quagmires, while in summer the streets dried out into dust bowls.

Several different materials, including wooden planks and macadam, were used in the search for a satisfactory paving material that could withstand the extremes of Portland's climate. Beginning about 1880, basalt blocks were quarried near Ridgefield and barged upriver to Portland for use as paving material. The basalt was chipped into brick-shaped pieces of a standard size, called Belgian block, and laid on the streets. Sewer blocks were also cut from the quarries.

By 1885, three miles of Portland's streets were paved with Belgian block[1] and eventually the paving may have covered as much as 30 miles of streets[2] before its use was discontinued. It was used in both east and west Portland.

The stone was hard, and when it was evenly laid it made a firm - and noisy - street. Constant use created problems, however, because the corners of the blocks wore down. They then formed a cobblestone surface that was slippery when wet and water froze in the joints during cold weather. Horses pulling heavy loads could not get traction on the slick surface. The unfirm ground on which the blocks were laid caused the paving to warp, and the constant lifting of the blocks for sewer and water line repairs (Portland doesn't have alleyways for utilities) and the installation of street car tracks also contributed toward an uneven surface. The Belgian block paving eventually proved as unsatisfactory as the other paving materials in use at the time.

Much of the cobblestone, or Belgian block, is still intact under the streets of Portland, having been covered over with asphalt. A survey by the city engineer's office estimates that there could be as much as 4.8 million square feet of the stones.[3]

While most of the stones came from the Ridgefield quarries, the crosswalks were originally ships' ballast. Crosswalks of the streets were made of slabs of granite a foot wide and four to five feet long, laid treble. The granite was

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brought from England or China in ships as ballast.[4] On the return trip, the ballast was replaced by cargo from the Pacific Northwest. This explains the presence of Chloris radiata, a hardy, tropical grass native to Jamaica, in Portland. It is unknown anywhere else in Oregon, but it can be found in Portland pushing up through the asphalt that covers the old cobblestones.[5] Apparently the grass seed was on a cargo from a tropical port and became attached to the ballast, which then was used for street paving.

Portland City Ordinance No. 139670, passed by the City Council in 1975, calls for the preservation of cobblestones excavated during construction and maintenance activities on city streets. The cobblestones are warehoused by the City and are meant to be reused in appropriate civic historic restoration projects. In 1977,[6] the City estimated it had 60,000 cleaned stones and 200,000 uncleaned stones on hand.

The stones have been reused in a number of park projects including a short path in Washington Park, curbs along the Rose City Golf Course, fill in around street tree plantings, and under benches in Pettygrove Park.

Although they represented a significant industry in Ridgefield, very little is recorded about the quarries from which the cobblestones were obtained. The James Carty family owned the land and John (Jack) McKie operated the quarries, apparently leasing the sites from the Cartys. McKie worked under contract to the Portland Contracting Company and employed many Ridgefield residents.

Several stories concerning the quarries are retained in the oral histories of the Carty and McKie families. For example, the rock was removed from the quarries by blasting with dynamite. A man named John McKay was killed on December 21, 1892 while tamping a charge of powder. To dispel the curse of his death, a photograph was taken of the scene to find the ghost. If a face or figure was found in the rock, it was blasted out to lay to rest the evil spirit responsible for the death. This Scottish quarryman's custom allayed the fears of the workmen that there would be another accident.[7]

Another story involves a bookkeeper who absconded with the payroll. Consequently, John McKie worked the last year of the contract by himself because he could not pay anyone to help him. A second story about the payroll tells of Stewart McKie, the oldest son, going with his father to all the saloons to pay the workmen. Stewart, who was only five or six years old, carried all the gold in a gunnysack that he dragged behind him. It was so heavy he needed help when he came to the saloon steps, but no one ever bothered him or the gold.[8]

The most intriguing tale of the quarries comes from the Carty family. It seems two foremen, who paid the men in gold, hid their money near the quarries.[9] They were killed in an explosion and the $10,000 stash was never found.

Work book pages in the possession of the McKie family indicate that the quarries were still in operation in April 1903,[10] and the oral family history states that the contract expired in 1909.

Although the local significance of the quarries was short-lived, they played a significant role in the economic and cultural growth of Nineteenth Century Portland and Ridgefield. Since Portland was not the only American city searching for a satisfactory paving material for its streets during the Nineteenth Century, on a national level the quarries represent an important technological experiment in the evolution of American cities.

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1 H.W. Scott, History of Portland, Oregon, (Syracuse, N.Y. 1890), p. 206.

2 The Sunday Oregonian, 19 May 1974.

3 Oregon Journal, 15 July 1974.

4 Scott, p. 206

5 The Sunday Oregonian, 19 May 1974.

6 Doug Bridges, memorandum to Bob Gustafson, (City of Portland, Oregon: Bureau to Planning), 15 June 1977.

7 The Columbian, 13 December 1978.

8 The Columbian, 13 December 1978.

9 The Columbian, 13 December 1978.

10 Mrs. Allan McKie, letter to James E. Carty, 28 May 1975.

III. CURRENT USE OF BLOCKS

The City's current use of Belgian Blocks is limited to a few small areas that do not get an appreciable amount of foot traffic. Some of these areas are:

- Catherdral Park
- Laurelhurst Park
- Ankeny Square
- 1st Avenue Parking Strips

Lewis and Clark College has used Belgian Blocks extensively in roadway and pedestrian areas. The Belgian Block paving at the college is 7 years old. Lewis and Clark has had no injury or property damage claims to date related to Belgian Block paving. The only complaint has been that the blocks are noisy to drive on and snow removal is difficult.

Seattle has used Belgian Blocks in a public improvement called Pioneer Square. This is a highly used pedestrian area located in a part of town that has a large percentage of transients that loiter in and around the Park. The Belgian Block paving at Pioneer Square is 9 years old.

The Risk Management Departments of Seattle and Metro Transit report that there have been no injury or property damage claims to date, although they get many complaints about the blocks being uncomfortable to walk on. The Attorney for Metro Transit in Seattle attributes the lack of claims to the fact that when people are faced with crossing a large expanse of stone block paving, they expect uneven surfaces and take extra caution when walking on Belgian Block. The Seattle Parks Department has noted that the elderly and handicapped have a difficult time negotiating the cobblestones and that alternate routes should be provided to the elderly and handicapped. Seattle has not developed any standards for Belgian Block paving and does not plan to use them on any future projects. Their stockpile of blocks is limited and the blocks that are left will be

used to repair existing cobble streets. The Belgian Blocks installed at Seattle's Pioneer Square are set in a sand bed. The Parks Department has noticed many rats inhabiting the area. They attribute this to the fact that rats like to burrow in the sand bedding material. The Parks Department also notes that routine cleaning of broken glass and other debris is more difficult due to the irregular surface of the blocks.

IV. FIELD INSPECTION

Lewis and Clark College uses large areas of Belgian Block paving exposed to heavy pedestrian usage. Therefore, it was studied closely to determine some basic criteria for using Belgian Block as a paving material.

Blocks have been installed using a variety of procedures at Lewis and Clark. Some areas were paved by placing blocks on sand bed with sand joints. In other area, blocks were placed on mortar bed and grouted joints. The mortar bed type installations were smoothest to walk on. Noted characteristics of the smoother areas that appeared acceptable as a walking surface were as follows:

(A) Grout joint width did not exceed 1 inch.
(B) Surface irregularities did not vary more than ¼" in 4 feet. (A 4 foot carpenter level was used as a straight edge.)
(C) Each block did not vary more than 1/8 inch ± on the diagonal using a straight edge.

It was also noted that due to the rougher surface of Belgian Block paving, water did not drain as easily as compared to a smooth concrete surface. Even at 2% paved slopes the flow of water was hindered by the irregulatities of cobblestone paving.

Field inspection of other areas around the City did not yield any significant observations due to the size of the areas (small). It

was noted, however, that it is possible to pave with irregularities $\leq$ ¼ inch similar to the City's current standards for concrete sidewalks.

V. TESTING

The City of Portland Testing Lab and Northwest Testing Laboratories performed some qualifying tests on Belgian Blocks from the stockpile at West Delta Park. The results are as follows:

Absorption		Sample 1	0.3%
		Sample 2	0.4%
Modulus of Rupture		3,280 PSI	
Compressive Strength		12,105 PSI	
Friction	Dry	Leather	.47
		Neolite	.60
	Wet	Leather	.77
		Neolite	.56

The follwoing conclusing can be drawn from these tests:

(1) The absorption of Belgian Blocks falls well below the 4% minimum City Standard for brick pavers. This minimum standard was established to ensure adequate bonding between the brick paver and the mortar bed it is set in. The low absorption of Belgian Block will minimize the bond strength between the block and mortar. However, this is offset by the fact that the sides and bottoms of Belgian Blocks are irregular and rough, which adds greatly to the bonding strength. J.A. Wiley, a local masonry contractor, has recommended use of a mortar additive such as Laticrete to increase bonding strength. This would be a good insurance policy in lieu of the fact that absorption values are very low.

(2) The compressive strength of Belgian Blocks exceeds the City Standard of 10,000 PSI for brick pavers.

(3) Belgian Blocks have minimum acceptable skid resistence characteristics for pedestrian usage. According to tests done for the Transit Mall by Truesdail Laboratories, Inc., in Los Angles California, a coefficient of friction greater than or equal to .4 is acceptable for areas where pedestrian usage is expected.

VI. AVAILABILITY OF BLOCKS

All Belgian Blocks are currently stored at West Delta Park next to the Police horse barn. They are located in piles, some covered by weeds, and are not clean; hand cleaning of asphalt and/or concrete would be required.

Bob Gustafson, Park Bureau, has estimated that the existing inventory of blocks numbers 700,000 to 900,000. However, the Park Bureau files have no documentation to support this estimate. Therefore, an independent estimate was performed. An aerial photograph was taken of the stock pile. From the photograph, the piles were counted and then multiplied by an estimate of the number of blocks in each pile. Following are the results:

248 Piles x 1500-2000 Blocks/Pile = 372,000 to 500,000 Blocks

This is significantly less than the Park Bureau estimate. The pile is continually growing, however, due to new street construction projects, expecially the Front Avenue Project now underway. The Light Rail Project will produce a significant amount also. Following is an approximate estimate of all blocks available:

Supply of Belgian Blocks

180,000 Sq.Ft. Front Avenue reconstruction now underway
109,000 Sq.Ft. Delta Park Stockpile
(372,000-500,000 blocks, 4 to 5 blocks/sq.ft. yields 93,000-125,000 sq.ft.)

Existing Blocks in LRT Streets

18,000 Sq.Ft.	1st Avenue between Couch and Everett (2 blocks x 200'/block/42' street width)
33,000 Sq.Ft.	1st Avenue between Ankeny and Stark (4 blocks x 200'/block x 42/ street width)
21,000 Sq.Ft.	Morrison Street between trolley tracks (9.51 blocks and intersection x 280'/block and intersection x 2 trolley tracks x 4' between tracks.

361,000 Sq.Ft. TOTAL ESTIMATED SUPPLY

AMOUNT OF BLOCKS REQUIRED FOR LRT

The LRT Project will require a total of approximately 128,000 Sq.Ft. of paving or 768,000 blocks broken down as follows:

Required LRT Belgian Block Paving

52,000 Sq.Ft.	1st Avenue Skidmore Historic District, Davis Street to Stark Street
6,000 Sq.Ft.	1st Avenue Yamhill Historic District
34,000 Sq.Ft.	Yamhill and Morrison excluding Historic District (19 blocks x 200'/block x 9' width)
20,000 Sq.Ft.	1st Avenue Morrison bridgehead (720' x 27' trackways)
16,000 Sq.Ft.	11th Avenue Terminal

128,000 Sq.Ft. TOTAL LRT BELGIAN BLOCK PAVING

NOTE-The Skidmore Fountain area that will be exposed to pedestrian traffic will require 32,000 $ft.^2$ of suitable blocks (this is included in the 52,000 Sq.Ft. number above).

VII. TOLERANCES

A sampling of 285 blocks was made to determine the amount of usable blocks in the stockpile for paving areas where pedestrian usage was expected. This sample size gives a 90% confidence interval with an error of ±5%. Following is a summary of the results:

BELGIAN BLOCK SAMPLING
SUMMARY

No. of Blocks sampled = 285		
No. of Blocks 1/8" surface irregularities & rectangular	= (18%)	52
No. of Blocks 1/8" surface irregularities & non-rectangular	= (21%)	59
No. of Blocks 1/4" surface irregularities & rectangular	= (17%)	48
No. of Blocks 1/4" surface irregularities & non-rectangular	= (18%)	50
No of Blocks not acceptable	= (26%)	75
TOTAL	=(100%)	284

Average depth = 4.574"
Standard Dev. = ±.479"
Average width = 3.89"
Standard Dev. = ±.53"
Ave. Length = 6.21"
Standard Dev. = ±.98"

# Sampled	=	285
Miscount	=	1 (OK)

VIII. RECOMMENDED STANDARDS

The primary purpose of this short study was to develop a paving standard for Belgian Blocks for areas where pedestrian traffic is expected. From the results of the sampling and field inspection of various installations, the following standard is proposed:

Pedestrian and Traffic Use Areas

- Belgian Blocks will not be allowed in any legal cross-walk areas.
- Belgian Blocks shall be rectangular in shape and uniform in size for a given paved area.

- Blocks shall be placed on a Portland cement concrete base a minimum of 3½" thick. In areas where future vehicle traffic is suspected or proposed, the base will be designed to support that traffic.
- Blocks shall be set in a 1"-2" thick mortar bed. A latex bonding agent, such as Laticrete, or an approved equal, shall be used in the mortar.
- Surface irregularities in individual blocks shall not vary more than 1/8", measured on the diagonal.
- Blocks shall be placed such that there is not more than 1/4" surface irregularitiey within 4 feet.
- Grout joints shall not exceed 1" in width.
- Grades where drainage of water is intended shall not be flatter than 2%.

Large areas of cobblestone seem to alert an approaching pedestrian to the fact that the surface may be irregular, which causes that pedestrian to take extra caution. In contrast, smaller areas of stone block paving will reduce this pedestrian "expectancy factor"; therefore, locations and sizes of stone block paving will be reviewed on an individual basis subject to the approval of the City Engineer. The elderly and handicapped will be provided alternate routes also, i.e., no cobblestones will be allowed in legal crosswalk areas.

IX. IMPACTS OF STANDARDS TO THE LIGHT RAIL PROJECT

The only area which would require compliance with the above standard on the Light Rail Project is the Skidmore Fountain area (1st Avenue from Ash to Couch). About 32,000 $Ft.^2$ of blocks are needed to pave this area. The blocks available that comply with the above standards is 18% of the total available or:

$$.18 \times 361{,}000 = 64{,}980\ Ft.^2 \text{ available}$$

This means that on the average, one out of every five to six blocks is suitable for paving in accordance with tolerances set above.

All other areas on the Light Rail Project using Belgian Blocks will be between warning strips in the trackway area. This area is not intended for pedestrian or auto traffic. Therefore, the paving standards set forth above would not apply. In fact, a slightly roughier surface would help deter both pedestrian and traffic from using the trackway area, as it would be uncomfortable to walk on and noisy to drive on.

X. FUTURE PROJECTS

Since the stone block paving on the Light Rail Project in the public right-of-way will be extensive and unique for the City of Portland, it would be advisable to monitor it for a time before allowing future street improvements to utilize further any stone block paving. Besides, the Light Rail Project will substantially deplete the City's supply of Belgian Blocks and the remaining blocks should be retained for maintenance purposes only, until such time the stockpile is built up again.

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Portland City Ordinance No. 139670, passed by the City Council in 1975, calls for the preservation of cobblestones excavated during construction and maintenance activities on city streets. The cobblestones are warehoused by the City and are meant to be reused in appropriate civic historic restoration projects. In 1977,[6] the City estimated it had 60,000 cleaned stones and 200,000 uncleaned stones on hand.

The stones have been reused in a number of park projects including a short path in Washington Park, curbs along the Rose City Golf Course, fill in around street tree plantings, and under benches in Pettygrove Park.

Although they represented a significant industry in Ridgefield, very little is recorded about the quarries from which the cobblestones were obtained. The James Carty family owned the land and John (Jack) McKie operated the quarries, apparently leasing the sites from the Cartys. McKie worked under contract to the Portland Contracting Company and employed many Ridgefield residents.

Several stories concerning the quarries are retained in the oral histories of the Carty and McKie families. For example, the rock was removed from the quarries by blasting with dynamite. A man named John McKay was killed on December 21, 1892 while tamping a charge of powder. To dispel the curse of his death, a photograph was taken of the scene to find the ghost. If a face or figure was found in the rock, it was blasted out to lay to rest the evil spirit responsible for the death. This Scottish quarryman's custom allayed the fears of the workmen that there would be another accident.[7]

Another story involves a bookkeeper who absconded with the payroll. Consequently, John McKie worked the last year of the contract by himself because he could not pay anyone to help him. A second story about the payroll tells of Stewart McKie, the oldest son, going with his father to all the saloons to pay the workmen. Stewart, who was only five or six years old, carried all the gold in a gunnysack that he dragged behind him. It was so heavy he needed help when he came to the saloon steps, but no one ever bothered him or the gold.[8]

The most intriguing tale of the quarries comes from the Carty family. It seems two foremen, who paid the men in gold, hid their money near the quarries.[9] They were killed in an explosion and the $10,000 stash was never found.

Work book pages in the possession of the McKie family indicate that the quarries were still in operation in April 1903, and the oral family history states that the contract expired in 1909.[10]

Although the local significance of the quarries was short-lived, they played a significant role in the economic and cultural growth of Nineteenth Century Portland and Ridgefield. Since Portland was not the only American city searching for a satisfactory paving material for its streets during the Nineteenth Century, on a national level the quarries represent an important technological experiment in the evolution of American cities.

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1 H.W. Scott, History of Portland, Oregon, (Syracuse, N.Y. 1890), p. 206.

2 The Sunday Oregonian, 19 May 1974.

3 Oregon Journal, 15 July 1974.

4 Scott, p. 206

5 The Sunday Oregonian, 19 May 1974.

6 Doug Bridges, memorandum to Bob Gustafson, (City of Portland, Oregon: Bureau to Planning), 15 June 1977.

7 The Columbian, 13 December 1978.

8 The Columbian, 13 December 1978.

9 The Columbian, 13 December 1978.

10 Mrs. Allan McKie, letter to James E. Carty, 28 May 1975.

III. CURRENT USE OF BLOCKS

The City's current use of Belgian Blocks is limited to a few small areas that do not get an appreciable amount of foot traffic. Some of these areas are:

- Catherdral Park
- Laurelhurst Park
- Ankeny Square
- 1st Avenue Parking Strips

Lewis and Clark College has used Belgian Blocks extensively in roadway and pedestrian areas. The Belgian Block paving at the college is 7 years old. Lewis and Clark has had no injury or property damage claims to date related to Belgian Block paving. The only complaint has been that the blocks are noisy to drive on and snow removal is difficult.

Seattle has used Belgian Blocks in a public improvement called Pioneer Square. This is a highly used pedestrian area located in a part of town that has a large percentage of transients that loiter in and around the Park. The Belgian Block paving at Pioneer Square is 9 years old.

The Risk Management Departments of Seattle and Metro Transit report that there have been no injury or property damage claims to date, although they get many complaints about the blocks being uncomfortable to walk on. The Attorney for Metro Transit in Seattle attributes the lack of claims to the fact that when people are faced with crossing a large expanse of stone block paving, they expect uneven surfaces and take extra caution when walking on Belgian Block. The Seattle Parks Department has noted that the elderly and handicapped have a difficult time negotiating the cobblestones and that alternate routes should be provided to the elderly and handicapped. Seattle has not developed any standards for Belgian Block paving and does not plan to use them on any future projects. Their stockpile of blocks is limited and the blocks that are left will be

used to repair existing cobble streets. The Belgian Blocks installed at Seattle's Pioneer Square are set in a sand bed. The Parks Department has noticed many rats inhabiting the area. They attribute this to the fact that rats like to burrow in the sand bedding material. The Parks Department also notes that routine cleaning of broken glass and other debris is more difficult due to the irregular surface of the blocks.

IV. FIELD INSPECTION

Lewis and Clark College uses large areas of Belgian Block paving exposed to heavy pedestrian usage. Therefore, it was studied closely to determine some basic criteria for using Belgian Block as a paving material.

Blocks have been installed using a variety of procedures at Lewis and Clark. Some areas were paved by placing blocks on sand bed with sand joints. In other area, blocks were placed on mortar bed and grouted joints. The mortar bed type installations were smoothest to walk on. Noted characteristics of the smoother areas that appeared acceptable as a walking surface were as follows:

(A) Grout joint width did not exceed 1 inch.
(B) Surface irregularities did not vary more than ¼" in 4 feet. (A 4 foot carpenter level was used as a straight edge.)
(C) Each block did not vary more than 1/8 inch ± on the diagonal using a straight edge.

It was also noted that due to the rougher surface of Belgian Block paving, water did not drain as easily as compared to a smooth concrete surface. Even at 2% paved slopes the flow of water was hindered by the irregulatities of cobblestone paving.

Field inspection of other areas around the City did not yield any significant observations due to the size of the areas (small). It

was noted, however, that it is possible to pave with irregularities $\leq$ ¼ inch similar to the City's current standards for concrete sidewalks.

V. TESTING

The City of Portland Testing Lab and Northwest Testing Laboratories performed some qualifying tests on Belgian Blocks from the stockpile at West Delta Park. The results are as follows:

Absorption		Sample 1	0.3%
		Sample 2	0.4%
Modulus of Rupture		3,280 PSI	
Compressive Strength		12,105 PSI	
Friction	Dry	Leather	.47
		Neolite	.60
	Wet	Leather	.77
		Neolite	.56

The follwoing conclusing can be drawn from these tests:

(1) The absorption of Belgian Blocks falls well below the 4% minimum City Standard for brick pavers. This minimum standard was established to ensure adequate bonding between the brick paver and the mortar bed it is set in. The low absorption of Belgian Block will minimize the bond strength between the block and mortar. However, this is offset by the fact that the sides and bottoms of Belgian Blocks are irregular and rough, which adds greatly to the bonding strength. J.A. Wiley, a local masonry contractor, has recommended use of a mortar additive such as Laticrete to increase bonding strength. This would be a good insurance policy in lieu of the fact that absorption values are very low.

(2) The compressive strength of Belgian Blocks exceeds the City Standard of 10,000 PSI for brick pavers.

(3) Belgian Blocks have minimum acceptable skid resistence characteristics for pedestrian usage. According to tests done for the Transit Mall by Truesdail Laboratories, Inc., in Los Angles California, a coefficient of friction greater than or equal to .4 is acceptable for areas where pedestrian usage is expected.

VI. AVAILABILITY OF BLOCKS

All Belgian Blocks are currently stored at West Delta Park next to the Police horse barn. They are located in piles, some covered by weeds, and are not clean; hand cleaning of asphalt and/or concrete would be required.

Bob Gustafson, Park Bureau, has estimated that the existing inventory of blocks numbers 700,000 to 900,000. However, the Park Bureau files have no documentation to support this estimate. Therefore, an independent estimate was performed. An aerial photograph was taken of the stock pile. From the photograph, the piles were counted and then multiplied by an estimate of the number of blocks in each pile. Following are the results:

248 Piles x 1500-2000 Blocks/Pile = 372,000 to 500,000 Blocks

This is significantly less than the Park Bureau estimate. The pile is continually growing, however, due to new street construction projects, expecially the Front Avenue Project now underway. The Light Rail Project will produce a significant amount also. Following is an approximate estimate of all blocks available:

Supply of Belgian Blocks

180,000 Sq.Ft. Front Avenue reconstruction now underway
109,000 Sq.Ft. Delta Park Stockpile
(372,000-500,000 blocks, 4 to 5 blocks/sq.ft. yields 93,000-125,000 sq.ft.)

Existing Blocks in LRT Streets

18,000 Sq.Ft.	1st Avenue between Couch and Everett (2 blocks x 200'/block/42' street width)
33,000 Sq.Ft.	1st Avenue between Ankeny and Stark (4 blocks x 200'/block x 42/ street width)
21,000 Sq.Ft.	Morrison Street between trolley tracks (9.51 blocks and intersection x 280'/block and intersection x 2 trolley tracks x 4' between tracks.

361,000 Sq.Ft. TOTAL ESTIMATED SUPPLY

AMOUNT OF BLOCKS REQUIRED FOR LRT

The LRT Project will require a total of approximately 128,000 Sq.Ft. of paving or 768,000 blocks broken down as follows:

Required LRT Belgian Block Paving

52,000 Sq.Ft.	1st Avenue Skidmore Historic District, Davis Street to Stark Street
6,000 Sq.Ft.	1st Avenue Yamhill Historic District
34,000 Sq.Ft.	Yamhill and Morrison excluding Historic District (19 blocks x 200'/block x 9' width)
20,000 Sq.Ft.	1st Avenue Morrison bridgehead (720' x 27' trackways)
16,000 Sq.Ft.	11th Avenue Terminal

128,000 Sq.Ft. TOTAL LRT BELGIAN BLOCK PAVING

NOTE-The Skidmore Fountain area that will be exposed to pedestrian traffic will require 32,000 $ft.^2$ of suitable blocks (this is included in the 52,000 Sq.Ft. number above).

VII. TOLERANCES

A sampling of 285 blocks was made to determine the amount of usable blocks in the stockpile for paving areas where pedestrian usage was expected. This sample size gives a 90% confidence interval with an error of ±5%. Following is a summary of the results:

BELGIAN BLOCK SAMPLING
SUMMARY

No. of Blocks sampled = 285		
No. of Blocks 1/8" surface irregularities & rectangular	= (18%)	52
No. of Blocks 1/8" surface irregularities & non-rectangular	= (21%)	59
No. of Blocks 1/4" surface irregularities & rectangular	= (17%)	48
No. of Blocks 1/4" surface irregularities & non-rectangular	= (18%)	50
No of Blocks not acceptable	= (26%)	75
TOTAL	=(100%)	284

Average depth = 4.574"
Standard Dev. = ±.479"
Average width = 3.89"
Standard Dev. = ±.53"
Ave. Length = 6.21"
Standard Dev. = ±.98"

# Sampled = 285
Miscount = 1 (OK)

VIII. RECOMMENDED STANDARDS

The primary purpose of this short study was to develop a paving standard for Belgian Blocks for areas where pedestrian traffic is expected. From the results of the sampling and field inspection of various installations, the following standard is proposed:

Pedestrian and Traffic Use Areas

- Belgian Blocks will not be allowed in any legal cross-walk areas.
- Belgian Blocks shall be rectangular in shape and uniform in size for a given paved area.

- Blocks shall be placed on a Portland cement concrete base a minimum of 3½" thick. In areas where future vehicle traffic is suspected or proposed, the base will be designed to support that traffic.
- Blocks shall be set in a 1"-2" thick mortar bed. A latex bonding agent, such as Laticrete, or an approved equal, shall be used in the mortar.
- Surface irregularities in individual blocks shall not vary more than 1/8", measured on the diagonal.
- Blocks shall be placed such that there is not more than 1/4" surface irregularitiey within 4 feet.
- Grout joints shall not exceed 1" in width.
- Grades where drainage of water is intended shall not be flatter than 2%.

Large areas of cobblestone seem to alert an approaching pedestrian to the fact that the surface may be irregular, which causes that pedestrian to take extra caution. In contrast, smaller areas of stone block paving will reduce this pedestrian "expectancy factor"; therefore, locations and sizes of stone block paving will be reviewed on an individual basis subject to the approval of the City Engineer. The elderly and handicapped will be provided alternate routes also, i.e., no cobblestones will be allowed in legal crosswalk areas.

IX. IMPACTS OF STANDARDS TO THE LIGHT RAIL PROJECT

The only area which would require compliance with the above standard on the Light Rail Project is the Skidmore Fountain area (1st Avenue from Ash to Couch). About 32,000 $Ft.^2$ of blocks are needed to pave this area. The blocks available that comply with the above standards is 18% of the total available or:

$$.18 \times 361{,}000 = 64{,}980\ Ft.^2 \text{ available}$$

This means that on the average, one out of every five to six blocks is suitable for paving in accordance with tolerances set above.

All other areas on the Light Rail Project using Belgian Blocks will be between warning strips in the trackway area. This area is not intended for pedestrian or auto traffic. Therefore, the paving standards set forth above would not apply. In fact, a slightly roughier surface would help deter both pedestrian and traffic from using the trackway area, as it would be uncomfortable to walk on and noisy to drive on.

X. FUTURE PROJECTS

Since the stone block paving on the Light Rail Project in the public right-of-way will be extensive and unique for the City of Portland, it would be advisable to monitor it for a time before allowing future street improvements to utilize further any stone block paving. Besides, the Light Rail Project will substantially deplete the City's supply of Belgian Blocks and the remaining blocks should be retained for maintenance purposes only, until such time the stockpile is built up again.

CITY OF
PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS

Mike Lindberg, Commissioner
Office of Public Works Administrator
1120 S.W. Fifth Ave.
Room 702
Portland, Oregon 97204-1957
(503) 796-7015

May 2, 1983

Steve Crouch
Light Rail Project
421 SW 5th Avenue, Suite 600
Portland, Oregon 97204

Re: LRT Project, Belgian Block Paving

Dear Steve:

Attached for your use on the Light Rail Project is a set of standards for selection and installation of Belgian blocks in pedestrian and traffic use areas.

Sincerely,

John M. Lang
Public Works Administrator

SET:jw

Attachment

c: Roger Shiels
Greg Baldwin

CITY OF PORTLAND
STANDARD FOR BELGIAN BLOCK PAVING

Pedestrian and Traffic Use Areas

- Belgian Blocks will not be allowed in any legal crosswalk areas
- Belgian Blocks shall be rectangular in shape and uniform in size for a given paved area.
- Blocks shall be placed on a Portland cement concrete base a minimum of 3½" thick. In areas where future vehicle traffic is suspected or proposed, the base will be designed to support that traffic.
- Blocks shall be set in a 1"-2" thick mortar bed. A latex bonding agent, such as Latricrete, or an approved equal, shall be used in the mortar.
- Surface irregularities in individual blocks shall not vary more than 1/8", measured on the diagonal.
- Blocks shall be placed such that there is not more than 1/4" surface irregularity within 4 feet.
- Grout joints shall not exceed 1" in width.
- Grades where drainage of water is intended shall not be flatter than 2%.
- Blocks may not be used on the Skidmore Fountain Station platforms.