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THESIS
AN INVESTIGATION OF PAVEMENTS
OF CITY OF GRAND RAPIDS
E. F. PERKINS M. A. R. REEVES

1920

THESIS



Commentary

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MICHIGAN AGRICULTURAL COLLEGE

JUNE 1920

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FOR
Investigation of Pavements in the city
Grand Rapids, Michigan.

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The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry, no matter how small, should be recorded to ensure the integrity of the financial data. This includes not only sales and purchases but also expenses and income.

The second part of the document provides a detailed breakdown of the company's assets and liabilities. It lists all fixed assets, including property, plant, and equipment, and provides their respective values. It also details the company's current liabilities, such as accounts payable and short-term debt.

The third part of the document presents the company's income statement for the period. It shows the total revenue generated, the cost of goods sold, and the resulting gross profit. It also details the operating expenses and the final net income for the period.

The fourth part of the document discusses the company's cash flow. It shows the cash generated from operations, the cash used for capital expenditures, and the net change in cash for the period. This section is crucial for understanding the company's liquidity and its ability to meet its financial obligations.

The fifth part of the document provides a summary of the company's financial position at the end of the period. It includes a balance sheet showing the company's assets, liabilities, and equity. This summary provides a snapshot of the company's financial health and its ability to sustain its operations.

The final part of the document contains a concluding statement from the management. It expresses confidence in the company's financial performance and its commitment to maintaining transparency and accuracy in its reporting. It also outlines the company's future goals and the strategies it plans to implement to achieve them.

AN INVESTIGATION OF THE PAVEMENTS
OF
THE CITY OF GRAND RAPIDS.

The object of this investigation is to study the pavements of the streets in Grand Rapids, Michigan, and from their construction, present condition, and the amount of traffic passing over them, to present some conclusions as to the relative merits of different forms of pavements, and the different methods of paving construction as found in the city.

There are approximately three hundred miles of pavements in this city at the present time. All data concerning the cost, dimensions, different types of sketches etc., were obtained from the records of the City Engineer. We are showing along with these records a map of the city together with different types of streets in their own distinctive coloring on this same map and blueprint.

Grand Rapids is a city which has great number of streets with a per centage of grade of more than five, which is the usual grade allowed in all highway work and paving work, as a maximum. The brick furnishes a very good toe-hold in climbing up them, and so we find a great deal of brick used. One of the streets which we examined had a grade of thirteen per cent., and two others had grades respectively of eight and seventy-one hundredths, and nine and nine-hundredths per cent. These last two grades are found on Michigan Avenue from Ottawa



Street west to Barclay Avenue, and have big hand cut Medina blocks with considerable space between them to prevent slipping. The price for such a pavement is prohibitive now, however.

1. The first step in the process of the scientific method is to ask a question. This question should be based on observation and should be something that can be tested. For example, a scientist might ask, "Does the amount of water affect the growth of a plant?"

2. The second step is to do background research. This involves looking up information about the topic to see what is already known. This can be done by reading books, articles, or looking up information on the internet.

3. The third step is to form a hypothesis. A hypothesis is a statement that can be tested. It is usually written in the form of "If...then..." For example, "If a plant gets more water, then it will grow taller."

4. The fourth step is to test the hypothesis. This is done by conducting an experiment. The experiment should be designed so that it can be repeated and the results can be compared to the hypothesis.

5. The fifth step is to analyze the data. This involves looking at the results of the experiment and seeing if they support the hypothesis. If the results do support the hypothesis, then the hypothesis is accepted. If the results do not support the hypothesis, then the hypothesis is rejected and a new hypothesis is formed.

6. The sixth step is to communicate the results. This involves writing a report or giving a presentation about the experiment and the results. This allows other scientists to see the results and see if they can replicate the experiment.

A HISTORY OF THE CITY'S PAVEMENTS.

The statistics which follow were taken from the records of the city engineer, Mr. Page, who was very kind in offering every kind of assistance.

From the report of April 1873 to May 1875:

Improvements of streets and alleys:

Streets grading and paving - - - - -	1526	Lin.Ft.
Grading, graveling and paving gutters-34994	"	"
Grading and graveling - - - - -	23357	"
Alleys grading and graveling - - - - -	2186	"
Alleys grading - - - - -	400	"

Total length of improvements - - - - 62460 " "

Miles - - - 11.83

Total costs of these pavements was \$134,766.19.

The streets paved were Monroe St., from the west line of Waterloo to the south line of Pearl St., Ottawa St., from the north line of Monroe St., to the center line of Pearl St., and Pearl St., from the center of Ottawa St., to the west line of Canal St.

Pavement used is what is known as Chicago Free pavement which consists of pine blocks four inches thick and six inches long, set on end in rows running diagonally across the street with one inch space between rows, which are filled with gravel well rammed. The foundation is six inches or more of sand or fine gravel well rammed and shaped to the crown of the street.

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• 2221. 2222. 2223. 2224. 2225. 2226. 2227. 2228. 2229. 2230.

The reasons for preferring this form of pavement were its cheapness, its simplicity, and the rapidity with which it can be laid, and the ease with which it can be taken up and relaid when necessary for laying or repairing sewers, gas or water pipes.

Gutters were paved with Joliet Stone flagging four inches thick by eighteen inches wide.

Space between the rails of car tracks on Monroe and Pearl Sts., was paved with cobble stones.

On Ottawa and Pearl Sts., the experiment was tried of paving only sixteen feet in width in the center with wood blocks, and the sides with cobble stones set in gravel. Economy in this as stone paving cost less than half as much as wood, and being practically indestructible, while the wood will probably not last more than ten years at the most.

On a street sixty feet wide, the cost of such a pavement with sixteen feet of wood and the balance of stone, would at present prices, not exceed \$3.70 per running foot.

Total length of streets now opened in the city is about 129 miles, of which counting those in progress of construction as finished are,

Graded and paved with wood - - - -	0.15 miles.
" " " " " & stone	0.27 "
" " " " stone - - -	3.25 "
" " graveled with	
paved gutters - - - - -	18.53 "
Graded and Graveled - - - - -	28.69 "

1. The first part of the report is a general introduction.

2. The second part of the report is a detailed description of the project.

3. The third part of the report is a discussion of the results.

4. The fourth part of the report is a conclusion.

5. The fifth part of the report is a list of references.

6. The sixth part of the report is a list of appendices.

7. The seventh part of the report is a list of figures.

8. The eighth part of the report is a list of tables.

9. The ninth part of the report is a list of symbols.

10. The tenth part of the report is a list of abbreviations.

11. The eleventh part of the report is a list of acronyms.

12. The twelfth part of the report is a list of footnotes.

13. The thirteenth part of the report is a list of endnotes.

14. The fourteenth part of the report is a list of references.

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23. The twenty-third part of the report is a list of references.

24. The twenty-fourth part of the report is a list of appendices.

25. The twenty-fifth part of the report is a list of figures.

Graded - - - - -	8.12 miles
Unimproved - - - - -	<u>70.20 "</u>
Total - - - - -	129.21 Miles.

Report of May 1, 1876: -

The following street improvements have been completed:

Grading and paving - - - - -	18.85 Lin.Ft.
" graveling & paving gutters - -	12737 " "
" " . - - - - -	10317 " "
Paving Gutters - - - - -	<u>1282 " "</u>
Total - - - - -	26221 " "

Miles - 4.86

Contracts were let for

Grading and paving - - - - -	11352 Lin.Ft.
" ,Graveling & paving gutters - -	16590 " "
" " . - - - - -	924 " "
" . - - - - -	<u>1356 " "</u>
Total - - - - -	30222 " "

Miles - 5.72

The paving is all of the kind adopted by the Board in 1874, wood blocks in the center and cobble stones on the side of the street which so far appears successful and popular.

Total length of streets now opened in the city is over 131 miles, of which counting those now under improvement as finished are:

Graded and paved with wood - - - - -	0.15 miles
" " " " " & stone - - -	2.68 "

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Graded and paved with stone - - - - -	1.55 miles
" ,graveled & gutters paved - - -	21.56 "
" & " . - - - - -	29.50 "
" . - - - - -	8.02 "
Unimproved - - - - -	<u>67.66 "</u>
Total - - - - -	131.12 "

In 1877 few improvements were made.

The same is true for 1880, altho the total estimated length of the streets now opened in the city is 132.57 miles, unimproved 67.28 miles.

In 1889 the mileage of streets had been increased by platting and street opening 5.45 miles, making the total miles of streets on April 30, 1889, 148.462 miles.

The number of miles of improved streets had been increased by 31,218 lineal feet, making the aggregate of improved streets 92.308 miles.

In 1897, while the total expenditure \$105,420.00 has not been as much as usual, it is gratifying to know that the greater part of it has been expended on the higher grades of work. The total length of the improved streets is 150.726 miles.

In 1898:-

Mileage of the streets in the city is shown by the following table which gives the lengths of the various kinds of pavements :

Graded and paved with asphalt - - - - -	4.221 miles
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Graded and paved with brick on concrete - - - - -	3.512 miles
Graded and macadamised - - - - -	1.260 "
" " paved with tar concrete - - - - -	0.282 "
" " " " cedar blocks on concrete -	6.254 "
" " " " " " planks - -	.528 "
" " " " " " gravel - -	2.973 "
" " " " " " & cobble - - -	90.785 "
" " " " cobbles on gravel - - - -	.958 "
" ,graveled and gutters paved with brick - -	4.356 "
" . - - - - -	-31.049 "
Unimproved - - - - -	<u>129.071 "</u>
Total - - - - -	283.698 "

In 1900 added improvement brought the total mileage to 286.263 reported a year ago. 174.110 miles have been improved leaving 11,087 miles or about 39 per cent of the total mileage still unimproved.

Bituminous macadam improvement on the north side of North Lafayette St., was completed and presents a pleasing appearance and is entirely satisfactory, except for the hardness of the bitumen used in the surface. If this had been softer it would have given a better foothold for the horses and had greater life. This defect can be remedied when the street has had more wear, by the application of a flush coat of bitumen and stone chips or coarse sand rolled in.

North Union St., was improved with asphalt blocks on a gravel and cobble stone foundation. Under protest from this

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department the above foundation was used. All possible precautions were used to secure a good foundation but the vibration of the rails makes it difficult to hold the blocks in position. The contractor has relaid some portions several times and will be to some expense and trouble during the life of the guarantee. The old cobble stone combined with grave; and properly rolled makes an excellent foundation on residence streets. Only a concrete foundation should be used in streets having street car tracks.

Hocking Valley and Wooster blocks were chiefly used during the past year. Hocking Valley proved very satisfactory but so much trouble with Wooster that they were finally barred from the streets and work completed with Metropolitan blocks.

Testing each car load of blocks was practiced.

Total mileage of streets to date increased to 287.197 miles.

In 1910 - - - 2.9 miles of streets have been added to the total mileage of 296.37 reported a year ago, making a total of 299.27 miles. 187.738 miles have been improved, 10.738 miles of which have been improved this year, leaving 111.532 miles, or about 37 per cent of total miles still unimproved.

In brick paved streets the type of construction employed during the previous year was followed, all brick used being Metropolitan, except in the paving of Monroe St., This

street west of Division was repaved outside the Street Railway tracks with Bessemer blocks. Repairing between the outer rails of the tracks was done by the Grand Rapids Railway Company, using grooved granite railblocks along the rails and Metropolitan blocks for the balance of that portion of the pavement.

On all brick pavements cement grout filler was used as a filler, expansion being provided for by pouring a single wide joint cross-wise of the street about every fifty feet, also the joints along the curbs with Pioneer Asphalt filler. Expansion joints across the roadway were omitted in the repaving of Monroe St., and joint full depth of the brick and an inch and one half in thickness was formed along the curbs by inserting a wooden strip which was drawn after the brick were laid, and the space thus left was filled with the asphalt filler.

Tar-filled macadam was locally employed for the first time in the improvement of North College Avenue, between East Fulton St., and Lyon St.

The second stretch of creosoted wood block pavement put down in this city was laid on North Lafayette St., between Fountain and Lyon Sts., the construction being similar to that previously employed in the paving of a part of Fountain St.

In investigating the different types of pavement now in use in this city, we found the brick pavement predominating and giving the best wearing satisfaction with least cost of maintenance.

CEMENT CONCRETE PAVEMENTS.

Location of Concrete Pavements:

1. On Apline Ave., north from North St., fine condition, residence district. (1909)
2. On Tamarack Ave., from Leonard St., to North St., good condition, slightly wavy, residence district. (1917).
3. On Davis Ave., from Seventh St., to Leonard St., Monolithic gutter and pavement, fair condition, slightly pitted, some cracks, curb breaking off considerably. (1916).
4. On National Ave., from Shawmut St., to Bridge St., Monolithic gutter and pavement, fair condition, curb breaking off considerably. (1916).
5. On Straight Ave., from Fulton to Shawmut St., the two streets are in good condition, two street car tracks with brick pavement therein. (1916).
6. On Union Ave., north to city limits from Leonard St., in very good condition. (1916)
7. On Burr Oak St., east from Monroe Ave., excellent condition. (1916).
8. On Cleveland Ave., from Franklin to Alexander, good condition. (1919).
9. On Liberty St., off Granville Ave., excellent type of concrete pavement, perfect condition. (1919).
10. On Madison Ave., south from Crawford St., to the city limits, fair condition. (1919).

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11. On Hastings St., from Ionia to Fairview, excellent condition, steep grade, (fifteen per cent) little on no travel, residence district, put in in 1913.

One of the main and first things to think of in the design, is the sub-drain. This does not apply alone to cement concrete pavements but should be carefully considered in any type. If sub-drains are put in properly, the imminent trouble of freezing (meaning heaving and cracking) will be avoided.

For the specifications for the one course cement concrete see the standard specifications which follow:

“ Materials: The cement shall meet the requirements of the Standard Specifications and Tests for Portland Cement, adopted by the American Society for Testing Materials, September 1, 1916. ”

“ Fine aggregate shall consist of natural sand or screenings from hard, tough, durable crushed rock or gravel consisting of quartzite, grains or other equally hard material graded from fine to course with the course particles predominating. Fine aggregates, when dry, shall pass a screen having four (4) meshes per linear inch; not more than twenty-five (25) per cent. Shall pass having fifty (50) meshes per linear inch and not more than five per cent. shall pass a sieve having one hundred (100) meshes per linear inch. Fine aggregate shall not contain vegetable or other deleterious matter. ”

“ Fine aggregate shall be of such quality that motor

composed of one part Portland cement and three parts fine aggregate, by weight, when made into briquettes, shall show a tensile strength (at seven (7) and twenty eight days) equal or greater than the strength of briquettes composed of one part of the same cement and three parts of standard Ottawa sand by weight. "

"The percentage of water used in mixing the briquettes of cement and fine aggregate shall be such as to produce a mortar of the same consistency as that of the Ottawa sand briquettes of standard consistency. In other respects other briquettes shall be made in accordance with the methods outlined in the Standard Specifications and Tests for Portland Cement, adopted by the American Society for Testing Materials, September 1st, 1916."

"Coarse aggregate shall consist of clean, hard, tough, durable crushed rock or pebbles, graded in size, free from vegetable or other deleterious matter, and shall contain no soft, flat or elongated particles. The size of coarse aggregate shall be such as to pass a one and one-half (1- $\frac{1}{2}$) inches down, not more than five (5) per cent. passing a screen having four (4) meshes per linear inch, and no intermediate sizes shall be removed."

"Crusher-run stone, bank-run gravel or artificially prepared mixtures shall not be used."

"Water shall be clean, free from oil, acid, alkali or vegetable matter."

"Grading: "Grading" shall include all cuts, fills,

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properties of the function $f(x)$ defined by the equation

$f(x) = \int_0^x f(t) dt$ and the function $g(x)$ defined by the equation

$g(x) = \int_0^x g(t) dt$ and the function $h(x)$ defined by the equation

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$ah(x) = \int_0^x ah(t) dt$ and the function $ai(x)$ defined by the equation

approaches and earth or rock moving for whatever purposes, where such work is an essential part of, or necessary to the prosecution of the contract."

"Stakes will be set by the engineer for the center line, finished grades and other necessary points."

"When the material excavated from the cuts is not sufficient to make the fills, the contractor shall furnish the necessary extra materials, to bring the fills to the proper width and grade. When the earthwork is completed, the cross-section of the roadbed shall conform to the cross-sectional drawings and profile attached hereto."

"All approaches connecting the specified pavement with other streets or alleys intersecting, shall also be cut or filled and secured from settlement, to form a slope of not more than one (1) vertical to ten (10) horizontal as shown on profile and plans attached hereto."

"The sub-grade shall be brought to density by rolling the entire area with a self-propelled roller. All portions of the surface of the sub-grade which are inaccessible to the roller, shall be thoroughly tamped with a hand tamp weighing not less than fifty (50) pounds, the face of which shall not exceed one hundred (100) square inches in area. All soft, spongy or yielding matter shall be entirely removed and the space refilled with suitable material."

"When considered necessary or of assistance in producing a compact, solid surface, a sub-grade, before being rolled, shall be well sprinkled with water."

"When the cement is to be constructed over an old pavement composed of gravel or macadam, the latter shall be entirely loosened and spread for the width of the pavement and rolled. All interstices shall be filled with fine material and rolled to make a dense, tight surface.

Drainage: All the catch basins and manhole tops and all covers of openings of any kind shall be adjusted to the grade by the contractor at the price shown under this item, in his bid.

Under drains shall be constructed as shown on the street plan and as directed by the Engineer. These drains shall be connected with sewer or catch-basins. Each contractor shall submit a price per lineal foot for under-drain work. In case no bid for under-drain has been submitted and the Engineer shall order same constructed, the contractor shall construct same for the actual cost plus ten per cent as provided by the contract, paragraph No. 8.

No concrete shall be deposited until the sub-grade is checked and accepted by the Engineer.

Pavement Section: The concrete shall have the thickness shown on the plans. Contractor shall shape sub-grade to the exact contour as shown by plan.

Joints: Transverse shall be three eighths (3/8) of an inch wide and shall be placed across the pavement perpendicular to the center line, not more than forty-five feet apart. When the pavement is laid adjacent to buildings or other masonry structures, a joint shall be constructed between the pavement and the structure.

A jointing tool as shown on the attached detail will be used on all joints.

All catch basins, manhole tops, poles or other fixed objects, which project through the pavement, shall be separated from the concrete by joint filler at least one-half of an inch.

All joints shall be formed by inserting during the construction the required thickness, and leaving in place, prepared strips of fiber matrix and bitumen, or other similar material of approved quality, which shall extend through the entire thickness of the pavement.

The longitudinal joints shall extend through the thickness of the pavement, and the filler shall project not less than one-half ($\frac{1}{2}$) inch above the finished surface. Before the pavement is opened to traffic, joint filler shall be cut off to the height of one quarter ($\frac{1}{4}$) inch above the surface of the pavement.

Measuring Material and Mixing Concrete: The method of measuring the materials for the concrete, including water, shall be one which will insure separate and uniform proportions of each of the materials at all times. A sack of Portland Cement (94 pounds net) shall be considered one (1) cubic foot.

The materials ~~shall be mixed~~ in a batch mixer approved by the Engineer, and irrespective of the size of the batch and rate of speed used, mixing shall continue after all materials are in the drum for at least one (1) minute before any part of the batch is discharged from the drum.

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The drum shall be completely emptied before receiving any material ~~mx~~ for the succeeding batch. The volume of the mixed material used per batch shall not exceed the manufacturers rated capacity of the drum~~mm~~ in cubic feet of the mixed material.

Re-tempering of mortar or concrete which has partly hardened , that is, re-mixing it with or without additional materials or water, shall not be permitted.

The concrete shall be mixed in the proportions of one (1) sack of Portland Cement to not more than two (2) cubic feet of the fine aggregate, and not more than four (4) cubic feet of the coarse aggregate, and in no case shall the volume of the fine aggregate be less than one half ($\frac{1}{2}$) of the volume of the coarse aggregate.

A cubic yard of concrete in place shall contain not less than one and three quarters ($1\frac{3}{4}$) barrels of cement.

The inspector shall compare the calculated amount of cement required according to the specifications with the amounts used in each section of concrete between successive transverse joints, as determined by actual count of the number of sacks of cement used in each section. If the amount of cement used in any three (3) adjacent sections (between transverse joints) is less than 2 per cent, or if the amount of cement used in any one section is less by more than five (5) per cent of the amount hereinbefore required, the contractor shall remove all such sections, and replace the same with new materials, according to these specifications, at his own expense.

1. The first step is to identify the problem or question that needs to be answered.

2. The second step is to gather relevant information and data.

3. The third step is to analyze the information and data to identify patterns and trends.

4. The fourth step is to develop a hypothesis or a proposed solution.

5. The fifth step is to test the hypothesis or solution through experiments or observations.

6. The sixth step is to evaluate the results of the tests and determine if the hypothesis is supported or refuted.

7. The seventh step is to draw conclusions based on the results of the tests.

8. The eighth step is to communicate the findings of the study to others.

9. The ninth step is to reflect on the process and identify areas for improvement.

10. The tenth step is to apply the findings to real-world situations.

11. The eleventh step is to continue to explore the topic and seek further knowledge.

12. The twelfth step is to share the knowledge with others and contribute to the field.

13. The thirteenth step is to stay up-to-date on the latest research and developments.

14. The fourteenth step is to collaborate with others and seek feedback.

15. The fifteenth step is to maintain a positive attitude and a growth mindset.

16. The sixteenth step is to be open to new ideas and perspectives.

17. The seventeenth step is to be persistent and not give up easily.

18. The eighteenth step is to be curious and ask questions.

19. The nineteenth step is to be organized and manage time effectively.

20. The twentieth step is to be a lifelong learner and always seeking to improve.

21. The twenty-first step is to be a team player and work well with others.

22. The twenty-second step is to be a good communicator and listen actively.

23. The twenty-third step is to be a good problem solver and think creatively.

24. The twenty-fourth step is to be a good decision maker and take responsibility for choices.

25. The twenty-fifth step is to be a good leader and inspire others.

26. The twenty-sixth step is to be a good mentor and help others grow.

27. The twenty-seventh step is to be a good role model and set a positive example.

28. The twenty-eighth step is to be a good citizen and contribute to society.

29. The twenty-ninth step is to be a good friend and support others.

30. The thirtieth step is to be a good person and live with integrity.

The materials shall be mixed with only sufficient water to produce a concrete which will hold its shape when struck off with a template. The consistency shall not be such as to cause a separation of the mortar from the coarse aggregate in handling.

Placing Concrete: Immediately prior to placing the concrete the sub-grade shall be brought to an even surface. The surface of the sub-grade shall be thoroughly wet, but shall show no pools of water when the concrete is placed.

After mixing, the concrete shall be deposited rapidly upon the sub-grade, to the required depth and on the entire width of the pavement in successive batches, and in a continuous operation without the use of intermediate forms or bulkheads between the expansion joints. Any concrete in excess of that needed to complete a section at the stopping of work, shall not be used.

Re-Inforcements: The pavement shall be re-inforced with wire fabric. The cross-section area of the metal shall amount to at least 0.066 square inches per foot, measured parallel to the axis of the street, and weigh not less than 25 pounds per 100 square feet. The re-inforcing steel shall be placed two (2) inches below the finished surface of the pavement. It shall not cross expansion joints, and shall be lapped about six (6) inches sufficiently to develop the full length of the material.

Finishing: The surface of the concrete shall be

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text outlines various methods for organizing and storing data, including digital databases and physical filing systems. It also mentions the need for regular audits and reviews to ensure the integrity of the information.

2. The second section focuses on the role of communication in the organization. It highlights that effective communication is crucial for coordinating efforts and ensuring that all team members are aligned with the organization's goals. The text provides guidelines for both internal and external communication, stressing the importance of clarity, brevity, and timeliness. It also discusses the use of various communication channels, such as email, meetings, and public relations, to reach different audiences.

3. The third part of the document addresses the issue of resource management. It explains that resources, whether human or material, must be allocated wisely to achieve the organization's objectives. The text offers strategies for identifying available resources, assessing their needs, and prioritizing their use. It also touches upon the importance of training and development to enhance the skills and capabilities of the workforce.

4. The final section discusses the overall mission and vision of the organization. It states that a clear and compelling mission statement is vital for guiding the organization's actions and inspiring its members. The text encourages the organization to stay true to its core values and to adapt to changing circumstances while maintaining its long-term vision. It concludes by emphasizing the importance of continuous improvement and innovation in achieving the organization's goals.

struck off for the entire width of the pavement by means of a template or strike-board. Any holes left by removing any material or device used in constructing the joint shall be immediately filled with mortar composed of one (1) part cement and two (2) parts of fine aggregate.

As soon as possible after the concrete has been struck off, it shall be rolled with an approved metal roller, having a smooth, even surface, approximately six (6) feet in length not less than eight (8) inches, nor more than twelve (12) inches in diameter, and weighing not more than one hundred (100) pounds. On pavements less than twenty (20) feet in width the roller may be operated with a handle, which shall be at least two (2) feet longer than the width of the pavement and all rolling shall be done from one side of the slab. On pavements twenty (20) feet or more in width, the roller shall be provided with two (2) bails to which ropes shall be attached, and the roller pulled across the pavement. The roller shall be operated at such an angle with the center line of the pavement, that it advances along the pavement about two (2) feet for each time across. The roller shall pass from edge of the pavement to the other. After the roller has covered a given area in the manner described, the same area shall be similarly covered by the roller as many times as may be necessary to remove excess water.

After the rolling has been completed, the pavement shall be finished by two applications of a belt made of

canvas or rubber belting, nor less than six (6) inches wide and not less than two (2) feet longer than the width of the pavement. The belt shall be applied with a combined cross-wise and longitudinal motion. For the first application, vigorous strokes of at least twelve (12) inches long shall be used, and the longitudinal movement of the belt along the pavement shall be very slight. The second application of the belt shall be immediately after the water glaze or sheen disappears, the stroke of the belt shall be not more than four (4) inches, and the longitudinal movement shall be much greater than the first belting.

Curing and Protection: Excepting as hereinafter specified, the surface of the pavement shall be sprayed with water as soon as the concrete is sufficiently hardened to prevent pitting, and shall be kept wet until an earth or other improved covering is placed. As soon as it can be done without damaging the concrete, the surface of the pavement shall be covered with not less than two (2) inches of earth or other material approved by the Engineer, which covers shall be kept wet for at least ten (10) days. When deemed necessary or advisable by the Engineer, freshly laid concrete shall be protected by canvas until such covering can be placed.

Under the most favorable conditions for hardening in hot weather, the pavement shall be closed to traffic for at least fourteen (14) days, and in cool weather for

1. The first step in the process of the scientific method is to make an observation or ask a question.

2. The second step is to do background research to learn what is already known about the topic.

3. The third step is to form a hypothesis, which is a prediction or an educated guess about the outcome of the experiment.

4. The fourth step is to design and conduct an experiment to test the hypothesis.

5. The fifth step is to analyze the data and draw a conclusion based on the results of the experiment.

6. The sixth step is to communicate the results of the experiment to others.

7. The seventh step is to repeat the experiment to verify the results.

8. The eighth step is to use the results of the experiment to make a generalization or a theory.

9. The ninth step is to use the theory to make predictions about future events.

10. The tenth step is to use the predictions to design and conduct further experiments.

11. The eleventh step is to use the results of the further experiments to refine the theory.

12. The twelfth step is to use the refined theory to make new predictions.

13. The thirteenth step is to use the new predictions to design and conduct further experiments.

14. The fourteenth step is to use the results of the further experiments to refine the theory.

an additional time, to be determined by the Engineer.

At the season of the year when the average temperature is below 50 degrees Fahrenheit sprinkling and covering of the pavements may be omitted at the direction of the Engineer.

Liability of Contractor: The contractor shall erect suitable barriers to protect the concrete from traffic, and any part of the pavement damaged from traffic or other causes, occurring prior to its official acceptance, shall be repaired or replaced by the contractor at his expense, in manner satisfactory to the Engineer. Before the pavement is thrown open to traffic the covering shall be removed and disposed of as directed by the Engineer.

All loss and damage arising from the nature of the work to be done, or from any unforeseen or unusual obstruction or difficulty, which may be encountered in the prosecution of the work undertaken by him, or from the actions of the elements, shall be sustained and borne by the contractor.

Defects Before Acceptance: All depressions, defects and imperfections in any portion of the pavement, whether due to public traffic, rain, snow, ice, frost, or other causes, shall be repaired and made good by the contractor at his own expense before final acceptance of the work by the Engineer. All rubbish which may accumulate during and by reason of the work herein provided, shall be removed by the contractor as fast as the pavement is laid and the street left clean and in good condition.

Temperature Below 35 Degrees Fahrenheit: Concrete shall not be mixed when the temperature is below freezing.

If at any time during the progress of the work, the temperature is, or in the opinion of the Engineer will, within twenty-four (24) hours drop to thirty-five (35) degrees Fahrenheit, the water and aggregates shall be heated, and precautions taken to protect the work from freezing for at least ten (10) days. In no case shall concrete be deposited upon a frozen sub-grade.

The curbing is to be combined curb and gutter on all straight work, and straight curb and alley intersections."

MAINTENANCE AND GUARANTY.

"The contractor shall give good and sufficient bond, running for a period of three years (3) after the completion of the work and its acceptance by the City Manager.

To keep and maintain the concrete roadway, walks, curbs, gutters, etc., constructed under this contract, in repair, and turn the same over to the city at the end of the guarantee period in good condition so that the city shall not be at any expense for repairs made necessary by defective work or material.

The contractor agrees that he will, within ten days after having been notified in writing, make such repairs as the City Engineer may direct, such repairs to be made in the presence of the Inspector, appointed by the Engineer and paid by the contractor; and the contractor further agrees

to notify the Engineer when ready to make such repairs, and in case the repairs are not made in the time specified the city may make such repairs at the expense of the contractor.

The walk and curb work shall be considered out of repair whenever the works show hair cracks or defects due to poor workmanship or the use of faulty materials; the breaking down of edges of stones, the development of double joints not being marked where templates were withdrawn, or where stones have broken and settled from the line of grade.

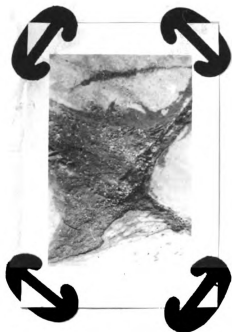
No walk, or curb stones shall be patched in making repairs, but shall be entirely removed and replaced with new. Only new material of the quality called for in the original specifications shall be used. The workmanship shall be of the quality specified under this contract.

The bond shall apply to all work repair during its life. Before the expiration of the guarantee period the work will be inspected by the city manager, and any imperfections as measured by the above standard shall be corrected before the release from the bond will be granted.

The concrete roadway shall be considered out of repair whenever the surface becomes uneven, holding water one fourth ($\frac{1}{4}$) of an inch in depth in a distance of four (4) feet or less, or when the pavement has settled over trenches or fills, or when the surface has disintegrated or shows defects due to poor workmanship or the use of faulty materials or whenever there are cracks in the



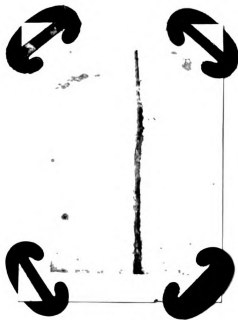
Picture No. 1.
On Stanley Court at Union



Picture No. 2.
On Waverly Ave. at Cherry



Picture No. 3
On Liberty St. off Granville



Picture No.4
On Liberty St. off
Granville

pavement or the expansion joints are chipped or the edges broken off. "

- - - - -

From the experience as shown in some of the accompanying pictures, expansion joints are absolutely necessary. Pictures No. 1 and No. 2 show the effect of no expansion joints. The expanding has caused the concrete to break and flake off, leaving a hole as shown. Pictures No. 3 and No. 4 show three-fourths ($\frac{3}{4}$) inch Carry preformed expansion joint, as was used in the construction in the last three years. Note that it is used around the manholes ^{as} ~~and~~ well as around the gutter line, and transversely every forty-five (45) feet. This allows for free expansion and contraction with the result that not a crack or a flaw was found in the whole four blocks on Liberty St., on which pictures No. 3 and No. 4 were taken. Transverse joints are a bit of trouble for contractors to put in so he will avoid them if possible. In finishing up an expansion joint a split-strike must be used, then an edger with the result that unless considerable is taken one side of the joint will be enough higher to be quite noticeable; this was the effect on Cleveland Ave., otherwise, it was in perfect condition.

Another point in the failure of cement concrete pavements is the effect that the mix is not thorough and complete, this can be avoided as is shown in the specification requiring the batch to mix for at least one minute



Picture No. 6 -- On Cleveland Ave. north from
Franklin St.



Picture No. 7 -- On Hastings St. off Ionia Ave.
Concrete with Toe-hold

irrespective of the size of the batch or the speed of the drum. An example of poor mix is shown in picture No. 5 which illustrates how the surface is wearing unevenly although the pavement had been in but a short time.

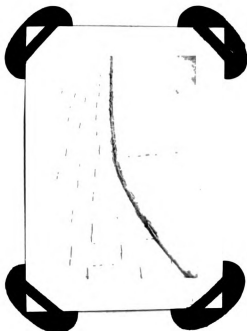
Cement concrete pavements are used in the steepest grades in this city, one of the fourteen and ninety-eight hundredths per cent built in 1913 on Hastings St., Pictures No. 7 and No. 8 show how the surface was corrugated which served as a tow-hold. This being such a steep grade thirty-seven (37 degrees) there is little traffic on it, so little can be said about its wearing qualities, the grade being so steep that the expansion joints tend to run out. Double catch-basins were used at either side at the foot of the hill.

In conclusion we wish to state that the pavements that have been laid within the last three years are proving very satisfactory and any pavements laid in the future will give as good results if the above specifications are carefully adhered to. Altho the cement concrete pavement is rather a new type of pavement certain conclusions have already been made and certain points found necessary to follow. These points are measurement of all ingredience know the proper proportions, have the ingredience thoroughly mixed, have plenty of sub-drains properly placed, see that the proper grades have been established and have a competent inspector to see that these points are fulfilled by the contractor.

Costs: Average cost per square yard \$0.99 to \$1.16.



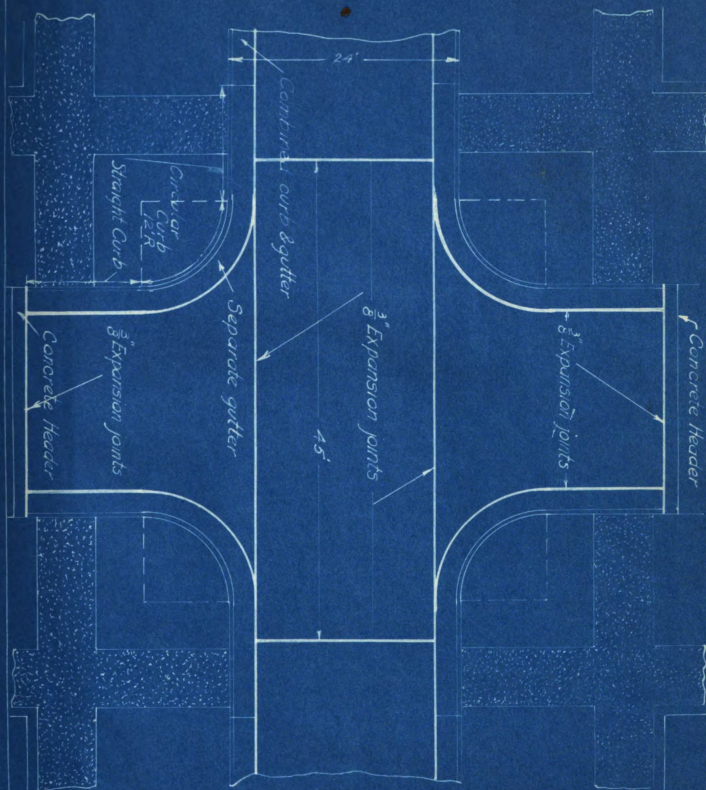
Picture No.5
On Madison Ave. out at city
limits.



Picture No.8.
On Hastings St. off
Ionia Ave.



Picture No.9
On Plainfield Ave. near
city limits.



DETAIL OF STREET INTERSECTION
— FOR —
CONCRETE ROADWAY
Scale 1" = 10'

ASPHALT BLOCK.

Asphalt block pavement makes an excellent street for residence sections. It is laid on a good concrete foundation, as shown in pictures No. 12 and No. 13 but it is of little value if laid on a dirt or gravel base as in Picture No. 14.

This type of pavement is slightly more expensive than other kinds except wood or Medina block.

The city engineer advises that the company manufacturing the blocks should be in charge of laying this pavement, as it takes an expert to have the one (1) inch cement-concrete cushion with the proper amount of water; the block placed right, etc.

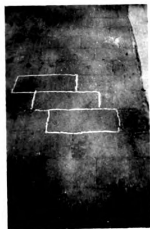
We found in our investigation that Union Ave., from Fulton to Lyon Sts., was in very bad condition because the blocks had been laid on a gravel base. Sheldon Ave., from Buckley St., to Wealthy st., was the same way.

We also found two streets where the concrete base had been used. On Madison Ave., from Wealthy St., to Cherry St., there was a very fine stretch of this pavement. It is in fine residence district, and is an expensive pavement. On Paris Ave., from Cherry St., south to Thomas St., was the same kind of pavement and concrete base. This was put down in 1910 and still is in excellent condition in a fine residence district.

This pavement on Paris Ave., was layed on an old



Picture No. 12.-- On Paris / Ave. off Cherry St. So.
Asphalt Block in fine condition.



Picture No. 13. Same
as No. 12.



Picture No. 14. --On Union
Ave. north from Fulton.

concrete road which was pitted some. The two and one-half ($2\frac{1}{2}$) inch asphalt blocks were laid in a one-half ($\frac{1}{2}$ ") inch layer of cement mortar, fresh. The old concrete bed was smoothed off, and the blocks laid one-half ($\frac{1}{2}$ ") inch above the gutter level.

We would recommend here that the blocks were laid slightly high above the gutter and only should have been about one-quarter ($\frac{1}{4}$ ") inch as they were on Paris Ave., from Wealthy St., to Thomas St., built in 1913. Here the blocks were set in a new concrete bed made six (6") inches deep, with the gutter the depth of the concrete five (5") inches and the blocks only one quarter ($\frac{1}{4}$) of an inch above the gutter.

Cost: Average cost per square yard \$1.46 to \$1.65.

In conclusion we wish to say that this kind of a pavement certainly gives fine service and has a good appearance. Its wearing qualities are excellent and the cost for maintenance is practically low, if the blocks are laid properly in the concrete base. The blocks cost slightly more than wood blocks or most other types of pavement but give excellent satisfaction.

COBBLE STONE PAVEMENTS.

The cobble stone pavements have been abandoned for several years as they proved to be far too rough for modern vehicles.

In picture No. 25 is shown a bit of old cobble stone pavement still left on one block of Browbridge St. This one block has little or no travel as the grade is very steep. Pictures No.'s 26 and 27 show a cobble stone paving on Mason St. The total length is about one-hundred-fifty (150) feet up a steep grade ending in the side of a hill. This last named street is used for delivery only.

Cost: The average cost per square yard \$2.00 to \$2.30.

In conclusion it can be said that this type of pavement is not satisfactory and therefore is of little use except in rare cases where a short length of cheap pavement is very necessary.



Picture No. 25.
On Trowbridge off
Clancy. Showing cobble
stone.



Picture No. 27.--
On Hastings St. off Ionia
Ave. Type of cobble stone.



Picture No. 26. -- Same as No. 27.

SHEET ASPHALT PAVEMENT.

This city has about seven and four-tenths 7.4 miles of this type of pavement, located in different sections; all of it getting considerable traffic. This gives an excellent opportunity to determine its durability.

We have come to the conclusion that there should be a good foundation of four inches (4") or more of concrete; one (1") inch of binder, and two (2") inches of top. An excellent example of this type is on Cherry St., from Madison Ave., to Sheldon Ave., or on Sheldon Ave., from Fulton St., to Wealthy St.; Cherry St., which was laid in 1902 with Trinidad Pitch Lake, is in as nearly as good condition as when laid, even though it is a much travelled street. The same can be said for Sheldon Ave.

For a top of less than two (2") inches the effect is shown on both Crescent and Prospect Sts. These pavements were laid similar to the two mentioned above only the top was only one and one-half ($1\frac{1}{2}$ ") inch thick. They are pitted and rough, most of the surface worn away and are sadly in need of repair.

We will have to take into consideration that the last two mentioned are a few years old, but they have been in need of repair at least that long, while Cherry St., and Sheldon Ave., will apparently, under similar conditions, last at least twice their present age.

Sheet asphalt pavement in this city is located on

Monroe Ave., from Pearl St., to Michigan St. (laid in 1913) and from Newberry St. (laid in 1910) to Coldbrook St. On Crescent St., from Bostwick Ave. to Union Ave. This street is in fair condition but the surface was pitted and wearing away. On Sheldon Ave., from Wealthy St., to Fulton St., pavement in good condition in spite of the heavy traffic. On Jefferson Ave., from Wealthy St., to State St., in fine condition. The two (2") inch wearing surface was put in in 1906. On Cherry St., from Sheldon to Madison Ave., in fine condition, of very good type and eighteen (18) years old. On Prospect Ave., from Washington St. to Fountain St. And on College Ave., from Wealthy to Pleasant St. This pavement was laid in 1913.

One of the most destructive agents or actions on pavements is the ^etaring up of them, after they have been properly laid, to put in some new underground work, as sewers, water mains, etc. This can be avoided by proper action of the city officials taken in advance. The water pipes and sewers can be planned on a big enough scale in the first place and in advance of the city's need. As the old saying goes "An ounce of prevention is worth a pound of cure". After a cut into the pavement has been made it is very necessary that the refill be well tamped into place either by hand or machine tamps.



Picture No. 28.--
On Crescent St. off Bostwick.



Picture No. 29. --
On Washington St. at Lafayette.
Sheet asphalt in excellent condition.



Picture Nol 30. On Sheldon Ave. at
Oak St. Sheet asphalt in fine
condition.



Picture No. 31. On Cherry St. west from
Madison Ave. Eighteen year old sheet
asphalt in fine condition.

Extract from contract for paving sheet asphalt on concrete base, Sheldon Ave., from Fulton to Wealthy St. Contract price \$23,739.88. August 10th, 1917.

"Sheet Asphalt Pavement Binder one and one half ($1\frac{1}{2}$) inch in thickness when compressed. Wearing surface one and one half ($1\frac{1}{2}$) inch. Penetrations are expressed in hundredths of a centimeter and are to be taken with a No. 2 needle acting as follows: at thirty-two (32) degrees Fahrenheit, two hundred (200) grams for one (1) minute, not less than ten; at seventy seven (77) degrees Fahrenheit, one hundred (100) grams for five (5) seconds, not less than sixty three (63); at one hundred and fifteen (115) degrees Fahrenheit, fifty (50) grams for five (5) seconds, not less than two hundred and fifty (250).

Binder Stone: This shall be clean hard stone free from any particles that have been weathered or soft material. It shall pass a one and one fourth ($1\frac{1}{4}$)^{inch}/screen and what is generally termed a close binder and shall conform to the following:

Bitumen not less than 5%.

Passing 200 screen 3%.

" 10 " 30%

" 8 " 2%

" $\frac{1}{4}$ " " 10%

" $\frac{1}{2}$ " " 25%

" $\frac{3}{4}$ " " 10%

" 1" " 10%

3 / Retained 1" " 5%

Sand: Shall be hard, clean gravel and moderately sharp. On sifting it shall have the following mesh compositions:

Standard top mixtures

Bitumen		10 $\frac{1}{2}$ %
Passing	200	13 %
"	100	13
"	80	13
"	50	24
"	40	11
"	30	8
"	20	4.5
"	10	3.0
Total		100%

Filler: This shall be Lime stone dust or dust from other satisfactory stone. The whole of which shall pass a 30 mesh per linear inch screen and at least sixty-six (66) per cent of which shall pass a two hundred (200) mesh screen. Surface mixture shall contain from six (6) to twenty (20) per cent of this filler, depending upon kind of sand and asphalt used and traffic conditions.

Asphaltic Cement: (a) Shall have a penetration of sixty three (63) at seventy seven (77) degrees Fahrenheit any asphalt which varies more than three (3) points either way from sixty three (63) will be rejected. (b) It shall not flush below three hundred and fifty (350) degrees when tested in a New York closed oil tester.

Asphaltic cement at a penetration of sixty three (63)

shall have a _____ of not less than thirty (30) centimeters at seventy seven (77) degrees Fahrenheit. Test shall be made with a briquette of a cross-section of one of cementimeter. This material being elongated at the rate of five (5) centimeters per minute. Finished part to conform to established grade and have a thickness of not less than three (3) inches.

Guarantee for this class of pavement shall be five (5) years. Plant and equipment must be sufficient to normally turn out and lay one hundred (100) sq.yas. of wearing surface per hour.

Length of street - - - - - 2573 feet.

Width " " - - - - - 86 " .

" " roadway - - - - - 40 "

" Sidewalk and lawn - - 23 "

Foundation concrete 11,300 Sq.Yds. @ .65

Asphalt Sheet Pavement 11,300 " " "1.24 "

VITRIFIED BRICK PAVEMENT.

This type of pavement has been used most extensively throughout the city. The total number of mile is about forty-five (45). Being laid where the traffic is heavier it has met with the severest tests that a pavement has to undergo, but in spite of this condition, the brick pavements are in fine condition today.

In the accompanying photographs are several typical illustrations of the effect and resulting condition of the brick pavements in street car tracks. This is undoubtedly the effect of the street car traffic, but in general the company helps keep their part in repair. Due to many handicaps, such as shortage of material, etc., the company has not been able to make the ordinary repairs it should. Although the car tracks help to break up a pavement, it was noticed that everywhere where there were car tracks there was a good pavement. The street car company has to bear a considerable portion of the paving expense, and this makes a cheaper pavement for the taxpayer.

One of the new features in the laying of brick pavement is the placing of preformed joints every fifty (50) feet at right angles to the curbing, as well as along the curb. Also a joint is placed around all manholes and catch-basins. This precaution is claimed to be unnecessary by many good engineers, but from experience the city engineer here claims that considerable heaving of the bricks is prevented in this way, as well as preventing the



Picture No. 16.
On Granville Ave.
Showing expansion joint



Picture No. 17.
On Fulton St at
Dwight Ave.
Showing poor repair



Picture No. 18
On Logan St.
at Morris Ave.
Fine strip of brick.



Picture No. 19
On Jefferson and
Island St.



Picture No. 20
On Division Ave., anywhere

Failures along tracks



Picture No. 21
On Division, at Cherry St.



Picture No. 22.
On Cherry St. at Eastern

smashing up of the catch-basins and the manholes.

In comparing cement grout with tar filler it should be noted that the cement grout is more durable, but in a very busy section where a street cannot be kept closed without great loss to the merchants, the tar filler can be poured in one day, and the street opened to traffic the next. This is not desirable with the cement grout filler.

In the following paragraphs are given the specifications as used in Grand Rapids:

“ 1. All brick shall be laid on a six (6) inch concrete base with sand cushion.

2. Over the foundation shall be spread to a uniform depth of not less than one (1) inch, nor greater than one and one-half ($1\frac{1}{2}$) inches (after rolling), a cushion of clean, sharp sand, free from foreign matter, except that it may contain not to exceed 10% of loam. The sand must be fairly well graded from one-quarter ($\frac{1}{4}$) inch to that which will be retained on a No. 50 standard mesh sieve. The cushion shall be carefully shaped to a true cross-section of the roadway by means of a template having a steel faced edge, covering at least one-half ($\frac{1}{2}$) the width of the brick work, and so fitted with rollers as to be easily drawn on the curb and guide timbers of rail.

3. The template for shaping the sand cushion shall be constructed in accordance with the general detail drawing for a brick pavement template on file in the office of the

City Engineer.

4. Guide timbers shall be one and one-half ($1\frac{1}{2}$) inches by four (4) inches by sixteen (16) feet, dressed on the two sides, laid to a true surface in the center of the street, and next to the curb, if curb cannot be used.

5. Before shaping the cushion a one-half ($\frac{1}{2}$) inch strip shall be laid on the curb, and guide timbers or rail, and the template drawn over the same, after which the one-half ($\frac{1}{2}$) inch strip shall be removed, the cushion slightly moistened and rolled over its entire surface with a hand roller. The roller shall be not less than thirty-six (36) inches in diameter, twenty four (24) inches in width, and weighing not less than ten (10) pounds per inch in width, and having a handle twelve (12) feet in length. After rolling, the template shall be drawn over the curb and guide timbers or rail, to complete the cushion. The cushion shall be prepared at least fifty (50) feet in advance of the brick laying.

6. The brick shall be laid in straight lines on edge, at right angles to the curb. At intersections they shall be laid as directed. Brick shall be laid with the lug side in the same direction. Brick must be placed close together, breaking joints at least three (3) inches. At every fourth course the brick shall be driven together to secure tight joints and straight courses, and all thick brick shall be removed. Brick shall be used with best edge up. Broken, chipped or warped brick, not suitable as a whole, may be used for batting.

When any section shall contain more than ten (10) per cent. of culls, the brick shall be taken up and the cushion adjusted. Brick shall be laid from curb to curb, or car track to curb.

No bats or broken brick shall be used except at curbs or at the street car tracks. After the brick are laid and immediately before batting the end joints are to be made close by use of a bar applied at the end next the curb. Batting for closures shall immediately follow the laying.

Joints shall be cut square with the top and sides of brick, and all joints must be kept clean and open to the bottom until filled as specified.

7. Along the street car tracks, the brick must not be laid within one-quarter ($\frac{1}{4}$) of an inch of the rail, and when rolled shall be one-quarter ($\frac{1}{4}$) inch below the top of the rail.

The space between the web of rail and the brick shall be filled with cement mortar consisting of two (2) parts sand, and one (1) part Portland cement. The mortar shall be in proper condition and the edge constructed to a straight line before the brick are laid.

8. Where "girder" rails are used case iron blocks shall be set, as shown on the detail drawings, across intersecting streets and for a distance of twenty (20) feet each side thereof. The blocks will be furnished by the Grand Rapids Railway Company. Where the "T" rail is used a groove for the flange of the wheels shall be made by use of a specially moulded and pressed paving brick of the form

shown on the detail plan on file in the office of the City Engineer. Alternate bricks shall be half the length of the whole block made and pressed to this dimension.

9. When granite blocks are used to form a groove for the flange of wheels along "T" rails, the granite shall be of a durable, sound, uniform quality of granite, and shall be of uniform color. Blocks shall be cut to lay with two courses of brick paving blocks, and alternate blocks shall have a length at right angles to the rails of from eight (8) inches for the shorter to twelve (12) inches for the longer. Blocks shall have a depth of from $3\frac{5}{8}$ to $4\frac{1}{2}$ inches and shall have parallel sides and ends with the vertical faces at right angles to the top face. When set in place they shall have joints as close together as possible, not exceeding $\frac{3}{8}$ of an inch in the top $3\frac{1}{2}$ inches. Tops of blocks shall show no projections or depressions greater than $\frac{1}{4}$ of an inch. The groove for wheel flange shall be dressed to the forms shown on detail plan with no irregularity exceeding $\frac{1}{8}$ of an inch. The stone block shall be laid, rolled and grouted in the same manner as the brick, blocks breaking joints with each other and the brick at least three (3) inches.

10. Expansion joints shall be placed parallel with and at each of the curb lines, and shall be at right angles to the curb lines at intervals of 50 feet, and a

pre-formed expansion strip made of a material unaffected by the action of water or street liquids, provided it meets all the requirements. The strips parallel to the curb lines shall not be less than three quarters ($\frac{3}{4}$) of an inch in width for a thirty (30) foot roadway or under, increasing proportionately in width to one and one ($1\frac{1}{2}$) inches in width for a fifty (50) foot roadway or over. The transverse joints shall be three-eighths ($\frac{3}{8}$) inch in width. Three-quarters ($\frac{3}{4}$) inch expansion strips shall be placed around all catch basin and man-hole castings.

11. After the brick in the pavement have been passed for rolling and the surface swept clean, the pavement shall be rolled with a roller weighing not less than three (3) nor more than five (5) tons in the following manner. The brick next to the curb shall be tamped with a hardwood tamper, to the proper grade. The rolling will then commence near the curb at a very slow pace, and continue back and forth toward the center until the center of the street is reached, then passing to the opposite curb, and repeat in the same manner to the center of the street. After this first passing of the roller, the pace may be quickened, and the rolling continued until the brick pavement has a smooth surface. The pavement shall be rolled transversely at an angle of forty five (45) degrees from curb to curb, repeating the rolling in opposite forty-five (45) degrees direction. Before and after this transverse rolling has taken place, all broken or injured brick must be taken up and replaced with perfect ones. The substitute brick must be brought

to the true surface by tamping.

After final rolling the pavement shall be tested with a ten (10) foot straight edge, laid parallel with the curb, and any depression exceeding one quarter ($\frac{1}{4}$) of an inch must be taken out. If necessary the pavement shall be again rolled.

12. The filler shall be composed of one part each of fine, clean, sharp sand and Portland Cement. All cement used for this work must stand the test as approved and adopted by the American Society for Testing Materials, August 17, 1916, with subsequent amendments. The sand shall be clean and sharp, fairly well graded from that passing a No. 20 standard sieve to that retained on a No. 100 standard sieve. Sand shall be measured in a box having the same cubical contents as one sack of cement.

13. Before any grouting is done, a sufficient amount of cement and an equal amount of sand, to complete the work prepared for grouting at that time but not to exceed one-half ($\frac{1}{2}$) days run, shall be thoroughly mixed dry until the mass assumes a uniform color. From this mixture an amount, not exceeding two (2) cubic feet, shall be taken and placed in the grouting box and enough clean water added to obtain a grout that will penetrate to the bottom of the brick.

The water shall be added to this dry mixture in a box preferably about four (4) feet, eight (8) inches long, thirty (30) inches wide and fourteen (14) inches deep, resting on legs different lengths, so that the mixture will rapidly

flow to the lower corner of the box, the bottom of which shall be about three (3) inches above the pavement. One box shall be used for each fourteen (14) feet in width of roadway, and at least two (2) boxes must be used in all cases. From the time the water is applied until all is removed and floated into the joints of the pavements, the mixture must be kept in a constant motion. Before the grout is applied the brick shall be thoroughly wet by being gently sprayed.

The grout must be removed from the box with scopp shovels and applied to the brick in front of the sweepers, who shall rapidly sweep it lengthwise of the brick into the unfilled joints until the joints are filled to within not more than one (1) inch of the top of the brick. After the grout has had a chance to settle into the joint, and before the initial set develops, the balance of the joints shall be filled with a thicker grout, and if necessary re-filled, until the joints remain full to the top. In no case is the mixture in the box to be dumped onto the pavement.

After this last application has had time to settle and before the initial set takes place, the pavement shall be finished to a smooth surface, with a squeegee or wooden scraper, having a rubber edge which shall be worked over the brick at an angle with the brick.

When completed and the cement has received its initial set, the pavement shall be covered with a one-half ($\frac{1}{2}$) inch

layer of sand, which shall be frequently springled in warm weather. No travel shall be permitted on the pavement for a period of seven (7) days after grouting or longer as the Director of Public Service may require on account of weather conditions.

Ample Barricades and watchmen shall be provided by the contractor for the proper protection of the grouting. "

VITRIFIED BRICK
FOR PAVING STREETS, ALLEYS AND CROSSWALKS.

L. " Whenever the word "brick" is used in these specifications it shall mean strickly No. 1 pavers of the size commercially known as "vitrified block", the widths of which must^{not} vary more than one-eighth ($1/8$) of an inch. They must be thoroughly annealed, tough, and durable, regular in size, shape and evenly burned.

When broken, the brick shall show a dense stone-like body free from lime, air pockets, cracks or marked laminations . They must not be fire-flashed, smoked or treated in any manner tending to give artificially a uniform color outside. Kiln marks must not exceed three-sixteenths (3-16) of an inch , one edge at least to show but slight kiln marks. All brick so distorted in burning as to lay unevenly in the pavement shall be rejected.

The standard size of brick shall be three and one-

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half ($3\frac{1}{2}$) inches in width; four (4) inches in depth; and eight and one-half ($8\frac{1}{2}$) inches in length. They shall not vary from these dimensions to exceed one-eighth ($\frac{1}{8}$) of an inch in width and depth, and not more than one-half ($\frac{1}{2}$) inch in length. If the edges of the brick are rounded, the radius should not exceed three-sixteenths ($\frac{3}{16}$) of an inch. Only brick with raised lugs on one side, not to exceed one-fourth ($\frac{1}{4}$) of an inch in height shall be used.

2. All brick shall be subject to thorough inspection before and after laying and rolling, and all rejected material shall be immediately removed from the street.

Factory inspection of brick, including the rattler test, shall be made, if in the judgment of the Director of Public Service, it be expedient. This test shall, however, in no wise prevent further tests of the brick after they have been received upon the improvement if, in the judgment of the Director, such is warranted.

3. The brick shall be hauled, carefully unloaded by hand and neatly piled on the walks or outside of the curb before the grading is finished, and in laying shall be carried from there to the pavement.

4. The brick shall not lose more than 10 per cent. of their weight after being submitted to the following tests; provided, however, that brick from any one factory and used in any one improvement shall not vary more than eight (8) points. Samples of brick of

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uniform shape and appearance shall be taken from each car tested (estimated at 10,000 bricks). Brick having a defect that would cull them, shall not be used. Three grades of samples shall be tested, one of the softest one of the medium, and one of the hardest burned. If all the tests overrun the above percentage of loss, the car shall be rejected. If one or two of the tests overrun, another test of said grade or grades shall be made. Should only one of these tests overrun the specified percentage of loss, the Contractor may cull said grade, provided they do not exceed ten (10) per cent. of the amount of brick in the car, and deliver the balance on the improvement. Otherwise the whole car will be rejected.

In order to prevent the continued shipment of inferior brick only two cars of two separate shipments of any make of brick will be tested. Should they fail to meet the requirements stated above, said make of brick will be rejected for this improvement.

5. Ten paving brick shall constitute the number to be used in a single test. The brick shall be thoroughly dried for at least three (3) hours, in a temperature of one hundred (100) degrees F. before testing.

6. The Contractor shall notify the Director of Public Service of the location and car number of each car-load of brick received so that samples, if deemed necessary, may be taken and tested, by the City, and no brick shall be delivered on or adjacent to any improvement on which

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the brick are to be used until in receipt of a written statement from the Director or his authorized representative that they have been superficially inspected or have passed the required tests. Decision relative to each car load will be made within twenty-four (24) hours of notice. Permission to deliver brick on the line of work shall not be considered a final acceptance in any respect.

7. The rattler employed in testing the brick and the abrasive charge of spherical shot used in connection therewith shall conform in all respects to the specifications for the same as approved and adopted by the Organization of City Officials for Standardizing Paving Specifications, January, 1911, and all tests shall be conducted and records kept in accordance therewith. Copies of the above specifications are on file in the office of the city Engineer.

8. The rattler shall be rotated at a rate of not less than 29 $\frac{1}{2}$ nor more than 30 $\frac{1}{2}$ revolutions per minute, and 1800 revolutions shall constitute the standard test.

A counting machine shall be attached to the rattler for counting the revolutions.

A Margin of not to exceed ten (10) revolutions will be allowed for stopping, In case a charge is allowed to run several minutes beyond its proper termination, and the loss incurred is still within the prescribed limits, then the test shall not be discarded, but the fact shall

be entered on the record.

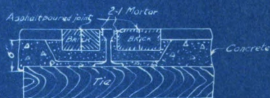
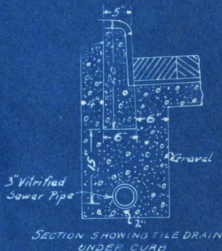
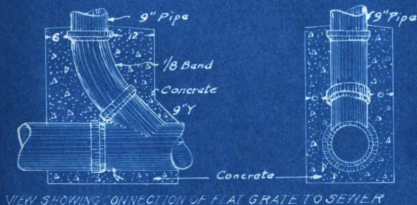
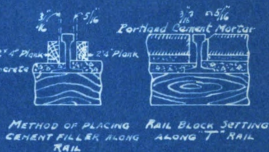
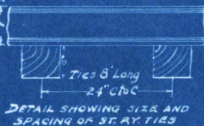
Only one (1) start and stop per test is regular and acceptable. If from any accidental causes, a test is stopped and started twice extra, and the loss exceeds the maximum permissible, the test shall be disqualified and another made.

9. The loss shall be calculated in percentage of the original weight of the dried brick composing the charge. In weighing the rattler brick, any piece weighing less than one (1) pound shall be rejected.

BRICK FOR GUTTERS ON GRAVEL STREETS.

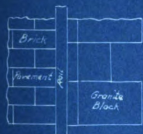
10. The brick used for paving gutters shall be of the character specified above for street paving brick, and shall be of uniform size, free from cracks and other defects, and shall lose not more than 10 per cent. of their weight when subjected to the standard Rattler test.✓

DETAILS OF PAVING ALONG CAR TRACKS,
DRAIN UNDER CURBS, FLAT GRATE
CONNECTION TO SEWER,
SIDEWALKS AT TURNS

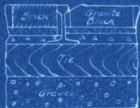


Picture No. 10
On Union Ave.
Showing interior of
cracking off.

DETAILS OF PAVING ALONG CAR TRACKS AND DRAIN UNDER CURBS



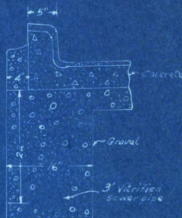
PLAN



SECTION



SECTION OF NEW
WALKOVER
AREA WALL



SECTION SHOWING TILE DRAIN
UNDER COMBINED CURB

GRANITE BLOCK ALONG CAR TRACKS

Picture No. 10
On Union Ave.
Showing interior view
of building.

CONCRETE FOUNDATION FOR PAVEMENTS.

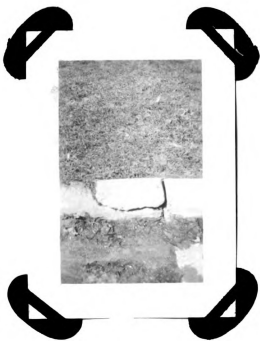
As experience has made the engineer wiser he has come to know that a good pavement means a good foundation, and a good foundation means one that will not break up and go to pieces in one year, or two years ,or a dozen years, if it has been properly put in, but one that will last year after year and require little or no repair.

The concrete foundation, which was first used in Grand Rapids in 1892, has come to be the foundation that so far has come nearest to the ideals of the engineer.

As was stated under the topic of cement concrete pavements, one of the most important things to think about is the sub-drain. This applies to the foundation of all pavements, as the foundation is the support of backbone of the whole pavement. One part is dependent upon the other, so to have the sub-drains function properly the grades must be so arranged to take care of this. In this city of many hills plenty of grade can be obtained for the great part, which cuts down a great deal of this difficulty.

In the preservation of a good foundation all water mains and sewers should, as far as possible, be installed before the pavement is laid, which will avoid tearing up at some future date. These precautions can be observed in a greater number of cases, rendering a longer life and a better pavement.

cracking off.
Showing integral corp
On Union Ave.
Picture No. 10



Picture No. 10
On Union Ave.
Showing integral curb
cracking off.

The specifications following, have been used since 1916, and the investigation which we have carried out permits us to criticize them most favorably.

CONCRETE FOUNDATION FOR PAVEMENTS.

L 1. The cement shall meet the requirements of the specifications for cement as adopted by the Association for Standardizing Paving Specifications January, 1911 a copy of which is on file in the office of the City Engineer.

2. The fine aggregate shall consist of any material of siliceous or igneous origin, free from mica in excess of five per cent, and other impurities, uniformly graded, the particles ranging in size from one-fourth ($\frac{1}{4}$) inch to that which will pass a No. 100 Standard sieve.

3. The coarse aggregate shall be sound gravel, or broken stone, having a specific gravity of not less than 2.6. It shall be free from all foreign matter, uniformly graded, and shall range in size from one-fourth ($\frac{1}{4}$) inch up, the largest particles not to exceed in any dimension one-half ($\frac{1}{2}$) the ^hthickness of the concrete in place.

4. In preparing the concrete, the cement and aggregate shall be measured separately and then mixed in such proportions that the resulting concrete shall contain fine aggregate amounting to one-half of the volume of the coarse aggregate; and that seven cubic feet of concrete in place will contain ninety-four pounds of cement.

5. The ingredients of the concrete shall be thoroughly mixed, sufficient water being added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed, and each particle of the fine aggregate is thoroughly coated with cement, and each particle of the coarse aggregate is thoroughly coated with mortar.

If mixed by hand the materials shall be spread upon a plank platform, and the runners under the mixing platform shall be of sufficient width to prevent their cutting into the subgrade, as the platform is drawn ahead in advance of the placing of the foundation. An amount of concrete requiring more than the volume of one barrel of cement shall not be mixed by hand at any one time.

6. Where a mechanical concrete mixer is used, the materials must be proportioned dry, and then deposited in the mixer all at the same time. The mixer must produce a concrete of uniform consistency and color, with the stone thoroughly mixed with the water, sand and cement. Continuous mixers will not be allowed.

7. The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under light tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

Re-tempering, that is, remixing with additional water, mortar or concrete that has partially hardened, will not be permitted.

8. The concrete shall be deposited in a layer on the subgrade in such quantities that, after being thoroughly rammed in place, it will be of the required thickness, and the upper surface shall be true, uniform and parallel with the surface of the finished pavement.

In conveying the concrete from the place of mixing to the place of deposit the operation must be conducted in such a manner that no mortar will be lost and the concrete must be so handled that the foundation will be of uniform composition throughout, showing no excess nor lack of mortar in any place.

9. This foundation shall be _____ inches in thickness, with its upper surface finished parallel to and _____ inches below the grade of the finished pavement.

10. When complete the foundation shall be kept moist for not less than two (2) days and it shall be protected from traffic until the concrete has thoroughly set.

11. No concrete shall be mixed while the air temperature is below 32 degrees F., and if this temperature is reached at any time before the foundation shall have been thoroughly set, it shall be immediately provided with such covering as will protect it from all damage.

In no event shall a concrete foundation be laid on a frozen sub-grade. ✓

CONCRETE WHERE REPAVING.

“ 12. In repaving streets which have an old con-

crete foundation, Item (53) in the proposal items shall be construed as including all concrete for replacing that disturbed in building or rebuilding basins, manholes, intakes and basin connections, or for replacing those portions of the original foundation which for any reason the Engineer shall consider necessary to entirely remove. The cost of concrete replaced in water service and house lateral trenches shall be included in the item price bid for such water services and house laterals respectively. Under Item (53) shall be included the replacing of all concrete disturbed in replaying the tracks and ties of the Grand Rapids Railway Company. All concrete replaced shall be six (6) inches in thickness. Where the old foundation is too high and must be entirely removed and replaced with new the cost of removing the old concrete shall be included in the price bid under Item (53). Under this item the Contractor shall, if required, replace the concrete over sewer or water trenches within the lines of the improvement.

13. Under item (56) for concrete foundation shall be included all batch concrete used for shaping up or raising the existing foundation where the same is not entirely replaced as specified above under surface measurements. One batch of concrete shall be the amount resulting from the use of one (1) barrel of Portland cement together with the proportions of sand and screened gravel specified. Bank gravel shall not be used. The Contractor shall check with the Inspector daily as to the amount used each day, and the Inspector shall enter the same on his weekly report.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text suggests that organizations should implement robust systems to track every detail, from small expenses to major investments.

2. The second section focuses on the role of technology in modern record-keeping. It highlights how digital tools can streamline data collection, storage, and retrieval, reducing the risk of human error and improving efficiency. The author argues that embracing technology is not just a convenience but a necessity for staying competitive in today's fast-paced environment.

3. The third part of the document addresses the challenges of data security and privacy. It notes that as organizations collect more data, they also increase their vulnerability to cyber threats. The text provides several recommendations for safeguarding information, including regular security audits, employee training, and the use of encrypted communication channels.

4. The fourth section explores the legal implications of record-keeping. It discusses how various regulations, such as the General Data Protection Regulation (GDPR), require organizations to maintain specific standards for data handling. The author advises that legal counsel should be consulted to ensure compliance with these regulations, as failure to do so can result in significant fines and reputational damage.

5. The fifth part of the document discusses the importance of data analysis in decision-making. It explains that raw data is only useful if it is properly analyzed and interpreted. The text suggests that organizations should invest in data analytics tools and personnel to extract meaningful insights from their records, which can then be used to inform strategic decisions and improve overall performance.

6. The sixth section covers the topic of data retention and archiving. It explains that not all data needs to be kept indefinitely, and organizations should have a clear policy for determining how long to retain different types of information. The text also discusses the importance of secure archiving methods to ensure that data remains accessible and intact over time.

7. The seventh part of the document discusses the role of record-keeping in disaster recovery and business continuity. It notes that in the event of a major disaster, having up-to-date and well-organized records is crucial for quickly assessing the damage and implementing recovery plans. The author recommends that organizations conduct regular drills to test their disaster recovery procedures.

8. The eighth section of the document discusses the importance of record-keeping in human resources management. It explains that maintaining accurate records of employee performance, attendance, and training is essential for fair and effective management. The text suggests that organizations should use these records to identify areas for improvement and provide targeted support to employees.

9. The ninth part of the document discusses the role of record-keeping in marketing and sales. It explains that tracking customer interactions and sales data can provide valuable insights into market trends and consumer behavior. The text suggests that organizations should use this information to develop more targeted marketing campaigns and improve their sales strategies.

10. The final section of the document discusses the importance of record-keeping in environmental management. It explains that organizations have a responsibility to monitor and report on their environmental impact. The text suggests that maintaining accurate records of energy usage, waste production, and other environmental factors is essential for meeting regulatory requirements and achieving sustainability goals.

The particles of the gravel shall not exceed in any dimension one-half the thickness of the layer of concrete to be placed. Where the concrete is to be less than one (1) inch in thickness a mortar consisting of one (1) part Portland cement and four (4) parts of clean sharp sand shall be used.

14. The surface and edges of the old concrete where new concrete is to be added, shall be thoroughly cleaned by flushing with water, accompanied by sweeping with a wire push broom, to secure a good bond between the old and new concrete.

15. The top of the old concrete surface shall be picked off where necessary to secure the proper grade at the price per square yard under item (57). //

CONCRETE GUARANTY.

// L. The Contractor shall give good and sufficient bond, running for a period of five years after the completion of the work and its acceptance by the Board of Public Works.

To keep and maintain all Portland cement concrete work - walks, curbs, gutters, etc., - - constructed under this contract, in repair, and to turn the same over to the city at the end of the guarantee period in good condition, the result of traffic not excepted, so that the city shall not be at any expense for repairs made necessary by either wear, defective work or material.

1. The first step in the process of the scientific method is to ask a question.

2. The second step is to do background research on the topic.

3. The third step is to form a hypothesis, which is a prediction about the outcome of the experiment.

4. The fourth step is to design and conduct the experiment.

5. The fifth step is to analyze the data and draw conclusions.

6. The sixth step is to communicate the results of the experiment.

7. The seventh step is to repeat the experiment to verify the results.

8. The eighth step is to apply the results to other situations.

9. The ninth step is to use the results to develop new questions.

10. The tenth step is to use the results to develop new hypotheses.

11. The eleventh step is to use the results to develop new experiments.

12. The twelfth step is to use the results to develop new theories.

13. The thirteenth step is to use the results to develop new models.

14. The fourteenth step is to use the results to develop new laws.

15. The fifteenth step is to use the results to develop new principles.

16. The sixteenth step is to use the results to develop new concepts.

17. The seventeenth step is to use the results to develop new ideas.

18. The eighteenth step is to use the results to develop new theories.

19. The nineteenth step is to use the results to develop new models.

20. The twentieth step is to use the results to develop new laws.

21. The twenty-first step is to use the results to develop new principles.

22. The twenty-second step is to use the results to develop new concepts.

23. The twenty-third step is to use the results to develop new ideas.

24. The twenty-fourth step is to use the results to develop new theories.

25. The twenty-fifth step is to use the results to develop new models.

26. The twenty-sixth step is to use the results to develop new laws.

27. The twenty-seventh step is to use the results to develop new principles.

28. The twenty-eighth step is to use the results to develop new concepts.

29. The twenty-ninth step is to use the results to develop new ideas.

30. The thirtieth step is to use the results to develop new theories.

2. The Contractor agrees that he will, within ten days after having been notified in writing, make such repairs as the City Engineer may direct, such repairs to be made in the presence of an Inspector, appointed by the Engineer and paid by the Contractor; and the Contractor further agrees to notify the Engineer when ready to make such repairs and in case the repairs are not made in the time specified, the City may make such repairs at the expense of the Contractor.

3. The Portland cement concrete work shall be considered out of repair whenever the work shows hair cracks or defects due to poor workmanship or the use of faulty materials; the breaking down of edges of stone, the development of double joints due to joints not being marked where templates were withdrawn, or where stones have broken and settled from the line of grade.

4. No stones shall be patched in making repairs, but shall be entirely removed and replaced with new. Only new material of the quality called for in the original specifications shall be used. The workmanship shall be of the quality specified under this contract.

The bond shall apply to all work repaired during its life. Before the expiration of the guarantee period the work will be inspected by the Board of Public Works and any imperfections as measured by the above standard, shall be corrected before release from the bond will be granted.

Advantages of Concrete Foundations:

1. It gives a smooth uniform surface upon which to lay the pavement.
2. It prevents the surface waters from percolating to the subgrade.
3. By its thickness and resistance to flexure, it distributes the concentrated load over a considerable area of subgrade.
4. Concrete acts as a bridge to support the pavement in case of a settlement of the subgrade.
5. Being impervious to water and a non-conductor of heat, concrete protects pipes from freezing.

There has always been considerable discussion among road builders about coarse and fine aggregate. In Bakers "Roads and Pavements" he says that concrete made of gravel is only 70 to 90 per cent. as strong as broken stone concrete, which is proven by experiment. But as is shown by the specification, a certain per cent. of the proper kind of fine aggregate can be used to satisfaction.

Building foundations in the late fall when freezing takes place is a risky thing to do, and often means complete rebuilding. A fair example of this type of failure took place under the car tracks of the Grand Rapids Street Railway Co., on lower Monroe Ave., at the city Filtration Plant. Here late in the fall of 1919 a concrete foundation was put on a permeable sub-soil, and in the spring of 1920 it all had to be taken up and a new one laid.

1. The curb work included in this contract con-

sists in redressing and resetting the old sandstone curb, constructing five (5) inch by twenty (20 inch concrete curb at corners and intersections or where shown on the plan ; the construction of concrete combination curb and gutter; the furnishing and setting of five (5) inch by twenty (20) inch Medina sandstone circular turns at streets and alleys; the furnishing and setting of Berea five (5) inches by twenty (20) inches sandstone curb, for approaches or intersecting streets; the furnishing and setting of four (4) inch by twelve (12) inch Medina sandstone headers; the furnishing and setting of private driveway turns.

2. Payment will be made in accordance with the item as listed under proposal items. Basin stones shall be included in the measurement of the curb. Where alleys are paved with concrete the Contractor will be paid for the curbing on the basis of the straight and circular curb and for the concrete paving at the item price per square yard including the foundation.

Private driveway turns will be paid for per corner of $\frac{1}{4}$ circular and the straight part as straight curb. Driveway turns with combined curb, gutter and apron will be paid for per lineal foot from end to end of turn.

3. The cement shall meet the requirements of the standard specifications for Portland cement as adopted in 1916 by the American Society for testing materials.

4. The fine aggregate shall consist of any material of siliceous, granitic or igneous origin, free from

mica in excess of five per cent., and other impurities, and shall be of graded sizes, ranging from 1/8 inch down to that which will be retained on a No. 80 Standard sieve for the top or wearing surface; and from 1/4 inch down to that which will pass a No. 100 Standard sieve for the base.

5. The coarse aggregate shall be sound gravel or broken stone having specific gravity of not less than 2.6. It shall be free from all foreign matter, uniformly graded and of sizes that will pass a one (1) inch screen and be retained on a one-quarter (1/4) inch screen.

6. The water used in mixing the concrete shall be clean, free from oil, acid, strong alkalies or vegetable matter .

7. In preparing the concrete base, the cement and aggregate shall be measured separately, and then mixed in such proportions that the resulting concrete shall contain fine aggregate amounting to one-half (1/2) of the volume of the coarse aggregate; and that 5 1/2 cubic feet of concrete in place will contain ninety-four (94) pounds of cement.

8. The curb of combined curb and gutter shall conform to the plans for same attached. The curbing shall be five inches thick by twenty inches deep. Curb and gutter shall show a curb 5 inches thick, with face as shown on plans. The gutter shall be 18 inches wide and 5 inches and due allowance shall be made in placing to allow for the facing or wearing surface ,which shall be 1 inch thick, as hereinafter stated. The top of the curb shall have a 1/4 inch bevel toward the roadway. The face of the curb shall have

an inclination outward from the roadway at the rate of one (1) inch for each foot in depth of curb. The back of the curb shall be vertical.

9. The ingredients of the concrete shall be thoroughly mixed, sufficient water being added to obtain the desired consistency, and the mixing continued until the materials are uniformly distributed and each particle of the fine aggregate is thoroughly coated with cement and each particle of the coarse aggregate is thoroughly coated with mortar. Materials for concrete shall be mixed upon a suitable smooth, level platform.

10. The materials shall be mixed to produce a concrete of such consistency that the water will flush to the surface under heavy tamping. Re-tampering, that is, remixing with additional water, mortar, or concrete that has partially hardened^e, will not be permitted.

11. The forms shall be smooth, free from warp, of sufficient strength to resist springing out of shape, and of a depth to conform to the depth of the proposed work. Mortar and dirt shall be removed from the forms that have been previously used. The forms shall be well staked and thoroughly braced and set to the established lines, their upper edge conforming to the grade of the finished ~~and~~ curb. The work shall be blocked out in sections which shall not measure more than six (6) feet in length. The cross forms shall be of $\frac{1}{4}$ inch metal, of a depth to correspond to the depth of the proposed work, and shall extend full width of the work. They shall be left in place until the wearing

surface is floated. Wood forms shall be moistened before concrete is placed.

12. The concrete shall be deposited in the forms and tamped into place, so that the upper surface shall be true, uniform and parallel with the surface of the finished work. In conveying the concrete from the place of mixing to the place of deposit, the operation must be conducted in such manner that no mortar will be lost and the concrete must be so handled that the foundation will be of uniform composition throughout, showing no excess nor lack of mortar in any place.

13. The facing or wearing surface shall be composed of one part of Portland cement and two parts of fine aggregate, mixed with sufficient water to produce mortar of a consistency which will not require tamping, and which can be easily spread into position with a straight edge.

The mortar for the facing shall be mixed in a mortar box and spread in place immediately after mixing. The facing or wearing surface of the curb shall be placed on the inside of the forms as the body of the curb is being built up. In no case shall the facing be placed after the base has set. After the facing has been worked to an approximately true plan, the section marking shall be directly over the joint in the base. Such marking shall be made with a tool which will cut entirely through and completely separate the surface of adjacent sections.

14. The facing or wearing surface shall be of the thickness shown on the detail plans.

15. The surface shall be troweled smooth. The application of neat cement to the surface in order to hasten hardening is prohibited.

16. When completed, the work shall be kept moist for four days, and protected from traffic and the elements for at least ten days.

17. No concrete shall be mixed when the air temperature is below 32 degrees F., and if this temperature is reached at any time before the wearing surface is laid, the foundation or other concrete shall be immediately provided with such covering as will protect it from damage. In no event shall a concrete curb and gutter be laid on a frozen foundation.

18. The curb shall be built on a bed of coarse bank gravel six (6) inches deep unless the sub-grade is solid, well drained sand. The filling back of the curbs where the sub-soil is not coarse sand shall be coarse bank gravel well tamped to within four (4) inches from the top of the curb. Gravel where required shall be included in the item price for curb.

19. Combination curb and gutter of the dimensions shown and specified shall be constructed on a four (4) inch bed of screened gravel unless otherwise noted. The gravel shall be rolled with a City steam roller. Provision shall be made for carrying depth of gutter at such points as may be directed and without additional compensation.

20. A one-quarter ($\frac{1}{4}$) inch by two (2) inch strip

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of band iron shall be inserted in the top portion of the face of the concrete curb at turns. This band shall be fastened by $\frac{3}{8}$ inch by 4 inch bolts with countersunk heads placed every two feet. The ends of the band shall be turned into the curbs at the ends of the turns for a depth of at least four (4) inches.

21. New sandstone curbing shall be of the best quality obtainable of the kind specified. Berea stones shall not be less than thirty six (36) inches in length and Medina not less than thirty (30) inches in length, and of the sectional dimensions noted above for each.

22. Curb stones shall be tool dressed, true and smooth, and out of wind, at least ten (10) inches down on face and ends, the top to be dressed to a straight line, and to such a bevel as to give a slope of one-fourth ($\frac{1}{4}$) of an inch toward the roadway when set and to a uniform thickness of five inches. The upper corner next to the roadway shall be rounded with proper tools to a curve of one inch radius. No depressions or projections greater than one-eighth of an inch will be allowed on the top, nor greater than one-fourth ($\frac{1}{4}$) of an inch on the face, for seven (7) inches down from the top. Where sidewalk approaches at street intersections or in front of private property will extend to the curb, the curb shall be dressed to a uniform thickness down four inches from the top.

23. The base of all stones shall be rectangular and have an area of not less than four-fifths ($\frac{4}{5}$) of the top area of the stone, when dressed. At least fifty per

cent. of the stones must have a base as long as the top. Short stones must not be set together, and stones with short bases must adjoin those with full length of base. the ends of new curb and curb reset shall be so dressed as to give, when set, joints not to exceed one-eighth ($\frac{1}{8}$) inch wide on top and face, and one-fourth ($\frac{1}{4}$) inch on the back, for at least ten inches down from the top.

24. All new curb shall, when set, have an inclination with the top outward from the roadway at the rate of one (1) inch for each foot in depth of curb. The old curb shall be reset with a vertical face.

25. Circular curb set at intersecting streets and alleys shall be of the radius noted on the plan, the ends, face and top to be dressed as described above, the back of the stones to be finished so as to show a uniform thickness throughout the curve, and to have a smooth and vertical back for four (4) inches down from the top.

26. Medina retaining curb of the sectional dimensions shown on the detail sheet shall be set at the ends of the pavement, at cross streets, alleys and where noted on the plan. Stone shall not be less than thirty (30) inches long, tool dressed true and smooth to a uniform thickness of four (4) inches. The ends and faces, adjacent to pavements, shall be dressed six (6) inches down from the top so that there shall be no depressions or projections greater than one-fourth ($\frac{1}{4}$) of an inch. A face when not adjacent to a pavement may be dressed down only one (1) inch, but shall have no depression greater than specified

above. The stone when set, shall show a joint not exceeding three-sixteenths (3-16) of an inch in width. Whenever it is provided on the plan for setting headers or retaining curb, the same shall fill the above requirements.

27. Retaining curb or headers shall be set vertically with the top of the curb at the surface of the pavements, on a bed of concrete as shown on detail sheet, The trench for the header shall be excavated of sufficient width to properly construct the concrete bed sixteen (16) inches wide, and to a depth to permit six (6) inches of compact concrete being placed below the header, and bring the same to grade. The concrete shall extend six (6) inches in front and back of the header and be carried up to the pavement or bottom of concrete foundation when used. When no pavement is laid back of the header, the concrete shall be carried up six (6) inches thick to four (4) inches below the top of the header. The header shall be adjusted to line and grade when the concrete is fresh by the use of wooden mauls or iron sledges used on a timber laid lengthwise of the curb. The concrete used shall conform to the requirements specified for paving foundations.

28. Where shown on the plan on unimproved streets the header shall be backed up by three (3) feet of cobble paving. The paving shall be set as close together as possible in a well ballasted bed of fine gravel possessing some binding qualities. Stone shall be set with their longest axis vertical. The paving shall be rammed with an 80 pound tamper and covered with gravel as specified on

the plan.

29. All old curb shall be reset in accordance with the above specifications except where walks are built on top of curb. Where full width walks are built adjacent to the curb the general line of the curb shall not be disturbed but shall be released as specified above. Any stone less than 24 inches long shall not be reset or left in the work. When the upper front edge or ends of stone are chipped out they shall be reset and dressed or replaced with new stone. New stone required to make good any shortage under the above requirements will be paid for at the item price for new curb stone in place. Openings where basins or other castings are removed shall be closed. Where the condition of the curb is such as not to require resetting, the old curb shall be redressed as specified above, except that no depressions or projections greater than $\frac{1}{4}$ of an inch will be allowed on top nor greater than $\frac{1}{4}$ of an inch on the face for a depth of 7 inches from the top. When required at intersecting streets new 5 inch by 20 inch curb corresponding in quality with that on the street and dressed and set as specified above in paragraphs (22) to (24) shall be set from the circular turns to the street lines or catch basins when these are beyond.

30. Where specified on the plan or where deemed necessary by the Engineer three (3) inch vitrified sewer tile shall be laid under the curb in coarse screened gravel of the quality used on the surface of gravel streets. The tile shall be connected to sewer laterals or catch basins as directed and paid for at the item price bid.

31. Private driveway turns of two foot radius shall be constructed where desired by property owners, and shall correspond in quality and workmanship to the adjacent curb. On re-improved streets having sand stone curbing, private driveways turns of concrete shall be replaced by two (2) foot radius curb of sand stone, corresponding to that for new drives. Existing sand stone circular turns shall be redressed and set the same as the balance of the old curbing.

Where private driveways occur on brick paved streets a row of header brick corresponding in quality to those in the pavement shall be set on end along the outer edge of the pavement. They shall be set in concrete as shown in the detail sheet. In private driveways on gravel or macadam streets with brick paved gutters, header brick shall be set on end along the inner edge of the gutter on a six (6) inch bed of coarse gravel, and backed up by the same. In driveways with combination curb and gutter shall be carried back as an apron two (2) feet from the face of the curb and the edge faced two (2) inches deep with top mortar, as shown on the detail sheet. On all concrete turns a one-fourth ($\frac{1}{4}$) inch by two (2) inch strip of band iron shall be inserted and anchored.

32. On streets having combination curb and gutter alley approaches shall be paved with concrete from the brick border to the street line, in accordance with the detail plan and sections. The circular turns and straight curb to the street lines shall be built independent of the con-

crete paving and as specified for concrete curb. The pavement shall be laid upon a four (4) inch gravel base constructed as specified under gravel streets.

On the gravel foundation shall be constructed a base five (5) inches thick as specified above for curbing. This base shall be struck with a template to a depth of one (1) inch below the finished surface, except at the street line, where allowance shall be made for thickening the top as shown on the detail. The pavement shall be constructed in two (2) separate blocks with a center point extending full depth. The facing mortar shall consist of one (1) part Portland cement and one and one-half ($1\frac{1}{2}$) parts granite screenings together with such proportions of sand as may be required to fill the voids in the screenings. The total of fine aggregate shall not exceed two parts. The facing mortar shall be placed as specified for curbing, struck off level with the forms, and corrugated as shown on the detail sheet by means of a marker, made in accordance with the standard drawing on file in the office of the City Engineer. This marker shall be placed in the proper position and tamped sufficiently to force the brass jointer into the facing mortar the required depth. It shall then be removed and any roughness or tool marks removed by a trowel.

Expansion joints shall be provided along each curb. The joints shall be formed by inserting a strip of four (4) siding covered with tarred paper. When the concrete has become sufficiently hard this strip and paper shall be removed and the joints immediately filled the full depth

with hot paving filler of the quality specified for brick pavement expansion joints, which shall be heated according to the directions furnished by the manufacturers and applied with cans suitable for pouring the joints.

33. Crosswalks shall be laid where shown on the plans. Crosswalk brick shall conform to the requirements for crosswalk brick elsewhere specified. The brick shall be laid on a coarse sand bed and thoroughly rolled and tamped to secure a smooth surface. All brick disturbed or broken by rollers shall be relaid or replaced with new at the expense of the Contractor.

34. Where shown on the plan flagstone cross-walks shall be relaid in straight lines in accordance with the detail sheet. Stone shall be thoroughly imbedded and the surface even with the pavement when completed. Space between the flagstone shall be paved with crosswalk brick unless otherwise provided. ✓

GUTTERS.

"1. All stones for Gutters must be sound, tough and durable. Limestone shall not be used. Stone set for the course next the roadway shall be not less than 8 inches nor more than 12 inches in their longest diameter, nor present a face more than 7 inches wide when laid.

2. In V shaped gutters, the stone set for the bottom line and in the line next; the sidewalk shall not be less than 8 inches nor more than 12 inches in their longest diameter, and three courses must be set in a straight line, except where otherwise shown on plans. All other stones

used in the gutters shall not be less than 4 inches, nor more than 7 inches in their greatest length.

3. All paving stones shall be set with their longest axis normal to the surface of the finished pavement, as close together as possible, in a well ballasted bed of fine gravel possessing some binding qualities. The bottom of the paving gravel shall not be less than twelve (12) inches below the surface of the finished pavement. When the sub-grade is well drained sand the paving gravel may be omitted.

4. All pavement shall be lightly tamped before any gravel is placed thereon, and when made smooth, a light dressing of fine gravel, as specified above, shall be spread over it, and the pavement shall then be thoroughly tamped over its entire surface with an 80 pound tamp. When the tamping is completed, the pavement must conform exactly to the cross-section on the plan or the lines given by the Engineer. The pavement shall then be covered with one-half ($\frac{1}{2}$) inch more of fine gravel, the same as specified above.

5. Upon the foundation as described under the gravel pavement, shall be spread a layer of coarse sand one inch deep, upon which the brick shall be laid, on edge, with their longest axis at right angles to the curb, and breaking joints as shown on the drawings. At turns of the curbs bricks shall be laid as indicated on the detail drawings.

Bats may be used only at the curbs or at the edge of the gutter to fill out the course, and then shall be care-

fully cut to fit the space. The brick shall be driven together with a sledge every six courses.

6. After the bricks are laid, and the road material is banked up against the outer line of bricks to hold them in position, the gutters shall be rolled with a hand roller weighing not less than 50 pounds per inch of roller. The pavement at the curb shall be made true to grade by means of a straight edge. The gravel or macadam roadway shall be completed as far as possible before the bricks are laid and the gravel or macadam shall lap a trifle on the line of the proposed gutters. This shall be excavated by the contractor when laying the gutters, so as to disturb the gravel or macadam as little as possible beyond the line of the gutter, and all spaces between the brick and gravel or macadam shall be filled with suitable material and thoroughly tamped with a narrow tamp.

After the rolling is nearly completed, the contractor shall relay and adjust the gutters as necessary to bring them to a true line, grade and uniform surface, and remove all defective or broken brick.

7. After the rolling or tamping, as specified above, has been completed, and the pavement has been finished the gutters shall be covered with coarse sand, and the rolling or tamping continued until the joints are completely filled, sand being added as long as necessary to accomplish this object.

8. Concrete gutters, not combined with curb, shall be constructed where called for on the plan five inches in

depth by _____ inches in width, and in accordance with the requirements for concrete curb and gutter as elsewhere specified. The top shall have a thickness of one inch except ~~at~~ the outer edge where it shall be thickened as shown on the plan. The gutters shall be constructed on a bed of gravel four (4) inches deep unless otherwise shown on plans. Gutters disturbed in either grade or alignment by rolling shall be adjusted or repaired by the Contractor at his expense.

All brick used for crosswalks shall be of the character, size and quality specified under brick pavements, and shall not lose more than 10 per cent of their weight when subjected to the standard rattler test therein provided.

Brick used in paving gutters shall be of standard size and shall conform to the requirements as to material and manufacture specified under brick pavements. They shall have one straight face and shall be free from makred defects and shall not lose more than 10 per cent. of their weight when subjected to the standard rattler test. ♪

CREOSOTED WOOD BLOCK PAVEMENT.

This type of pavement was found to be on Fountain St., from Lafayette Ave., to Union Ave.; it is in fine condition, but heaves every spring. On Lafayette Ave., from Fountain St., to Lyon St.; it is also in good condition now but heaves in the spring. This type of pavement is also found to be in use on Ann St., bridge for the bridge floor. However, right now is in bad shape.

This city has not had, what one would say, complete success with wood block pavements. Considerable money was spent on the old cedar block type of pavement, but this has long since been abandoned. There is only about one-half of a mile of Long Leaf Yellow Pine blocks on Fountain St., by the Central High School, and one tenth of a mile on Lafayette Ave., of Norway Pine blocks, just off Fountain St., from the school.

These two streets are not subject to heavy traffic so little can be said how it would act if subjected to a severe test, but at the time of the present investigation was carried on this pavement was in very good shape.

The difficulty which the engineer has to overcome is the bleeding of the blocks, then the expanding and the heaving, which soon means repair. From all reports the City of Minneapolis has been very successful with the wood block pavement. They have overcome the above difficulties by laying the blocks at right angles to the curb, instead of an angle nearly forty-five degrees, and at intervals of about fifty feet they place a one and one-half ($1\frac{1}{2}$) inch



Picture No. 11 -- On Fountain St. off
College. Fine appearance of
creosote wood block
pavement.

preformed expansion joint and another at either curb of about one and one-quarter ($1\frac{1}{4}$) inch.

The following specifications were used in this city in laying the creosoted wood block pavement:

CREOSOTED WOOD BLOCK PAVING.

1. The wood to be treated shall consist of long leaf yellow pine, Norway pine, black gum and tamarack, only one kind of wood, however, to be used in any one contract.

Yellow pine blocks shall be cut from what is known as prime timber, namely, all timber must be sound, commercial long leaf yellow pine, well manufactured, full size, saw butted, all square edge, and shall be free from the following defects: Unsound, loose and hollow knots, worm holes and knot holes, through shakes and round shakes that show on the surface. In yellow pine timber the annual rings shall average not less than six to the inch measured radially from the center of the heart.

Norway pine block, gum and tamarack blocks shall be cut from timber that is first class in every respect and shall be of the same grade as that defined for the yellow pine.

2. The blocks shall be from five to ten inches long, but shall average eight inches; they shall be _____ inches in depth; they shall be _____ inches in width.

A variation of one-sixteenth of an inch shall be allowed in the depth and one-eighth of an inch in the width of the blocks.

3. The blocks shall be treated with a preservative

oil elsewhere described, so that the pine and tamarack blocks shall contain not less than twenty (20) and the gum blocks not less than twenty-two (22) pounds per cubic foot.

4. The oil used shall be of a coal tar product, free from adulteration of any kind whatever, and shall comply with the following requirements:

(a) The specific gravity shall be at least 1.10 at a temperature of 38 degrees C.

(b) Not more than three (3) per cent of the oil shall be insoluble by hot continuous extraction with benzol and chloroform.

(c) On distillation, which shall be made exactly as described in Bulletin No. 65 of the American Railway Engineering and Maintenance of Way Association, the distillate shall not exceed two (2) per cent up to 150 degrees C. and 35 per cent up to 315 degrees C. The mean of three determinations to be taken.

The manufacturer of the oil shall permit full and complete inspection and sampling at the factory at which the oil is produced, of all materials, either crude or refined, entering into the manufacture of the finished product, as well as the finished product itself, in order that the materials used can be determined to be in accordance with the foregoing requirements. He shall also submit satisfactory proof of the origin of all materials entering into the composition of the finished product.

Oil samples taken by the inspector from the treating

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tank during progress of the work shall at no time be allowed to show an accumulation of more than two per cent of foreign matter, such as sawdust and dirt.

Due allowance shall be made for such accumulation of foreign matter by injecting an additional quantity of oil into the blocks.

5. The party manufacturing the blocks shall equip his plant with all the necessary guages, appliances and facilities to enable the inspector to satisfy himself that the requirements of the specifications are fulfilled.

6. Over the concrete foundation shall be spread to a uniform depth of one inch a cushion of coarse screened concrete sand passing a No. 4 mesh. The sand shall be shaped true and parallel to the finished cross-section of the street by experienced bed makers, and where such experienced bed makers cannot be secured, the cushion sand shall be shaped by means of a template covering at least one-half the width of the roadway and so fitted with rollers as to be easily and steadily drawn on gutter or guide timbers.

7. The blocks shall be laid in straight lines, with the grain vertical, and at an angle of about 22½ degrees with the curb. At street intersections they shall be laid as the Engineer shall direct. The blocks shall be laid in parallel courses, close together and blocks in adjoining courses shall break joints two (2) inches. The blocks shall be driven together as necessary to secure straight courses at the proper angle, which angle shall be laid out and maintained by means of a template furnished by the

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contractor. They shall be laid from one half ($\frac{1}{2}$) to five-eighths ($\frac{5}{8}$) of an inch from the gutter and castings and with a three-eighths ($\frac{3}{8}$) inch strip laid adjoining the gutter. After the street is rolled ready for pitching the strips shall be removed and the joints filled with a bituminous cement filler hereinafter specified.

The work of batting shall immediately follow the laying. Joints shall be cut square with the top and at the proper angle. The work must be done by experienced men with proper tools. All joints must be kept clean and open to the bottom until filled as specified.

8. As soon as the blocks are laid and battened they shall be swept clean and thoroughly inspected and culled by the contractor. The inspector shall then inspect and mark the block, and all defective block shall be removed. Any individual block or section of the pavement varying materially from the proper elevation or cross-section shall be adjusted before rolling. After the above conditions have been complied with, the upper surface shall be made smooth by rolling with a hand roller weighing not less than seventy-five (75) pounds per lineal inch of roller, and tamped where impossible to roll, as may be necessary. The tamping shall be done on a two (2) inch plank ten (10) or twelve (12) inches wide and not less than four (4) feet long, with a rammer weighing not less than eighty (80) pounds. After the above rolling and tamping, the pavement shall be rolled with a city steam roller of the tandem type, as the Engineer may direct. The pavement shall be thoroughly inspected and all defective

[illegible]

block removed and replaced with suitable block. As far as possible the block shall be replaced while the roller is working. All block above or below those adjacent shall have the cushion under them adjusted. On completion of the work, the surface of the pavement must be even and smooth throughout and shaped to conform to all street and alley intersections, drainage, detrails, manholes, etc. During the final rolling the pavement shall be tested with a ten (10) foot straight edge, to be furnished by the contractor, and any unevenness must be taken out. When the Engineer considers it necessary, the surface shall be rolled again to bring all block to a uniform bearing. Such hand roller shall be furnished and operated by the contractor. The engineer shall determine, when, where and to what extent the steam roller shall be operated.

9. All cracks, crevices and holes in the pavement shall be filled with Barrett's bituminous cement filler made for creosoted block pavements and shall be of such consistency as the Engineer shall direct. The filler shall be applied as hot as the blocks will permit and only in such quantities as to be immediately worked into joints. The bitumen shall be pushed forward with scraper having heavy rubber edges, that as little as possible of the bitumen shall remain on top of the pavement. Immediately while the bitumen is hot, the surface shall be covered with a one-half ($\frac{1}{2}$) inch coat of cushion sand.

10. Contractor shall place additional sand on the surface of the block as necessary from time to time to absorb the excess of tar. At such time as consider-

[illegible]

ed necessary by the Engineer, the surplus sand and all accumulations must be removed from street, and pavement swept with horse sweeper and left clean before the acceptance of the work by the Board of Public Works.

The Contractor shall give a good and sufficient bond, running ~~the~~ for a period of five (5) years after the completion of the work and its acceptance by the Board.

To keep and maintain the pavement, and all appurtenances thereto forming a part of this contract, in repair, and to turn the same over to the City at the end of the guarantee period in good condition, so that the City shall be at no expense for repairs made necessary by either wear, defective work, or material.

That he will at any time during the period of the guarantee within ten days after having been notified in writing make such repairs as the City Engineer may direct, such repairs to be made in the presence of and satisfactory to an inspector appointed by the Engineer and paid by the Contractor, and will notify the Engineer when ready to make such repairs, and in case the repairs are not made within the time specified, the City may make the repairs at the expense of the contractor.

That the pavement shall be considered out of repair whenever the surface shows indications of abnormal wear, rot, disintegration or decay of the material ; whenever any portion of the pavement shall have a thickness above the base of less than ninety (90) per cent thinner than the contract thickness, such portion shall be relaid as the Engineer directs.

and the other, "The Great Gatsby" by F. Scott Fitzgerald. The first is a novel about a man who is obsessed with the past and the second is a novel about a man who is obsessed with the future. Both are excellent examples of American literature and are well worth reading.

That only new material shall be used in making repairs and that the bond shall continue in force until such repairs are made. If at any time during the continuance of this guarantee the pavement shall be opened for the purpose of constructing sewer, or laying gas or water mains, or repairs of the same, or for any other purpose, the contract shall on request of the City Engineer, relay said pavement at a cost of twenty (20) per cent above the original cost, and when said pavement is relaid, and restored, said guarantee shall extend to the pavement so relaid and restored for the balance of the time for which said guarantee is to continue, and in no case where it shall become necessary to disturb said pavement for any of the purposes above mentioned and the pavement is relaid by said contractor, shall it be deemed as releasing said contractor from said guarantee.

The Portland cement concrete work shall be considered out of repair wherever places show cracks or defects of any kind, growing out of the imperfection or unsuitability of material or workmanship; the breaking down of edges of stones, the development of double joints due to joints not being marked where templates were withdrawn, where stones have broken or settled from line or grade.

No stones shall be patched in making repairs, but shall be entirely removed and replaced with new. Only new material approved by the Engineer shall be used. The workmanship shall be of the quality specified under this contract.

Just before the expiration of the guarantee period,

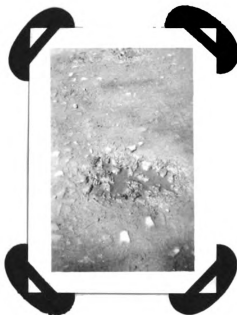
the work will be inspected by the Board and any imperfections in the surface of the pavement, alignment and grade of the curbs or other defects in the work, as measured by the above standard, shall be corrected before a release from the bond will be granted."

MACADAM PAVEMENTS.

Investigation showed that there were macadam pavements on Broadway Ave., from Bridge St., to North St. This pavement has been in so long that it is worn out and absolutely going to pieces and no good. On Turner Ave., the pavement is in the same condition as on Broadway. There are now and then a few depressions, and one really bad place about twenty (20) feet long. This street was rock dust bound macadam, but was repaired and surfaced with tar. On Jefferson Ave., from Hall St., to Franklin St.; On Fountain St., from Lafayette Ave., to Division Ave., the old surface was dressed up and two and one-half ($2\frac{1}{2}$) inches of bituminous concrete put on. It is in very good condition and in a residence district. On Ramson St., and Barclay Ave., either way from Fountain St., the pavement is fair, but pitted and

- doesn't seem to stand the traffic.

Macadam tar-filled pavements were located: On College Ave., from Fulton St., to Michigan St. This pavement is in fine condition. On Ally, South from Michigan St., first one west of Bostwick Ave., the grades are very steep, much pitted and washed out by rains.



Picture No. 15.
On Barkley Ave off
Fulton St.
(Example of failure of
macadam)

“1. Upon the sub-grade shall be constructed a foundation of broken stone, gravel or cobble stone, as shown on the plans.

2. The bottom course, or layer, shall consist of clean broken limestone of approved quality, free from dirt, the particles of which may vary in size from 2 to 5 inches in their greatest diameter. The stones shall be raked into an even layer over the entire roadway, so as to form, after rolling to the satisfaction of the Engineer, a uniform depth of six (6) inches.

3. The bottom course, or layer, shall consist of clean, screened gravel, the particles of which may vary in size from three-fourths ($\frac{3}{4}$) of an inch to four (4) inches in their greatest diameter. A small amount of binding material, of a quality to be approved by the City Engineer, shall be spread on the gravel, and the whole raked into an even layer over the entire roadway, so as to form, after rolling to the satisfaction of the Engineer, a uniform depth of six (6) inches.

4. Cobble stone shall be laid by hand in regular manner of paving, with their longest axes normal to the finished surface of the street. The stones used shall not be less than five (5) inches, nor more than nine (9) inches in depth; stones of greater depth being set in the center of roadway. The space between the stones shall then be filled with gravel, or stone chips, and rolled with a light roller. The paving shall then be rolled with city

1. The material shall be of the following

a foundation of broken stones, gravel or cobble stones,

as shown on this plan.

2. The bottom course, or layer, shall consist

of clean broken stones of approved quality, the size

being the equivalent of 3 inch nominal size in this case.

3. The stones in this layer shall be placed

so as to form an even layer over the entire roadway, so

as to form, after rolling to the satisfaction of the

engineer, a uniform depth of six (6) inches.

3. The bottom course, or layer, shall consist

of clean, selected gravel, the equivalent of 3 inch nominal size

in size from three-fourths (3/4) of an inch to one (1) inch

in their greatest diameter. A small amount of blinding at

the surface, of a quality to be approved by the City Engineer,

shall be spread on the gravel, and the whole rolled into an

even layer over the entire roadway, so as to form, after

rolling to the satisfaction of the engineer, a uniform

depth of six (6) inches.

4. Cobble stones shall be laid in the

manner of paving, with their longest ends normal to the

finished surface of the street. The stones used shall not

be less than five (5) inches, nor more than nine (9)

inches in depth; stones of greater depth being set in the

center of roadway. The space between the stones shall then

be filled with gravel, or stone chips, and rolled with a

light roller. The paving shall then be rolled with a

steam rollers to the satisfaction of the Engineer.

5. When that portion of the foundation lying under the brick gutters has been partially rolled, it shall be covered with a thin layer of limestone screenings, or fine gravel, the particles of which shall vary in size from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in greatest diameter. The proportions shall be such as to give the best results. After thorough sprinkling, the rolling shall be continued until a firm, smooth foundation has been secured for the gutters.

6. On the foundation specified above, shall be laid a course of broken granite or tough and durable boulders, free from dirt, and of such depth that the top, when thoroughly rolled shall be parallel with and not less than three (3) inches below the finished surface of the roadway, as shown on plan. The stone shall be as near cubical in form as practicable, and may vary from one (1) inch in their least, to two and one-half ($2\frac{1}{2}$) inches in their greatest dimensions. The stones shall be raked into a uniform surface, and rolled with a city steam roller until the stone does not creep or weave ahead of the roller. The surface shall then be covered with a thin layer of screened granite chips and dust which shall be thoroughly settled into the voids in the stones by means of rolling dry and sweeping with steel brooms. The surface shall then be springled by means of a sprinkling cart, and the rolling, sprinkling, and adding of dust and chips continued until the voids in the body of the stone are filled. Only enough

steam rollers to the satisfaction of the Engineer.
5. When the surface of the formation lying

under the roller is not sufficiently rolled, it
shall be covered with a thin layer of limestone or
gravel, or fine gravel, the particles of which shall vary
in size from 1/4 to 1/2 of an inch in greatest diameter. The
proportions shall be such as to give the best results.
After thorough application, the rolling shall be continued
until a firm, smooth foundation has been secured for the
cutters.

6. On the foundation specified above, shall be

laid a course of broken granite or tough and durable
boulders, free from dirt, and of such depth that the top,
when thoroughly rolled shall be parallel with and not less
than three (3) inches below the finished surface of the
roadway, as shown on plan. The stone shall be as near
cylindrical in form as practicable, and not very from one (1)
third in their least, to two and one-half (2 1/2) inches in
their greatest dimensions. The stones shall be rolled into
a uniform surface, and rolled with a city steam roller until
the stone does not crop or wave ahead of the roller. The
surface shall then be covered with a thin layer of gravel
granite chips and dust which shall be thoroughly rolled
into the voids in the stones by means of rolling dry and
sweeping with steel brooms. The surface shall then be
sprinkled by means of a spreading machine, and rolled
again, and then a thin layer of fine gravel shall be
laid in the voids in the stone and be rolled in.

chips and dust shall be used to fill the voids in the body of the stone, leaving the top open to permit of the top layer uniting therewith.

7. On the above shall be spread a layer of broken granite or tough and durable boulders, free from dirt, and of such thickness that the top shall conform to the cross-section shown on the plan, when the final rolling is completed. The particles of stone shall vary from three-fourths ($\frac{3}{4}$) of an inch to one and one-half ($1\frac{1}{2}$) inches in their greatest dimensions. The fine material shall only be sufficient to fill the voids in the coarse. The surface shall be rolled until the stone do not creep or weave ahead of the roller. A layer about one-half ($\frac{1}{2}$) inch deep of granite chips and dust, one-half ($\frac{1}{2}$) granite, and one-half ($\frac{1}{2}$) limestone, shall be spread over the surface and thoroughly worked into the voids of the stone by rolling dry and sweeping with steel brooms. More chips and dust shall be added as necessary to fill the voids, the above rolling and sweeping being continued. When the voids seem to be filled, the surface shall be thoroughly flushed with water applied by means of a sprinkling cart. The rolling, sprinkling and addition of dust and chips shall continue as the Engineer shall direct.

8. The chips shall consist of all particles passing a screen with three-fourths ($\frac{3}{4}$) inch mesh and retained on a screen with one-fourth ($\frac{1}{4}$) inch mesh. Dust shall be the portion passing the screen with one-quarter ($\frac{1}{4}$) inch mesh. No chips or dust shall be dumped on the

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roadbed.

9. When the stone is carted upon the streets in wagons and dumped, each wagon load shall be thoroughly mixed by being shoveled over at least once before it is spread, so that the finer particles shall not be left in the center where the load is dumped and the coarser particles that roll to the outside of the pile, spread on the sides.

10. Depressions in any layer shall be filled as the rolling progresses, the top being loozened with a pick if necessary to secure a union of the new material. No stone will be allowed to remain which is not sound, strong, and uniform in size and quality. The sprinkling and rolling shall be continued until a piece of the road metal will crush under the roller when placed on the road surface, and until all voids are completely filled, and a wave flows in front of the rollers.

11. Road metal must be crushed from stones larger than three (3) inches in least diameter. Limestone shall be crushed with the granite boulders in proportion of not to exceed one (1) part limestone and fifteen (15) parts granite boulders.

12. Each section of the finished work shall be barricaded and kept closed until thoroughly dry. If at any time before the final acceptance of the street it shows a tendency to disintegrate, the Contractor shall sprinkle, tend roller, or add more dust, as the Engineer shall direct, to secure a hard, firm surface. An excess of dust on the street after opening to travel shall be

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Cost: The average cost per sq.yd for this
type of pavement is about \$1.90.

The price of timber now would make a wood/^{block}pavement
almost prohibitive.

BITUMINOUS CONCRETE PAVEMENT.

The bituminous materials which have been used successfully in the construction of bituminous pavement built by penetration methods, including asphalt, refined water-gas tars, refined coal-gas tars, combinations of refined tars, and combinations of refined tars and asphalt.

The bituminous material used in the construction of a bituminous pavement is the same for both applications. It may be a comparatively soft petroleum asphalt, fluxed native asphalt, or a heavy refined tar. The function of a bituminous cement is not so much to hold the wearing course up as to keep the large stone fragments down under traffic. The Keyed stone itself has sufficient bearing quality or mechanical stability to carry traffic, and it is therefore possible to use a much softer cement than for the same thickness of fine aggregate, which lack inherent mechanical stability. The cements most advantageously used are, however, much nearer solid consistency than those which it is possible to use in the construction of a bituminous carpet alone. In general it is advisable to use a softer tar product than petroleum or asphalt product.

The bituminous concrete is one composed of broken stone, broken slag, gravel or shill, with or without sand. Portland cement, fine material or combination thereof, and a bituminous cement, incorporated together by a mixing method.



Picture No. 23. On Fountain St.
at Lafayette Ave. Bituminous
concrete on old macadam.
Fine condition.



Picture No. 23 & -- On Fulton St.
at Lafayette Ave. Similar to 23.

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Picture No. 24.-- On Grand Ave. off
Fulton St. Bituminous concrete
in excellent condition.

Bituminous concrete pavements may generally be grouped in three classes:

1. A bituminous concrete pavement having a mineral aggregate composed of one product of a crushing or screening plant.

2. A bituminous concrete pavement having a mineral aggregate composed of a certain number of parts by weight or volume of one product of crushing or screening plant, and a certain number of parts by weight or volume of sand, broken stone screenings or similar materials with or without a filler.

3. A bituminous concrete pavement having a predetermined mechanically graded aggregate composed of broken stone, broken slag or shell, with or without sand, Portland cement, fine ^{insert} ~~xxxxx~~ material or combinations thereof.

Pavements of the first type have been constructed of one or more courses of bituminous coated metal with and without seal coats of bituminous materials. When laid on an ordinary foundation the concrete should be laid in two layers or coats and should be from 6 to 8 inches thick when finished. Fine sand or any suitable fine hard substance may be sprinkled over the last coat just before or after rolling, to give the pavement a smooth compact surface.

The second type took asphalt 125 parts, petroleum oil 25 parts, These substances were melted and thoroughly incorporated together, and to this mixture added, in a heated state, sand or powdered stone, 750 parts and gravel

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or broken stone, also heated 1100 parts. The whole was thoroughly mixed .

The third type specifies predetermined mechanically graded aggregates. This means several sizes are mixed to form a closed mass without cavities. Broken stones are preferred for the whole pavement, and should alone be used for the covering. The greatest dimension of stones for the base should be between three (3) inches and one-fourth ($\frac{1}{4}$) inch, and for covering between two (2) inches and one-twentieth ($\frac{1}{20}$) inch; the sizes should be mixed in proportion varying with the size to form a close mass, which when dry and compact, can absorb not more than twenty (20) per cent of water.

Bituminous concrete pavements are usually more stable and durable than other bituminous pavements constructed with broken stone, gravel or broken slag. The methods employed in the construction of bituminous concrete pavements permit the most suitable kinds and grades of bituminous cements to be used. The proper use of mixing methods insures homogeneous wearing courses having all particles of the aggregates uniformly coated with bituminous cement. As the aggregate is usually heated at a mixing plant, delays of construction, due to wet weather, are not as prolonged as in the case of bituminous macadam pavements. By the use of modern mixing plants, it is practicable to lay certain type of bituminous concrete pavements of type one as economically as it is possible ordinarily to build bituminous macadam pavements.

The disadvantages are that with seal coats slipperiness may occur. Skilled labor is required and for some types

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Attest and seal my hand and the seal of the said court this 10th day of November 1964.

Library of Congress - 100 years of service to the people of the United States : 1800-2000 (2000)

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3. *Conclusions* – The authors conclude that the use of the proposed model is a promising approach to the study of the effects of the environment on the development of the child. The model is a simple and practical tool that can be used by researchers and clinicians to study the effects of the environment on the development of the child. The model is a simple and practical tool that can be used by researchers and clinicians to study the effects of the environment on the development of the child.

expensive plant equipment is essential.

From 1909 to 1915, 7,864 miles, 126,555 sq.yds., of this kind of pavement has been laid in this city with the total cost of pavement \$123,818.22 and average cost per sq.yd. \$.83 to \$1.25

RELAYING PAVEMENTS - GRAVEL.

1. All gravel, paving on the street, and all culverts, cross-walks, gutters, etc., that may be disturbed, are to be carefully laid aside and replaced in their proper position in the manner in which such pavement was originally laid, new materials being used when the old is broken or damaged, and the street left in as good condition as before the commencement of the work. Should the weather be unfavorable for properly repairing the street, such temporary repairs shall be made as the Engineer may require, until such time as permanent repairs can be satisfactorily made.

2. On gravel improvements the gravel shall be screened with a double screen, in order to separate the coarser from the finer materials and to remove dirt and sand. The coarse material shall be placed in the trench first and where the original foundation consisted of cobble stone, they shall be laid in by hand in the regular manner of paving, with the longest axis perpendicular to the surface of the street. A sufficient amount of binding materials, of a quality to be approved by the Engineer, shall be mixed with the broken stone or gravel, and the gravel or broken stone, when replaced, shall not be more than six (6) inches above the street before it is rolled.

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After the material has been carefully replaced, the trench shall be thoroughly rolled with a steam roller and springled by means of a sprinkling cart as directed. Depressions shall be filled as the rolling progresses with the same material as that in the trench. The rolling shall be continued until the street is hard and smooth and conforms to the same cross-section as before the commencement of the work.

3. Old gravel roadways shall have the backfilling left not less than four (4) inches below the grade of the street. The gravel shall be screened with a souble screen to free it of sand and dirt and to separate the coarser from the finer particles. New screened gravel shall be provided and sufficient binding material of a quality to be approved by the engineer, shall be mixed with both the old and ~~new~~ new gravel when it is placed in the trench. After the street has been replaced in a satisfactory manner, it shall be rolled with a City steam roller. New material shall be furnished and placed in all depressions as the rolling progresses, and the rolling continued until the street is hard and smooth and conforms to the same cross-section as before the commencement of the work.

1. 88.

After the material has been carefully inspected,

the trench shall be covered with a layer of 4 inches of

and compacted by means of a roller or other suitable

Depressions shall be filled with a rolling machine

the roller shall be moved in the trench, the roller shall

be continued until the street is level and a depth of 4 inches

to the same cross-section as before the completion of the

work.

3. Old gravel roadways shall have a thickness of

4 inches below the grade of the

street. The gravel shall be compacted with a roller or

to this is of sand and dirt and to replace the compacted

the finer particles. The compacted gravel shall be provided

and sufficient binding material of a quality to be approved

by the engineer, shall be mixed with the old and new

gravel when it is placed in the trench. After the street has

been replaced in a satisfactory manner, it shall be rolled with

a City steam roller. The material shall be finished and placed

in its depression as the roller progresses, and the rolling

continued until the street is level and a depth of 4 inches

to the same cross-section as before the completion of the

work.

**MICHIGAN
STATE HIGHWAY DEPARTMENT
LANSING**

NIGHT TRAFFIC RECORD

.....
Location of

.....
Weather Co

KIND OF VEHICLE	9:00 P. M. to 11:00 P. M.	11:00 P. M. to 1:00 A. M.	1:00 A. M. to 3:00 A. M.
SINGLE HORSE			
DOUBLE TEAM (Light)			
DOUBLE TEAM (Loaded)			
AUTOMOBILE RUNABOUT			
AUTOMOBILE TOURING CAR			
MOTOR TRUCK (Light)			
MOTOR TRUCK (Loaded)			
MOTOR CYCLE			
TOTALS			

Plates attached if correct:

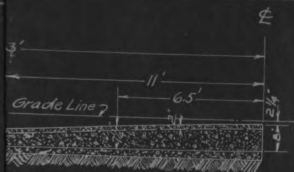
Plate No. 1. Main Fre. block pavement, plan & details

Plate No. 2. Plan for improvement of
Fine Ave., Grand Rapids, Mich.

ROOM USE ONLY

Plate No. 1

R 9/4 Circle



and or cinders as directed
Wire Co. #062P } or their equal
Steel Co. #25 }

ON OF STREET

CRETE

EMENT

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TH STREET

1920.

City Manager.

Plate No. 2.

1. The first part of the document is a list of the names of the persons who were present at the meeting.

2. The second part of the document is a list of the names of the persons who were present at the meeting.

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