PAVEMENTS OF GRAND RAPIDS, MICH.

Thesis for the Degree of B. S.

J. R. Quinn
F. W. Trezise

1916

SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK

Pavements of Grand Rapids, Mich.

A Thesis Submitted to

The Faculty of

MICHIGAN AGRICULTURAL COLLEGE

By

J.R. Quinn

F.W. Trezise

Candidates for the Degree of

Bachelor of Science

June, 1916.

Object.

The object in this study of the pavements in Grand Rapids is to determine the economic relation of the various types used in that city. Previous to the actual construction of a pavement a thorough investigation of existing conditions should be made. An investigation of this character carried out in an intelligent manner may not only preclude the use of certain types which would have otherwise been adopted, but would result in a direct saving in the first cost of the work. We have endeavored as far as possible with the aid of available data to develop in this thesis conclusions which may aid in the future construction of pavements in that city.

History.

The city of Grand Rapids, situated in the valley of the Grand River is 45 miles directly east of Lake Michigan and the mouth of the river. The "Valley City" as it is frequently called is indeed no misnomer, for the Grand River at this point threads its way among the hills of Western Michigan and invites a splendid site for the city. The remarkable growth of Grand Rapids to the rank of second city in the state has not been due only to this singularly beautiful location but because of its just claim to being the world's largest furniture and a trade market for the large fruit districts surrounding the city.

Any historical outline of paving construction in Grand Rapids must include a short history of the city as a

whole for the former is inseparably connected with the latter; the improvement of a city's streets is an index of progress in civic development and we could hardly trace the stages of progress of one without noting the corresponding advances in the other.

According to Dwight Goss in his "History of Grand Rapids", Grand Rapids was incorporated as a village April 5, 1838. Incorporation as a city followed in 1850. Canal Street (now Monroe Street) was a miry morass from Pearl Street to Coldbrook, and Division Street at that time was a slough of mud; Monroe Street itself was a bed of heavy clay mortar. The first effort to pave the streets was undertaken in 1847 when a piece of macadamized road from Bridge street southward on Canal was constructed. A foundation was laid upon the mud which was merely a thin layer of sand and gravel; a top dressing of broken limestone covered this. The road stood up for a short time, the limestone surface broke through and deep mire holes were formed.

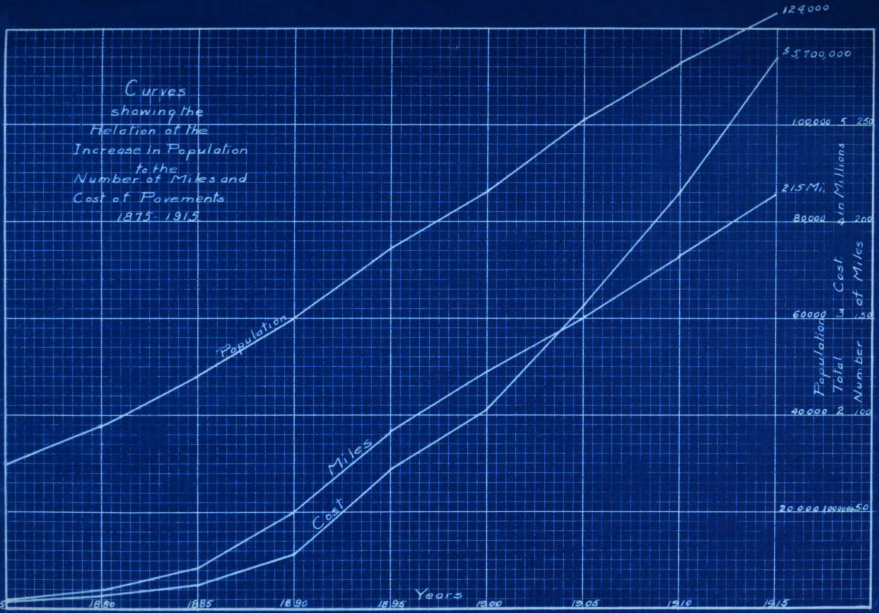
The next step in advance was taken in 1849 when a plank road was built upon the Fulton Street hill east of Jefferson Avenue. A short sketch of the steep part of Fountain Street was also planked but these streets were short-lived. The so-called Kalamazoo oak plank road was completed in 1855. This extended from the city line on Division Street to Monroe.

In the following year street paving began in earnest first on Monroe, built of cobblestone and extending to Ionia street. Later a further extension was made to Division

Street. In 1859 Canal Street was similarly paved as far north as Hastings Street. Cobble stones, well-laid on a solid even bed was a good pavement, indefinitely durable, but very hard, noisy and a distressing source of misery to horse-drawn traffic.

During the war period (1861-65) but very little was accomplished but in 1866 the Monroe Street pavement was extended to its intersection with Fulton Street. The latter street was paved with round stone from that point east over the hill to Lake Avenue. The Canal Street paving was extended in 1868 to the Grand Trunk Station.

In 1874 a change from stone to wood pavements was made. Wood blocks were used cut from four-inch pine plank, set on end upon a gravel bed, the interstices were well tamped with gravel and sand to make a roadway six inches in depth. Pearl Street and Monroe were the first streets so paved. Canal Street was soon after paved in the same manner and after this little if any stone pavement was laid except for gutters. Wood paving was completed on Lyon Street, West Bridge and a few other streets in 1875-76. Paving blocks of pine did not prove satisfactory. The wood decayed in five or six years. They were superseded by cedar blocks cut from the bodies of small trees in six-inch lengths with the bark and sapwood trimmed off. The blocks were set on end in the pavement. These were first used on Pearl Street from Canal Street to the bridge and on Monroe by way of experiment. The cedar block proved much more durable than the pine; and remained the most used permanent


Curves
showing the
Relation of the
Increase in Population
to the
Number of Miles and
Cost of Pavements
1875 1915
124000
$5700,000
100000 5 250
215 Mi.
80000 4 200
60000 3 150
40000 2 100
20000 1 50
Population
Miles
Cost
Population Total Cost in Millions
Number of Miles
1875
1880
1885
1890
1895
1900
1905
1910
1915
Years

type by far until 1891. In more recent years brick, sheet and block asphalt and bituminous concrete have been the more popular pavements.

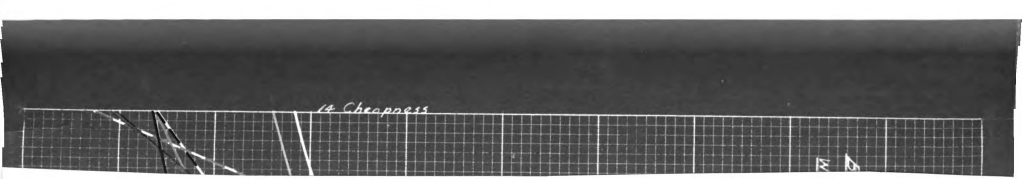
Acknowledgement.

We desire to acknowledge the assistance given by Mr. Moore, City Engineer, and Mr. Paige, Assistant City Engineer of Grand Rapids, in securing much of our data for this thesis.

One only needs to refer to Plate X to discover the striking relation which exists between the increase in population and the corresponding increase in the number of miles of streets paved during the same period. In 1875 there were approximately seven miles of pavement including all kinds and a population of 30,000, or an average of .00023 miles per capita. In 1915 the number of miles of pavements increased to 215 while the population was estimated at 124,000, the per capita mileage being .0016. The cost of paving per mile for all kinds of road constructed varied considerably throughout this period of time. The minimum average total initial cost was in 1890 at approximately $11,200.00 per mile. In 1915 the average initial cost was about $36,500.00 per mile.

The Ideal Pavement.

The determination of the object depends upon many variable factors all of which must be given due consideration. The great variety of materials, the methods of construction and maintenance, together with the absence


14 Cheapness

of some phases of cost data and traffic center which we have been unable to obtain because of insufficient records makes it a different matter to reduce all the different types of pavements to a comparable basis.

The ideal pavement should be durable, cheap, sanitary, generally acceptable; it should have a low traffic resistance, it must be favorable to travel, should be easy to maintain and easy to clean. A consideration of these important factors and characteristics reveals the lack of accurate data obtainable and the relative determination of these factors to consider when comparing this ideal pavement with the type in question. As an aid in determining an efficient and economical comparison between various pavements tables have been devised by numerous authors to show in a more concrete manner the relation between the qualities to be desired and their relation to the assigned ideal values. The values are purely assignable depending upon the local conditions. In our study of various tables we have found that the table proposed by the U.S. Department of Agriculture is worthy of consideration. After a thorough investigation of nation-wide conditions the Department has issued a table more adaptable to every condition than any other. Plate No.2 contains a copy of this table as recommended by the Government, also a graphical representation of the same in the nature of curves. The curve of the ideal pavement is merely an assumed curve, The vertical lines indicated representing the qualities as given in the table. The ordinates upon which these qualities lie are divided in

to the number of units representing the assigned ideal pave-ment value in the table. In plotting the actual pavement curves the number of units taken on each of the quality ordinates is the number corresponding in that pavement column opposite the quality. Example: The durability ordinate for the ideal pavement is assumed as 20 units long below the curve; referring to the table we find that the durability of block asphalt is assumed as 14. Hence the height of the block asphalt ordinate at that point is 14/20 of the heighth of the ideal ordinate at the same point. The above consideration of the ideal pavement, pertains, as has been stated, to the most general conditions existent throughout the entire country. In our application of this theory of comparison to Grand Rapids we find particular conditions which must be considered in determining the relative values to be assigned to the prime qualities found in this scale of an ideal pavement factors for the city. To illustrate this; we found that this municipality presents a similar local condition because of the fact that large hills surround the city necessitating the use of steep grades in constructing pavements. In these cases it will be found that the quality non-slipperiness will receive more than ordinary consideration. Other alterations will be required in other pavements of the city to determine the best pavement to use; hence to ascertain the ideal pavement for the city would be an impossible task. Traffic conditions to which a pavement is subjected forms the principal consideration in determining the ideal pavement. To a full consideration of the pavements in Grand Rapids it may

be stated with very little fear of contradiction that the ideal pavement for the city would be the most economical. The truly economical pavement is the one which is best suited to meet the local conditions as capable of withstanding the ravages of time and traffic with the least possible maintenance, first cost considered. It is our aim, then to point out the relation between the initial cost and the cost of maintenance of the various materials used in road construction.

Specifications.

A study of the specifications adopted by the city of Grand Rapids for permanent pavements shows that standard methods are used. Standard specifications are those adopted by most large cities and by the Association for Standardizing Paving Specifications.

A few recent and important changes are the following:

Concrete Foundations:— Before the year 1915 bank gravel was used for foundation concrete, but no bank gravel is allowed, the clause specifying this material having been struck out.

No continuous concrete mixers may now be used on any work.

Vitrified Brick:— The most important change in these specifications is the "expansion-joint" clause, which does away with poured tar or bituminous filler and calls for pre-formed joints.

Standard Rattler Specifications:— These comply with usual methods as regards the actual tests. There are no adequate means for keeping record of the brick after they leave the car. No attenpt has been made to trace a particular lot of brick to any particular section of a street.

Fillers:— In all there are about 169 brick paved streets in Grand Rapids. Of this number 137 are grout filled, 30 pitch filled and two sand filled. The last pitch was used in 1901. Since then cement grout has been used exclusively, except in a few cases, one being Bridge Street bridge.

General Inspection.

A tour of the city was made in a Ford automobile in order that each pavement might be inspected.

Noticeable and commentable points are the following: The sheet asphalt pavement of Ottawa Avenue, just west of the city hall was investigated. We found this street to be in a very bad condition and full of holes. This pavement was laid in 1899, but is now (1916) being replaced with brick.

A study of the maintenance figures shows that this pavement failed to hold up or else was not given the immediate and proper attention necessary when a defect or wear was first noted.

Ionia Avenue one block east is another example of this type of pavement. This was laid three years earlier and is about the same length as Ottawa Avenue. These

comparative maintenance figures show how much repair work has been done since 1908:

Ionia Avenue, - Crescent to Monroe, 1400 yds. repaired at $1720.00;

Ottawa Avenue, - Lyon to Michigan, 1720 yds. repaired at $1800.00.

These two are cited as examples of asphalt pavements because each received about the same amount of traffic. It is not to be concluded, however, that all asphalt pavements have not withstood the wear and traffic. These pictures show views of Ottawa and Ionia Avenue asphalt pavements.

Another stretch of asphalt pavement found to be in bad condition is at the intersection of Fulton and Ionia. This is the busiest part of the wholesale and heavy trucking district, two blocks from the Union Station, Pavement laid in 1907.

The block of asphalt pavement on Michigan Avenue in front of the Grand Trunk Depot is also very rough and contains several bad holes. The block was placed in 1902 and since has been repaired to the extent of 305 sq.yds. at a cost of $340.00, a considerable amount for such a short stretch.

LIST OF STREETS PAVED WITH SHEET ASPHALT

Street	EXTENT		Year.	Kind of Asphalt	THICKNESS		
	From	To			Binder	Top	Concrete Base
*Cherry Street	Sheldon	Madison	1902	Trinidad Pitch Lake	1"	2"	4"
*College Avenue	Wealthy	Pleasant	1913	Sarco	1"	2"	4"
Crescent Street	Bostwick	Union	1898	Trinidad Pitch Lake	1"	1-1/2"	5"
Foster's Drive	Across	Foster Park	1891	Trinidad Pitch Lake		2"	4"
Fountain Street	Ottawa	Division	1897	Trinidad Pitch Lake	1"	2"	6"
Ionia Avenue	Monroe	Pearl	1894	Trinidad Pitch Lake		2-1/2"	6"
Ionia Avenue	Pearl	Crescent	1897	Wasatch Utah Lime Rock	1"	2"	6"
*Ionia Avenue	Fulton	Intersection	1907	Acme (California)			6"
Jefferson Avenue	Cherry	Wealthy	1897	Assyrian (Utah)		2"	6"
*Jefferson Ave.	State	Cherry	1906	Trinidad Pitch Lake	1"	2"	4"
Lafayette Ave.	State	Cherry	1892	Trinidad Pitch Lake		2 "	4"
Michigan Street	Monroe	West End	1902	Trinidad Pitch Lake	1"	2"	6"
*Monroe Avenue	Pearl	Michigan	1913	Sarco	1"	2"	Old
Ottawa Ave.	Lyon	Michigan	1899	Standard (California)	1"	2"	6"
Pearl Street	Ionia	Division	1897	Wasatch Utah Lime Rock	1"	2"	6"
Prospect Ave.	Fulton	Fountain	1899	Trinidad Pitch Lake	1"	1-1/2"	5"
Terrace Ave.	Fulton	Washington	1897	Standard (California)		2"	4"
Waverly Place	State	Cherry	1896	Trinidad Pitch Lake		2"	4"

* = Resurfacing.

Asphalt Block.

The worst street in Grand Rapids is Sheldon Avenue, an asphalt block pavement laid on an old gravel foundation, in 1900. It has been repaired numerous times and is now a stretch of patches and holes. Just where to place the blame is doubtful. Probably two causes have helped to produce the many rough spots.

First, the kind of foundation. Undoubtedly, had a more substantial foundation been used these brick would have lasted longer.

Second, defective asphalt block. A review of the maintenance cost shows that considerable repair work has been done on Sheldon Avenue, approximately 700 sq.yds. have been relaid at a cost of over $1000.00.

The accompanying photos give clear views of the condition of the asphalt block pavement on Sheldon Avenue.

Other asphalt block pavements show no appreciable wear.

The following table gives a list of streets paved with asphalt block.

LIST OF STREETS PAVED WITH BLOCK ASPHALT

Street	EXTENT		Year	Thickness of Block	Foundation
	From	To			
Lafayette Avenue	Fulton	State	1910	2-1/2"	Old Gravel
Madison Avenue	Cherry	Wealthy	1910	2-1/2"	Old Gravel
Paris Avenue	Cherry	Wealthy	1910	2-1/2"	Old Gravel
Paris Avenue	Wealthy	Thomas	1913	2-1/2"	Concrete & Old concrete
Prospect Avenue	Fountain	Crescent	1905	4"	Concrete
Sheldon Avenue	Fulton	Buckley	1900	4"	Old Gravel
Union Avenue	Fulton	Lyon	1904	4"	Concrete

Wood Block.

Of the wood block pavement in Grand Rapids little need be said, except that the two streets paved with this material have proved quite satisfactory as a residence type and have cost very little for repair and up-keep.

This picture was taken on Fountain Street.

LIST OF STREETS PAVED WITH CREOSOTED WOOD BLOCK

Street	EXTENT From	To	Year	Kind of Block	Thickness of Block.	Foundation
Fountain Street	Lafayette	Union	1907	Long Leaf Yellow Pine	3"	6" concret
Lafayette Avenue	Fountain	Lyon	1909	Yellow or Norway Pine	3"	6" concrete

Granite Block.

Michigan Avenue, on the hill, is the only street in Grand Rapids paved with granite block. The stretch is about a quarter of a mile long and is on the steepest paved hill in the city. It has proved quite satisfactory from every viewpoint. Repairs have been inexpensive. These photos show the present condition.

Brick Pavements.

By far the most important permanent pavement to consider in Grand Rapids is the brick pavements. In the first place most of the permanent pavement is of this type, and seems to be in most favor.

Our personal inspection showed that certain streets were in worse condition than others and the exact causes for such differences we were not able to ascertain with any degree of certainty.

Cement grout is now used exclusively. Pitch filler has been used in the past but many streets on which pitch filler was employed seem to have become rough. Campau, Fulton and Ionia Streets are examples.

No transverse expansion joints are used; only joints parallel to the curb being called for. These are of pitch.

This photo gives a vivid idea of how the two fillers, pitch and cement, differ. The view is on W.Leonard

Street where a trench had been dug. Upon repaving the opening, pitch filler was placed, whereas the pavement proper had been grouted with cement. Due to some action or other, a large crack about fifty feet long appeared. Several brick were broken as a result. This can undoubtedly be attributed to the unequal expansive properties of pitch and cement.

This shows a departure from the ordinary curb and gutter, being a view of Front Avenue. The drainage provisions at this place are inadequate because there are no catch basins at the driveway shown. The street crown is higher than the crosswalk, and as a result water flows towards the driveway and walk and remains, causing inconvenience to pedestrians.

No attempts were made to arrive at the actual number of defects in brick pavements or the causes producing them. The brick pavements in downtown districts, especially the older ones, were found to be rough in many places.

LIST OF STREETS PAVED WITH BRICK

The Following is a List of Streets in the City that Have Been Paved with Brick, Giving Date of Paving, Kind of Brick, and the Material Used for Filling Joints. A similar Table of Sheet Asphalt is Also Given.

Street	EXTENT From	To	Date	Kind of Brick	Filler
Alabama Avenue	Bridge	First	1901	Buckeye	Pitch
Ary Court	Grandville	"E"	1913	Portsmouth	Cement grout
Bank Avenue	New England Place	Michigan	1910	Metropolitan	Pitch
Bond Avenue	Crescent	Fairbanks	1905	Metropolitan	Pioneer Asphalt
Bond Avenue	Lyon	Crescent	1907	Metropolitan	Pioneer Asphalt
Bartlett Street	Division	Ellsworth	1913	Metro. & Peebles	Cement grout
Bridge Street Alley	Front	Scribner	1914	Metropolitan	Cement grout
Bridge Street Bridge			1904	Trimble or Metro.	Pitch
Bridge Street	Stocking	Garfield	1905	Metropolitan	Cement grout
Bridge Street	Grand River	Stocking	1910	Metropolitan	Cement grout
Bostwick Avenue	Lyon	Park	1907	Metropolitan	Cement grout
Bostwick Avenue Alley	Fountain	Lyon	1913	Metropolitan	Cement grout
Buchanan Avenue	Wealthy	Prescott	1908	Metropolitan	Cement grout
Buckley Street	Division	Lafayette	1912	Metropolitan	Cement grout
Butterworth	Front	Lane	1912	Metropolitan	Cement grout
Campau Avenue	Pearl	Louis	1893	Canton	Pitch
Campau Avenue	Lyon	Pearl	1898	Harris	Pitch
Campau Avenue	Louis	Fulton	1899	Metropolitan	Pitch
Commerce Avenue	Fulton	Monroe	1895	Hallwood	Pitch
Commerce Avenue	Fulton	Wealthy	1909	Metropolitan	Cement grout
Cherry Street	Madison	Eastern	1901	Trimble or Metro.	Cement grout
Cherry Street	Ionia	Ottawa	1901	Metropolitan	Cement grout
Cherry Street	Eastern	Carroll	1904	Trimble or Metropolitan	Cem. "
Cherry Street Alley	Commerce	Ionia	1909	Metropolitan	Cement grout
Carrier Street	Plainfield	College	1907	Nelsonville	Cement grout
Crescent Street	Monroe	Division	1904	Hocking Valley	Cement grout
Division Avenue	Monroe	Fulton	1896	Harris	Pitch
Division Avenue	Fulton	Wealthy	1906	Metropolitan	Cement grout
Division Avenue	Wealthy	Franklin	1907	Metropolitan	Cement grout

LIST OF STREETS PAVED WITH BRICK - Continued

Street	EXTENT From	To	Date	Kind of Brick	Filler
Division Avenue	Franklin	P.M.R.R.	1908	Trimble	Cement grout
Division Avenue	P.M.R.R.	Burton	1909	Metropolitan	Cement grout
Division Avenue	Monroe	Lyon	1912	Metropolitan & Trimble	Cement grout
Division Avenue	Lyon	Crescent	1914	Metropolitan	Cement grout
Division Avenue Alley	Fulton	Island	1912	Metropolitan	Cement grout
Division Avenue Alley	Cherry	Williams	1913	Metropolitan	Cement grout
Ellsworth Avenue	Fulton	Wealthy	1903	Wooster	Cement grout
Ellsworth Avenue Alley E	Cherry	Williams	1911	Metropolitan	Cement grout
Erie Street	Monroe	West End	1906	Metropolitan	Cement grout
Franklin Street	Division	Hilton	1910	Metropolitan	Cement grout
Franklin Street	Hilton	Oakland	1914	Metropolitan	Cement grout
Front Avenue	Allen	Shawmut	1894	Canton	Pitch
Front Avenue	Bridge Street	Allen	1901	Metropolitan	Cement grout
Front Avenue	Fulton	Wealthy	1912	Metropolitan	Cement grout
Fulton Street	Division	Jefferson	1894	Hallwood	Pitch
Fulton Street	Division	Commerce	1898	Metropolitan	Pitch
Fulton Street	Commerce	Grand River	1901	Harris	Cement grout
Fulton Street	Grand River	Lexington	1903	Trimble	Cement grout
Fulton Street	Lexington	National	1907	Metropolitan	Cement grout
Fulton Street Alley	LaGrave	Jefferson	1910	Metropolitan	Cement grout
Fulton Street	Union	Carleton	1912	Metropolitan	Cement grout
Fulton Street Alley	Sheldon	LaGrave	1913	Metropolitan	Cement grout
Godfrey Avenue	R. R.	South	1901	Nelsonville	Cement grout
Goodrich Alley	Ionia	Commerce	1914	Metropolitan	Cement grout
Grandville Avenue	Bartlett	Hall	1903	Hocking Valley	Cement grout
Hastings Street	Monroe	Bond	1912	Metropolitan	Cement grout
Huron Street	Monroe	Lock	1913	Metropolitan	Cement grout
*Ionia Avenue	Oakes	Wealthy	1894	Hallwood made at Athens	Pitch
Ionia Avenue	Crescent	Michigan	1907	Metropolitan	Cement grout
Ionia Avenue	Monroe	Fulton	1907	Trimble	Cement grout

* = Resurfaced in 1913 with Metropolitan, cement grout filler.

LIST OF STREETS PAVED WITH BRICK- Continued

Street	EXTENT From	To	Date	Kind of Brick	Filler
Ionia Avenue Alley	City Hall Alley	Crescent	1911	Metropolitan	Cement grout
Ionia Avenue	Fulton	Oakes	1913	Metropolitan	Cement grout
Ionia Avenue	Wealthy	Prescott	1913	Metropolitan	Cement grout
Island Street	Division	Market	1905	Trimble	Pitch & " grout
Island Street	Division	Jefferson	1913	Metropolitan	Cement grout
James Avenue	Cherry	Wealthy	1911	Metropolitan	Cement grout
Jefferson Avenue	Fulton	Washington	1895	Hallwood	Pitch & " grout
Lafayette Avenue	Cherry	Wealthy	1914	Metropolitan	Cement grout
Louis Street	Campau	Fulton	1895	Hallwood	Pitch
Lexington Avenue	Shawmut Street	Butteworth	1913	Metropolitan	Cement grout
Lexington Avenue	Bridge	Shawmut	1914	Metropolitan	Cement grout
Lake Drive	Fuller	Wealthy	1897	Harris	Sand
Lake Drive	Carroll	Fuller	1910	Metropolitan	Cement grout
LaGrave Avenue	Fulton	Wealthy	1907	Metropolitan	Cement grout
LaGrave Avenue Alley	Maple	Goodrich	1911	Metropolitan	Cement grout
West Leonard Street	Grand River	Freemont	1907	Trimble	Cement grout
East Leonard Street	Grand River	Plainfield	1909	Metropolitan	Cement grout
West Leonard Street	Freemont	White	1911	Metropolitan	Cement grout
West Leonard Street	W. Dock Line	Near Front Ave	1913	Metropolitan	Cement grout
Leonard Street Bridge	Across Grand River		1913	Metropolitan	Cement grout
Logan Street	Lafayette	Paris	1914	Metropolitan -Wire Cut	Cement grout
Lyon Street	Monroe	Division	1897	Harris	Pitch
Lyon Street	Monroe	Campau	1898	Metropolitan	Pitch
Madison Avenue	Umatilla	Crawford	1914	Metropolitan	Cement grout
Market	Monroe	Fulton	1892	Hallwood	Pitch
Market Avenue	Fulton	Wealthy	1910	Metropolitan	Cement grout
Market & Godfrey Aves.	Wealthy	G. R. & I.Ry.	1912	Metropolitan	Cement grout
Monroe Avenue	Leonard	Coldbrook	1898	Metropolitan	Pitch
Monroe Avenue	Michigan	Newberry	1900	Iron Rock	Pitch & Cement "
Monroe Avenue	Leonard	Travis	1905	Trimble	Pitch
Monroe Avenue	Pearl	Division	1909	Bessemer	Cement grout
Michigan Street	Monroe	Ottawa	1897	Harris,Buckeye & Hallwood	Pitch
Michigan Street	Barcley	Lafayette	1897	Buckeye	Cement grout
Michigan Street	Lafayette	Grand	1908	Metropolitan	Cement grout

LIST OF STREETS PAVED WITH BRICK - continued

Street	EXTENT From	To	Date	Kind of Brick	Filler
Michigan Street	Grand	Fuller	1911	Metropolitan	Cement Grout
Newberry Street	Monroe	Grand River	1900	Canton Blocl	Pitch
New Eng. Place	Monroe	Bank	1900	Buckeye	Cement grout
Oakes Street	Division	Ionia	1905	Metropolitan	Cement grout
Oakes Street	Ellsworth	Ottawa	1910	Metropolitan	Cement grout
Oakes Street	Ellsworth	Market	1911	Metropolitan	Cement grout
Orchard Hill	Lake Drive	South End	1906	Metropolitan	Cement grout
Ottawa Avenue	Fairbanks	Coldbrook	1898	Metropolitan	Pitch
Ottawa Avenue	Michigan	Fairbanks	1899	Metropolitan	Pitch
Ottawa Avenue	Louis	Fulton	1901	Trimble	Pitch
Ottawa Avenue	Lyon	Monroe	1903	Nelsonville & Trimble	Cement grout
Ottawa Avenue	Monroe	Louis	1907	Metropolitan	Cement grout
Ottawa Avenue	Fulton	Island	1907	Metropolitan	Cement grout
Ottawa Avenue	Island	Cherry	1910	Metropolitan	Cement grout
Ottawa Avenue Alley	Michigan	Hastings	1911	Metropolitan	Cement grout
Ottawa Avenue Alley	Michigan	Crescent	1911	Metropolitan	Cement grout
Ottawa Avenue Alley	Mason	Walbridge	1912	Metropolitan	Cement grout
Pearl Street	Ottawa	Grand River	1891	Hallwood	Pitch
Pearl Street	Ionia	Ottawa	1895	Harris	Pitch
Pearl Street Alley	Campau	Campau Alley	1910	Metropolitan	Cement grout
Plainfield Avenue	Leonard	Quimby	1910	Nelsonville	Cement grout
Prescott Street	Division	Grandville	1911	Metropolitan	Cement grout
Quimby & Coit	Inter	Section	1914	Metropolitan	Cement grout
Scribner Avenue	Bridge	Webster	1905	Trimble	Cement grout
Scribner Avenue	Fulton	Shawmut	1914	Metropolitan	Cement grout
Scribner Avenue Alley	Bridge	Bowery	1913	Metropolitan	Cement grout
Second Street	Alabama	Seward	1912	Sciotoville	Cement grout
Shawmut Street	Front	Seward	1894	Canton	Sand
Shawmut Street	Seward	Straight	1914	Metropolitan	Cement grout
Sixth Street	Front	Muskegon	1914	Metropolitan	Cement grout
State Street			1903	Harris	Cement grout
Stocking Avenue	Bridge	Seventh	1906	Nelsonville	Cement grout
Summer Avenue	Fulton	Shawmut	1914	Metropolitan	Cement grout
Trowbridge Street	Monroe	Ottawa	1906	Metropolitan	Cement grout

LIST OF STREETS PAVED WITH BRICK, Continued.

Street	EXTENT From	To	Date	Kind of Brick	Filler
William Street		At Railroad	1901	Trimble	Cement grout
Wealthy Street	Division	Eastern	1902	Nelsonville	Cement grout
Wealthy Street	Eastern	Eureka	1903	Harris	Cement grout
Wealthy Street	Ionia	Ellsworth	1905	Hocking Valley & Metropolitan	Cement grout
Wealthy Street	Eureka	City Limits	1909	Metropolitan	Cement grout
Wealthy Street	Division	Ionia	1911	Metropolitan	Cement grout
Wealthy Street	Ellsworth	Oakland	1911	Metropolitan	Cement grout
Willow Court	Barclay	Lafayette	1909	Metropol.& Bessemer	Cement grout
Winter Avenue	Shawmut	Bridge	1913	Metropolitan	Cement grout

LIST OF STREETS PAVED WITH BITUMINOUS CONCRETE

Street	EXTENT From	To	Year	Kind of Asphalt	Thickness of Top	Thickness & kind of Foundation	Contractor
Claremont Place	Lyon	Willow Court	1910	Sarco	1½"	4"cobble,3"crushed	McDermott & Cooper
Clancy Avenue	Michigan	Fairbanks	1911	Westrumite	2"	6" concrete	C.E.Williams
Clark Place	Crescent	Michigan Alley	1913	Westrumite	1½"	4" cobble,2"crushed	McDermott & Cooper
Eastern Ave.	Wealthy	Franklin	1912	Fluxed Gilsonite	2"	6" concrete	H.Vander Veen (Wearig Surface Carpenter & Anderson (Base)
Fountain Street	Union	Eastern	1912	Fluxed "	2"	6" concrete	H.Vander Veen (Wearing Surfac Carpenter & Anderson (Base)
Fulton Street	Jefferson	Union	1910	Sarco	2"	Old Macadam	Carpenter & Anderson
Franklin Street	Division	Lafayette	1914	Sarco	2"	6" Concrete	Carpenter & Anderson
Franklin Street	Lafayette	Eastern	1913	Sarco	2"	6" concrete	Carpenter & Anderson
Fairview Ave.	Michigan	Mason	1910	Sarco	2"	6" concrete	Kloote & Vander Veen
Ghilda Court	Lyon	Fountain	1910	Sarco	1¼"	4"cobble, 3"crushed,	McDermott & Cooper
Jefferson Ave.	Wealthy	Franklin	1913	Sarco	2"	Old 5" concrete	Carpenter & Anderso
Lafayette Ave.	Lyon	Michigan	1909	Westrumite	2"	6" concrete	L.C. Hillding
Lafayette Ave.	Michigan	Fairbanks	1912	Westrumite	2"	6" concrete	O. P. Carpenter
Lyon Street	Division	Union	1910	Sarco	2"	6" concrete	Kloote & VanderVeen
Library Street	Division	Ransom	1910	Sarco	2"	6" concrete	Kloote & VanderVeen
Madison Ave.	Wealthy	Franklin	1914	Sarco	2"	Old concrete	Carpenter & Anderson
Plainfield Ave.	Quimby	Ann	1912	Bermundez	2"	Old gravel	Carpenter & Anderson
Prospect Ave.	Michigan	Crescent	1913	Westrumite	2"	6" concrete	McDermott & Cooper
West Park Ave.	Monroe	Park	1910	Sarco	2"	6" concrete	Kloote & VanderVeen
Scribner Ave.	Bridge	Shawmut	1911	Sarco	2"	6" concrete	L. C. Hillding
Union Ave.	Wealthy	Pleasant	1914	Sarco	2"	6" concrete	Carpenter & Anderson
Washington St.	State	College	1914	Sarco	2"	Old concrete	Carpenter & Anderson

LIST OF STREETS PAVED WITH CONCRETE

Street	EXTENT From	To	Year	Thickness of Top.	Thickness of Foundation
Arlington Place	Delaware	North End	1911	1"	5-1/2"
Auburn Ave. Alley	Lillian	Lake Drive Alley	1906	1"	6"
Atwood Street Alley	Union	Grand	1913	1"	5-1/2"
Cherry Drive	Fairmount	Cherry	1908	1-1/2"	6"
Cornwall Avenue	Franklin	Pleasant	1905	1"	6"
Clifton Place	Lyon	South Bend	1901	1"	6"
Congress Place	Fulton	Baldwin	1913	1"	5-1/2"
Diamond Ave. Alley	Baldwin	Lake Drive	1914	1"	5-1/2"
Donald Place	Wealthy	North End	1901	1"	6"
Fitch Place	Lake Drive	South End	1911	1"	5-1/2"
Freyling Court	Wealthy	North End	1909	1"	6"
Ghilda Place	Lyon	Crescent	1913	1"	5-1/2"
Hastings Street	Ionia	Fairview	1913	1"	5-1/2"
Lake Drive Alley	Auburn Alley	Fuller	1906	1"	6"
Marion Place	Bridge	1st Street Alley	1913		5-1/2"
Pleasant Alley North	Division	Cody Alley	1913	1"	5-1/2"
Portsmouth Terrace	Fulton	Fountain	1907	1-1/2"	6"
Quigley Blvd.	Division	Buchanan	1904	1"	6"
Trowbridge Street	Fairview	West End	1914	1"	5-1/2"
Van Dine Place	Fulton	North End	1906	1"	6"
Wealthy Alley	Benjamin	Giddings	1913	1"	5-1/2"
Wellington Court	Eastern	Fairmount	1907	1-1/2"	6"

From our table of maintenance costs we are able to learn, by noting the year laid, approximate amount of traffic, location and relative length, just how a certain street has lasted during its life up to this time.

Sheet Asphalt.

The first sheet asphalt paving was completed in 1891, when approximately one mile of pavement was laid. During that year 24,587 sq.yds. of sheet asphalt, costing $94,493.00 was laid making an average total cost per square yard of $3.86. The minimum cost of one square yard occurred in 1900 at an average of $1.71. Up to 1916, 153,331 square yards of sheet asphalt has been used for paving, costing $337,194.00 or the total average cost per square yard is $2.39. The total average cost of sheet asphalt for the largest cities of the country, according to Judson, amounts to $2.28. The average cost since 1891 bids fair to be lowered materially in the future according to indications during the past ten years. The average cost for the past decade is approximately $1.89 per sq.yd. which more nearly approaches the estimates made upon similar pavements for cities in this section of the country.

Bituminous Concrete.

Bituminous concrete as a paving material is of comparatively recent origin in Grand Rapids. In 1909 2,589 sq.yds. were laid which cost $7,690.00 or $2.98 per sq.yd. that price being the maximum of the yearly averages

since that time. In 1911 the minimum average was found at $3.02. The cost of bituminous concrete varies greatly according to the cost of the substance used in making up the aggregate compound. The processes of manufacture and method of laying have been patented to a large extent. Sarco, Westrumite and Warrenite are patented processes involving the use of bituminous concrete. The total average cost of bituminous concrete is $2.30 per sq.yd. We were unable to secure cost data for bituminous concrete from other cities which were uniform in any way. The great variation in cost was due to the character and grade of materials used in the patented process but the average in Grand Rapids compared favorably with that of the country as a whole.

Creosoted Wood Block.

In 1902 creosoted wood block was first introduced when 401 sq.yds. were laid. In 1907, 4,990 sq.yds. were paved in this way at the minimum cost of $2.86, The following year the cost became almost prohibitive for the enormous amount of $5.10 per sq.yd, was paid. Since 1909 no creosoted wood block have been used as new paving material. The average original cost of the wood block pavements now in use approximate $3.67 which is much higher than that of any other paving substance. The high cost of wood block is universal so that this condition in Grand Rapids is not singular but for the fact that the average cost is a trifle higher than that throughout the country. A consideration to be covered in a more complete study of this type of pave-

ment is the kind of wood used in the block.

Block Asphalt.

Block asphalt has varied a great deal in its original cost from $1.77 in 1910 to $3.13 per sq.yd. in 1905. The average cost of one square yard was found to be $2.42. This amount shows a most representative average of the unit cost of such paving in the country. For example, the city of Toledo for two years contracted to let contracts for block asphalt paving at $2.32 to $2.45 per square yard.

Concrete as a pavement has been found to be cheaper initially than any other type used in the city. The average costs per square yard have run from $1.35 in 1905 to $2.08 in 1911. The average unit cost since 1901, when concrete was first used has been $1.63. This amount is practically the mean unit cost for this section of the country. Data from the entire country reveal large differences in cost. The large Western cities pay 75 to 100% more than those in the east because of the expense of transportation. Concrete pavements have also been protected by patents to a certain extent. The more familiar names are Hassan and Granitoid.

Cost of Pavements.

If any intelligent conclusions are to be drawn relative to the economy of the various types of roads and pavements it is essential that records and cost data be available. After considerable search through the records in the office of the Board of Public Works we have obtained

figures relative to the original cost of the pavements. As is probably the case in many other cities in the United States the changes in the administration of the highway department of Grand Rapids renders complete scientific investigation almost impracticable. These investigations must extend over a sufficient length of time to warrant definite conclusions.

The first brick pavement was laid in 1891, when a section of Pearl Street from Ottawa to Grand River was paved with Hallwood brick, pitch filled. The total cost of the improvements averaged $1.55 per square yard. Since that time the initial cost of brick pavements have been much more uniform than any other paving material. The maximum cost per square yard was reached in 1893 at $2.83; in 1912 the cost fell to $1.28 as the minimum cost per square yard. The minimum cost is much lower than any data which we have been able to find for similar work done in other cities of the country. At that time(1912) furniture manufacture was in the throes of a strike. The extraordinary large supply of laborers at this time tended to cheapen the wages of workmen, hence the cost per square yard of pavement was lowered.

The total cost of the brick paving constructed by the city to 1916 amounted to $1,722,680.00. The amount of brick roadway laid totaled 902,237 square yards. From these figures it will be seen that the average cost per square yard of brick paving for the years 1891 to 1916 was $1.91. The kind of filler used determines to a large extent its cost. Paving cement in the form of bituminous pitch or asphaltic compounds is in some cases best but the cost is more than

cement roads as a general rule. In this connection it might be well to state that after a thorough investigation of the original cost average of brick pavements throughout the country amounted to $1.92. This figure compares quite favorably with the average of $1.91 given above. When we consider the cost of transportation of brick and other materials combined in the latter amount, Grand Rapids falls well within the average for the whole country.

Summary of Miscellaneous Improvements.

Year	Length in Miles	Sq. yds. Roadway	Av. Cost per Sq. yd. Improvements	Av. Cost per Sq. yd. Pavement	Total Cost Pavement	Total Cost of Improvement
BLOCK ASPHALT						
1900	.683	14,590	$2.57			$37,480.
1904	.293	4,780	3.09			14,750.
1905	.238	3,254	3.12			10,163.
1910	.663	10,516	1.77	$1.46	$15,353.21	18,740.
1913	.370	6,092	2.21	1.65	10,051.47	14,055.
Totals-	2.247	39,232	$2.42			$95,188.
CONCRETE						
1901	.187	2,196	1.72			$ 3,771.
1904	.236	4,502	1.42			6,415.
1905	.279	3,378	1.35			4,545.
1906	.120	1,003	1.90			1,904.
1907	.240	2,860	1.84			5,268.
1908	.125	605	1.70			1,023.
1909	.110	953	1.47	$1.00	$952.16	1,405.
1911	.100	1,249	2.08	1.01	1,250.94	2,615.
1913	.520	4,410	1.57	1.16	4,819.78	6,911.
1914	.156	1,738	1.68	1.13	1,970.07	2,910.
1915	.338	3,619	1.80	.99	3,511.62	6,535.
Totals-	2.411	26,513	1.63			$43,291.

Summary of Miscellaneous Improvements.

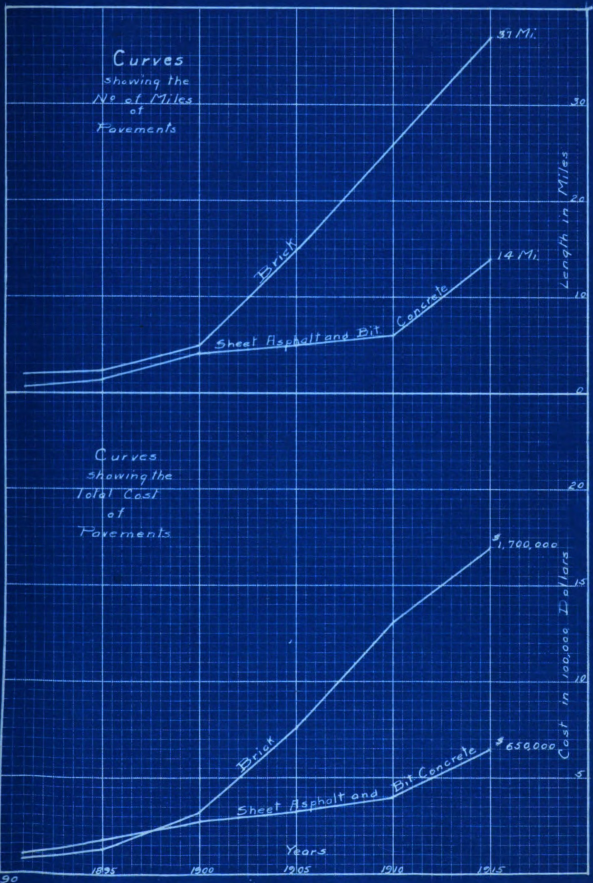
Year	Length in Miles	Sq. yds. Roadway	Av. Cost per Sq. yd. Improvements	Av. Cost per Sq. yd. Pavement	Total Cost Pavement	Total Cost of Improvement
SHEET ASPHALT						
1891	1.000	24,587	3.86			$94,493.
1892	.677	13,978	3.08			43,006.
1893	.277	4,877	2.89			14,080.
1894	.379	6,913	3.23			22,280.
1896	.450	7,707	1.95			15,050.
1897	1.366	27,111	1.89			51,025.
1898	.868	14,197	2.09			29,600.
1899	.356	5,840	2.55			14,800.
1900	.280	11,111	1.71			18,971.
1902	.590	11,974	2.43			29,000.
1906	.192	3,960	1.93			7,619.
1913	.561	12,976	1.79	$1.35	$17,518.42	23,145.
1915	.403	8,100	1.75	1.25	10,125.00	14,125.
Totals-	3.448	153,331	$2.39			$377,194.

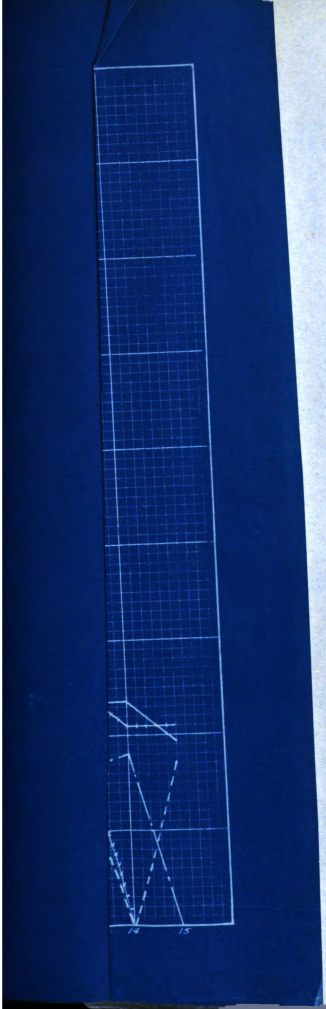
Summary of Miscellaneous Improvements.

Year	Length in Miles	Sq. yds. Roadway	Av. Cost per Sq. yd. Improvements	Av. Cost Pavement per Sq. yd.	Total Cost Pavement	Total Cost of Improvement
BITUMINOUS CONCRETE						
1909	.198	2,589	$2.98	$1.25	$ 3,235.88	$ 7,6[illegible].
1910	2.133	34,692	2.14	1.08	35,348.79	74,2[illegible].
1911	.832	14,516	2.02	.85	11,121.67	29.2[illegible].
1912	1.554	24,655	2.24	.83	20,198.26	55,161.
1913	1.273	20,189	2.54	.99	21,008.44	51,188.
1914	1.388	22,226	2.10	1.10	24,449.04	46,705.
1915	.486	7,688	2.10	1.10	8,546.14	16,815.
Totals-	7.864	126,555	2.30		123,818.22	281,049.
CREOSOTED WOOD BLOCK						
1902	.013	401	3.38			1,357.
1907	.351	4,990	2.86			14,270.
1908	.113	1,248	5.10			6,373.
1909	.130	1,709	3.36	1.90	3,269.24	5,720.
Totals-	.607	8,348	3.67½			27,720.

Summary of Brick Roadway Improvements.

Year	Length in Miles	Sq. yds. of Brick Roadway	Av. Cost per Sq. yd. Improvements	Av. Cost Brick per Sq. yd.	Total Cost of Brick	Total Cost of Improvement
1891	1.047	57,616	$1.55			$ 89,918.
1892	.000					
1893	.065	1,448	2.82			4,090.
1894	.882	21,640	2.02			43,651.
1895	.460	9,656	1.35			12,990.
1896	.080	1,816	2.12			3,840.
1897	.874	23,994	1.59			38,200.
1898	1.017	24,936	1.76			43,940.
1899	.586	15,060	2.25			33,700.
1900	1.274	28,501	1.94			55,415.
1901	1.058	24,241	1.76			42,738.
1902	1.028	23,788	1.86			44,060.
1903	2.592	75,401	2.14			162,051.
1904	.842	19,439	2.19			42,309.
1905	3.621	86,124	1.84			161,205.
1906	1.318	32,332	2.08			67,382.
1907	3.118	73,185	2.10			153,572.
1908	1.600	39,775	2.16			86,092.
1909	2.613	62,365	2.08	$1.20	$73,991.50	129,350.
1910	2.485	55,789	1.98	1.19	64,535.11	110.897.
1911	2.506	62,945	1.53	1.13	57,916.28	94,610.
1912	3.161	66,211	1.28	1.20	79,569.34	84,415.
1913	2.249	36,665	2.38	1.25	49,465.62	85,416.
1914	2.351	42,099	2.38	1.24	51,984.31	100,254.
1915	.988	17,211	1.92	1.32	22,229.16	32,525.
Totals	36.288	803,277	1.91			$1,702,000


Curves
showing the
No of Miles
of
Pavements
37 Mi.
30
20
14 Mi.
10
0
Length in Miles
Brick
Sheet Asphalt and Bit Concrete
Curves
showing the
Total Cost
of
Pavements
20
$1,700,000
15
12
$650,000
5
Cost in 100,000 Dollars
Brick
Sheet Asphalt and Bit Concrete
Years
1895
1900
1905
1910
1915


14
15

ITEM PRICES ON STREET IMPROVEMENTS SEASON - 1915

NO.	ITEMS	UNIT	Brick: Front Ave. Carpenter & Co.	Brick: Louis St. Carpenter C. Co	Brick: Market Ave. Carpenter C. Co	Brick: N.Y. Vernon Ave. Carpenter C. Co	Sheet Asphalt: Monroe Ave. Carpenter C. Co.	Bit Concrete: Lafayette Ave. Carpenter C. Co.	Bit Concrete: Cadwell Ave. Carpenter C. Co.	Concrete: Majors Ct. Hilding & Rabe	Concrete: Stella Ct. Hoan & Bulkema	Concrete: Ten Hoaf Ct. Hoan & Bulkema
19	6" Drain Tile	Lin.ft.										
20	Earth excav. Improved Streets to include trees	Lin.ft.	.20	.40	.40	.15		.25	.50	.30	.15	
21	House laterals & pipe, labor and material	each	18 00	13 00	16 00		17 00	21 00	15 00	7 00	12 50	10 00
30	Curbing - Circular Concrete.	Lin.Ft.	.35	.40	.35			.35	.35		.35	
31	" Straight "	" "	.30	.35	.35	.30		.30	.30		.25	
32	" " Combination C & G incl Fdn.	" "							4.25			
42	3" Sewer tile under curb including excavation & gravel	" "										
43	Concrete paving in alleys including Fdn etc.	Sq.yd							1.00			
53	Foundations concrete Portland	" "	.60	.60	.60	.50			.65			
54	" broken stone	" "					.45	.20				
56	" Concrete for shaping, etc.	Bat'n		1.00	2.00		4.00					
57	" picking off top of old conc.	Sq.yd		.10	.20							
58	Asphalt sheet pavement	" "					1.25					
60	" block " on sand cushion	" "										
61	" " " " mortar bed	" "										
62	Brick Pavement cement grout Filler	" "	1 20	1 20	1 30	1 20	1 30					
63	" " asphalt "	" "										
74	" " (rolcid) cement grout filler	" "	.10	1 00	.50	.40	1 00	.50				1.75
75	" " asphalt "	" "										
85	Concrete " sand mortar top	" "								1 00	1 00	1.00
115	Bituminous Concrete	" "						1 00	1 00			
116	Drain - 8" storm sewer	Lin.Ft		.80								

Cost of Maintenance.

Maintenance cost is a very important factor to be considered in determining the relative merits of pavements. From the ideal curve relations plotted according to the government data we find the maintenance cost relatively much less for wood block and granite than any other paving materials. The standards of maintenance differ widely throughout the country and they vary during each administrative tenure of office. It will thus be seen that any assumption or conclusion which we may draw as to cost of maintenance would be subject to the statement of the engineer as what maintenance means. Correct conclusions may only be drawn when the office is held continuously or for a sufficient length of time to show the adoption of a definite principal.

Brick has been found to have a larger cost of maintenance than any material used for paving in the city. In later years, since 1912 the cost of maintenance of brick paving has been practically uniform. This is undoubtedly due to the fact:

First. That the brick are tested and rattled to insure that they are perfect before being laid. This may be taken as the main reason.

Second. That the filler used more extensively at the present time is cement grout. Pitch which had been used almost entirely formerly did not permanently fill the joints, hence the brick chipped off.

Third. The former use of the sand base made a soft paving base which soon presented a very uneven surface.

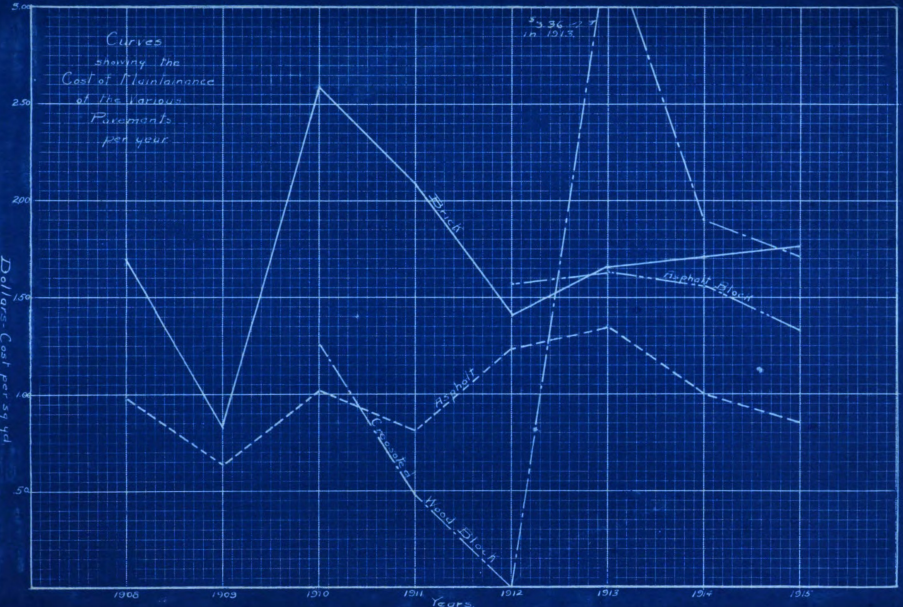
Fourth. The five year guarantee clause in the specifications has given the contractor an incentive to be more careful in the laying of the brick.

Asphalt failures have been due to many causes but the chief of these in Grand Rapids is apparently because it has been subjected to heavy traffic which it makes no claim to withstand. Asphalt is not a heavy traffic pavement and cannot stand up under the heavy loads which brick is designed to hold. This probably accounts for the asphalt failure in the vivinity of the city hall where it is being replaced with brick.

Another reason for failure is through the deterioration of the bitumen and cementing materials in the compound because of exposure and age. The factor may be reduced in size only by comparative tests of asphalts and a chemical analysis of each.

Defects of construction may be taken as a cause of failure. Municipalities are realizing that contractors must be held to strict accountability for every defect by careful inspection and the five-year guarantee clause in the specification.

Wood block as a general rule will be found the cheapest paving to maintain. In Grand Rapids such has been the case except for the year 1913 when the maintenance cost reached $3.36 per square yard. We have been unable to account for this erroneous sum being spent for maintenance.


Curves
showing the
Cost of Maintainance
of the Various
Pavements
per year
$3.36 per yd
in 1913.
Block
Asphalt Block
Asphalt
Granite
Wood Block
Dollars Cost per sq yd
5.00
2.50
2.00
1.50
1.00
.50
1908
1909
1910
1911
1912
1913
1914
1915
Years.

MAINTENANCE COSTS FOR PAVEMENTS IN GRAND RAPIDS, MICH.

BRICK.

STREET	From	To	Year Laid	1908 Sq Yds	1908 Cost	1909 Sq Yds	1909 Cost	1910 Sq Yds	1910 Cost	1911 Sq Yds	1911 Cost	1912 Sq Yds	1912 Cost	1913 Sq Yds	1913 Cost	1914 Sq Yds	1914 Cost	1915 Sq Yds	1915 Cost
Bond Ave	Lyon	Crescl.	1907	—	—	—	—	—	—	—	—	—	—	—	—	8	9.47	—	—
W. Bridge St.	Stocking	Leon	1905	—	—	96	59.33	—	—	—	—	—	—	—	—	—	—	—	—
Bostwick Av.	Lyon	Park	1907	—	—	—	—	—	—	—	—	—	—	—	—	—	—	60	78.25
W. Bridge St.	River	Stocking	1910	—	—	—	—	—	—	—	—	—	—	—	—	56	74.88	32	70.97
Campau Ave	Pearl	Louis	1897 1898																
Campau Ave	Lyon	Pearl	1898	24	31.43	46	32.67	23	28.38	—	—	—	—	—	—	—	—	37	25.99
Campau Ave	Louis	Fulton	1898																
Commerce Ave	Fulton	Monroe	1895	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	33.79
Commerce Ave	Fulton	Wealthy	1909	—	—	—	—	2	11.69	—	—	—	—	—	—	—	—	—	—
Crescent St.	Monroe	Division	1904	—	—	—	—	—	—	42	133.49	—	—	18	24.70	96	164.72	387	492.78
Division Ave	Monroe	Fulton	1896	—	—	225	122.31	—	—	—	—	—	—	—	—	—	—	—	—
Division Ave	Fulton	Wealthy	1906	—	—	—	—	—	—	—	—	—	—	—	—	2	6.58	115	147.68
Division Ave	Wealthy	Front	1907	—	—	—	—	—	—	—	—	—	—	12	18.76	41	83.75	230	144.47
Ellsworth Ave	Fulton	Wealthy	1903	25	18.78	—	—	16	11.00	—	—	6	10.00	103	115.35	93	78.14	46	85.98
Front Ave	Allen	Sherman St.	1894	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fulton St.	River	Valley	1894																
Fulton St.	"	"	1898 1898 1901	78	66.70	18	33.70	—	—	10	23.00	23	32.33	103	33.90	173	246.81	112	393.87
Fulton St.	River	Lexington	1903	—	—	—	—	—	—	—	—	33	46.66	—	—	16	35.44	366	345.52
Godfrey Ave.	Market	South	1901	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	14.14
Goodwillie Rd.	Ellsworth	Hall	1903	13	32.36	—	—	—	—	—	—	25	40.70	75	369.75	7	13.19	77	102.96
Ionia Ave.	Monroe	Fulton	1907	—	—	—	—	—	—	—	—	—	—	—	—	13	25.00	340	304.86
Ionia Ave.	Monroe	Crescent	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Island St.	Division	Ellsworth	1905	—	—	—	—	—	—	—	—	—	—	—	—	31	58.14	187	130.90

MAINTENANCE COSTS
FOR PAVEMENTS IN GRAND RAPIDS, MICH.
BRICK

STREET	From	To	Year laid	1908 Yds	1908 Cost	1909 Yds	1909 Cost	1910 Yds	1910 Cost	1911 Yds	1911 Cost	1912 Yds	1912 Cost	1913 Yds	1913 Cost	1914 Yds	1914 Cost	1915 Yds	1915 Cost
Jefferson Ave	Fulton	State	1895	—	—	—	—	—	—	—	—	—	—	—	—	78	134.65	222	211.39
Louis St	Ionia	Campau	1895	17	15.05	67	68.84	25	33.01	40	45.08	46	66.17	47	69.95	2	4.58	—	—
Lake Drive	Wealthy	Filer	1899	—	—	2	6.98	—	—	—	—	—	—	3	2.70	9	4.70	—	—
LaGrave Ave	Fulton	Wealthy	1907	—	—	—	—	—	—	—	—	—	—	—	—	13	15.91	—	—
W Leonard St	Pleasant	Waite	1904	—	—	—	—	—	—	—	—	—	—	—	—	10	13.49	356	672.54
Lyon St	Lake	Division	1898	3	2.68	5	8.65	—	—	—	—	29	45.47	—	—	31	63.53	193	224.54
Market Ave	Monroe	Fulton	1892	41	45.27	—	—	—	—	11	50.17	39	45.17	—	—	74	116.70	5	4.22
Market Ave	Wealthy	"	1910	—	—	—	—	—	—	—	—	—	—	—	—	57	62.98	—	—
Monroe Ave	Pearl	Fulton	1909	—	—	—	—	—	—	—	—	—	—	—	—	—	—	35	109.23
Monroe Ave	Mich.	Newberry	1900	—	—	—	—	—	—	—	—	—	—	—	—	47	65.60	187	259.62
Michigan St	Monroe	Ottawa	1897	—	—	—	—	—	—	—	—	—	—	51	48.04	—	—	—	—
Ottawa Ave	Mich.	Fulton	1894	—	—	—	—	—	—	—	—	—	—	—	—	21	23.09	15	35.59
Ottawa Ave	Fulton	Island	1900	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ottawa Ave	Chaney	"	1910	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ottawa Ave	Fulton	Louis	1901	—	—	—	—	—	—	—	—	—	—	—	—	—	—	76	75.87
Ottawa Ave	Monroe	"	1907	—	—	—	—	—	—	—	—	—	—	—	—	48	31.67	—	—
Ottawa Ave																			

MAINTENANCE COSTS
PAVEMENTS FOR IN GRAND RAPIDS, MICH.

ASPHALT

STREET	From	To	Year Laid	1908 Sq Yds	1908 Cost	1909 Sq Yds	1909 Cost	1910 Sq Yds	1910 Cost	1911 Sq Yds	1911 Cost	1912 Sq Yds	1912 Cost	1913 Sq Yds	1913 Cost	1914 Sq Yds	1914 Cost	1915 Sq Yds	1915 Cost
Crescent St.	Bridge	Union	1898	39	$ 2.73	420	190.20	117	135.98	98	87.80	114	139.39	76	492.15	432	262.41	675	633.72
Fountain St	Ottawa	Division	1897	44	42.46	17	11.00	31	47.42	20	13.17	24	23.32	59	32.85	136	114.50	183	136.46
Ionia Ave	Monroe	Pearl	1897	220	172.38	149	188.28	58	65.70	305	253.00	171	315.46	124	228.05	138	317.09	189	170.41
Jefferson Ave	State	Fountain	1906	1235	1171.30	1980	646.50	563	536.60	930	689.30	831	946.25	567	221.30	156	267.97	342	327.05
Michigan St.	River	Monroe	1902	—	—	—	—	—	—	—	—	26	33.10	212	245.44	—	—	78	61.51
Ottawa Ave.	Lyon	Mich.	1896	184	180.49	321	237.66	77	96.39	314	281.48	—	—	282	302.29	264	445.90	235	266.25
Pearl St	Division	Ionia	1897	10	13.18	—	—	—	—	—	—	—	—	48	37.00	58	55.30	47	30.39
Prospect St	Fulton	Fountain	1899	—	—	—	—	—	—	—	—	—	—	23	17.00	—	—	41	27.44
Waverly Pl.	State	Cherry	1896	—	—	—	—	—	—	—	—	—	—	51	28.67	48	20.88	121	89.20

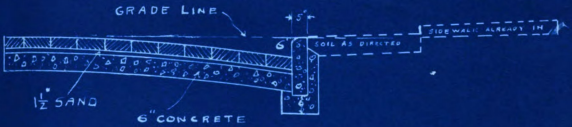
WOOD BLOCK

Fountain St	Lafayette	Union	1907	—	—	—	—	6	7.56	6	2.90	—	—	86	87.40	13	24.35	59	92.67

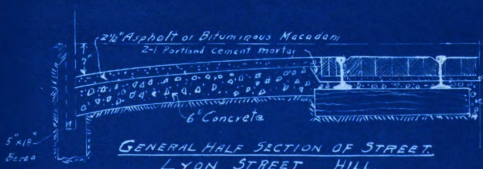
ASPHALT BLOCK

Sheldon Ave	Fulton	Bucklen	1900	—	—	—	—	—	—	—	—	6	9.41	144	326.70	238	369.50	220	320.14
Union Ave	Fulton	Lyon	1904	—	—	—	—	—	—	—	—	—	—	—	—	—	—	59	88.47

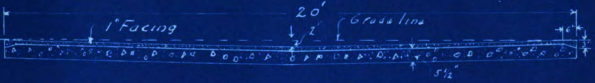
GENERAL SECTION OF CONCRETE ALLEY.



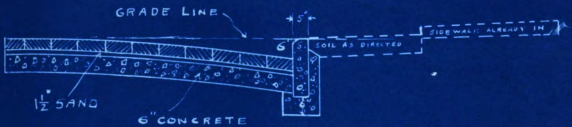
GENERAL HALF SECTION OF BRICK PAVED STREET.



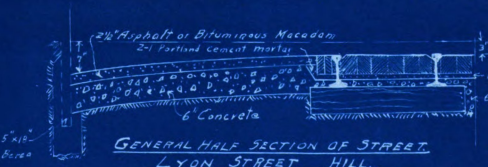
GENERAL HALF SECTION OF STREET.
LYON STREET HILL.



GENERAL-SECTION-OF-CONCRETE-ALLEY.



GENERAL HALF SECTION OF BRICK PAVED STREET.



GENERAL HALF SECTION OF STREET.
LYON STREET HILL.

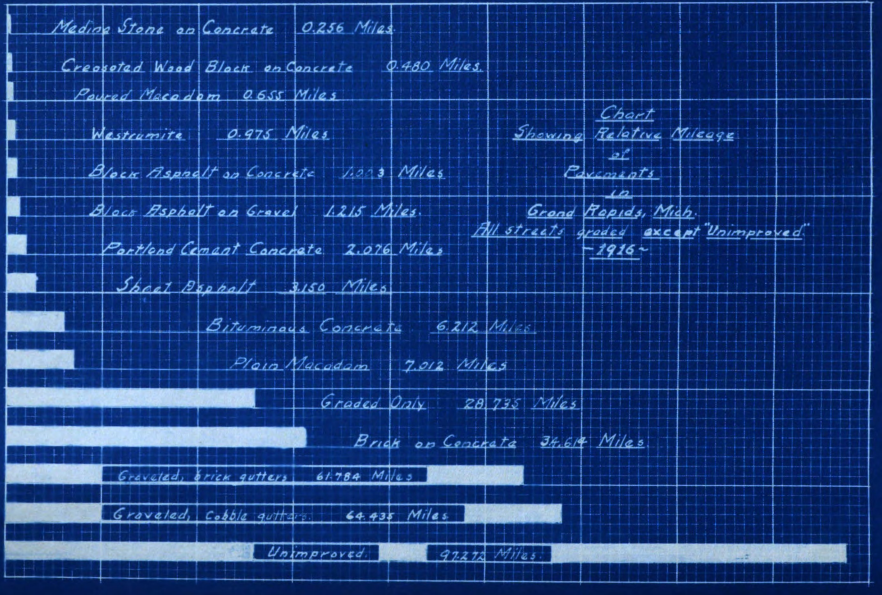


Chart
Showing Relative Mileage
of
Pavements
in
Grand Rapids, Mich.
All streets graded except "Unimproved"
-1916-

[illegible] pavements.

No data has been available concerning the maintenance cost of concrete or bituminous concrete.

The following table will serve to show the cost of maintenance of the various pavements per square yard for each year.

	Cost of maintenance per square yard.			
Year	Brick	Asphalt	Wood	Asphalt Block
1908	$1.70	$ .98		
1909	.835	.64		
1910	2.59	1.01	$1.26	
1911	2.18	.81	.48	
1912	1.41	1.24		$1.57
1913	1.66	1.35	3.36	1.63
1914	1.72	1.00	1.90	1.56
1915	1.76	.85	1.71	1.34

Before concluding our study it may be wise to state a few results which have been found peculiar to the local conditions existing in Grand Rapids in order that the various kinds of pavement, those that are best suited to existing conditions of slope, treasury and traffic and to the local market of proper materials.

During the past few years there has been a steadily increasing use of vitrified brick for the paving

[illegible]. The great objection to the [illegible] such pavements are noisy thereby [illegible] their use especially in the [illegible]. Cement grout as a filler tends to increase the noisiness of brick pavements. The grouting binds the brick firmly to make a solid hard pavement which is much more noisy than the more elastic and deadening pitch of bituminous filler. Pitch during the wide variations of temperature contracts and expands considerably, the pitch softens and runs from the crown of the pavement to the sides exposing the rough surfaces of the brick in the center of the road which soon chip off to destroy the brick. It has been found that the brick laid before the adoption of the specifications of the American Society of Testing Materials, have had a greater cost of maintenance than the more later paving brick. This has been particularly true of the Crescent Street and Grandville Avenue brick pavements.

Drainage for pavements in Grand Rapids seems to be well taken care of by nature itself. The city is especially fortunate in this particular for very little consideration need be given the matter in most cases. A heavy clay forms the base of the greater part of the streets

...alone.

...of the pavements and materials we ... peculiar local conditions such as climatic, topographic and economic well taken care of. During the past few years we have found that the cost of maintenance, one of the largest factors to be considered in paving work, has decreased materially which is evidence of the fact that greater care has been taken in using the most efficient material for the conditions for which it might be subjected. A more complete study would require years of investigation involving traffic censii, chemical research of materials used and the wear per unit area of the street.

We suggest from our investigation that more efficiency might be secured in this department if care were used in placing paving materials which were adapted to the traffic or wearing conditions. Wood block is not primarily a pavement for a residence district. It is more suitable to stand the wear and tear of heavy trucking. Asphalt, with a much lower initial cost has a maintenance value in Grand Rapids which will average less than that of wood block. In laying brick pavements, sand has been a failure as foundation material; the use of it being the reason for more or less uneveness in the surface and the cause of chipping and breaking of the brick.

The condition of the pavements might well be taken as representative of similar conditions throughout the country and indications point t o a more studied consideration of the department as each pavement is laid.

[redacted]