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STREET GRADES.

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(Class of 1890.)

THE grade of streets is one of the most important and even vital subjects influencing the general appearance and beauty as well as the prosperity of a city. It is one of the first questions that should be taken up by a growing community, yet many times it is neglected until it is forced to the front by some such matter as paving,—and in most states it is found that the law requires street grades to be established before the work of paving begins.

Almost anyone who has held a public office can recall some trouble in the matter of grades; long rows of buildings with every conceivable variation in height above and below the street, are the common sight—silent monuments of the lack of foresight and forethought in not having the grades studied out and established before building arrives at any great degree of permanency. It should require no lengthy argument to convince any business man or "City Father" of the wisdom of having a system of grades established while the town is young; but it should not be attempted haphazard, or a street at a time.

The author has several times heard the expression "Any fool can establish a grade," and this is woefully and disas-

trously true. Under our laws there is no restriction as to who or what shall constitute an engineer; or who shall undertake municipal work; "any" person is too often entrusted with this important work, which not only requires the best of judgment, but a thorough knowledge of hydraulics, sewerage, drainage and pavements, not only from a constructive and economic point of view but relative to their influence on the health and death rate of communities.

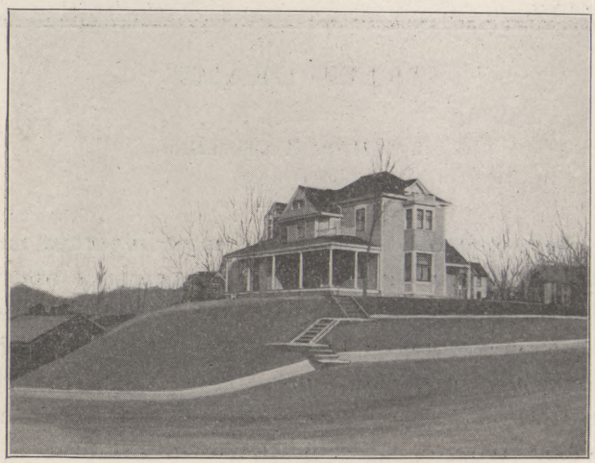


PLATE I.

The question of sewerage and drainage can hardly be separated from street grades, as the amount of surface water and the velocity with which it is carried on the surface determines the size of the storm sewer that takes it up. If then the grades are badly arranged and an immense amount of water is thrown to one point by reason of convergence of grades, or too steep grades, a costly storm sewer is the only remedy; hence a knowledge of the requirements of storm sewerage is necessary. Again, certain pavements allow water to flow more freely than others, and one pavement that would be permissible on a level surface would be too slippery on a steep grade. Or another application of the same principle:

one pavement, as asphalt, gives but a small resistance to traffic by friction, while gravel gives considerable, so that a knowledge of the action and effects of grades on all classes of pavements is necessary.

Judgment as to landscape features from the standpoint of abutting property is also a necessary requirement. To the trained eye the possibilities of the arrangement of terraces and grading of lots so as to give a good appearance are easy of

PLATE II.

The house on the extreme left of Plate II is the same as shown in Plate I.

comprehension and can be seen at a glance; but to those unaccustomed to looking ahead to the work as finished, and unacquainted with methods in vogue in various cities, the difficulties seem insurmountable. Such conditions are well illustrated in Plates I and II which are from photographs of streets in Iowa City. The author has known property holders to fight to the bitter end a cut of four or five feet, and in a year's time be well pleased with the gentle slope and terrace it gave them and boast of the fine appearance of their lots, which a year before they were sure would be ruined.

"System" is the bottom of all successful grade work. Without this real success can not be accomplished, and to ob-

tain it the preliminary work and surveys must also be full and complete. Our Supreme Courts have laid down the rule that establishing a grade consists in an actual survey, the passage of an ordinance or other proper legislative actions, and all the parts of the work made of official record.

The first step necessary in beginning the work is to obtain a working map of the city and surrounding territory, and carefully study the arrangement of the streets and peculiarities of the situation; this is best done by taking the map and going over the whole ground to become familiar with the its natural lay in relation to the plat.

A prominent and fixed point should be selected for the principal bench or datum and from this point side lines of benches in various directions should be established. In view of future use, as well as for convenience, these should be carefully placed and so arranged that in running cross levels you will be able to read on a bench at least every half mile. Then proceed to make a complete topographical survey of the whole city and as much of the outside territory as drains through the city or influences the work in hand. While practically not necessary to carry the readings in this topographical work to a fine point, it is best to insist on strict accuracy from instrument men, as the discipline is good, preventing that laxity which might result in costly errors.

Of course, the most substantial, permanent and reliable "datum" or main bench would be one on a natural ledge of rock, and next to this that of a stone foundation resting on natural rock. Reference to sea level or lake benches, while not necessary, would be a good feature in case all original benches should be destroyed. Hydrants, posts or other temporary structures should never be taken as benches to be recorded for permanent use as they are more or less subject to the action of frost.

In taking levels, it is generally advisable to have readings at both the center and sides of the streets, the block corners, opposite the center of all intersecting avenues, alleys, roads or highways; on the water tables or foundations of existing

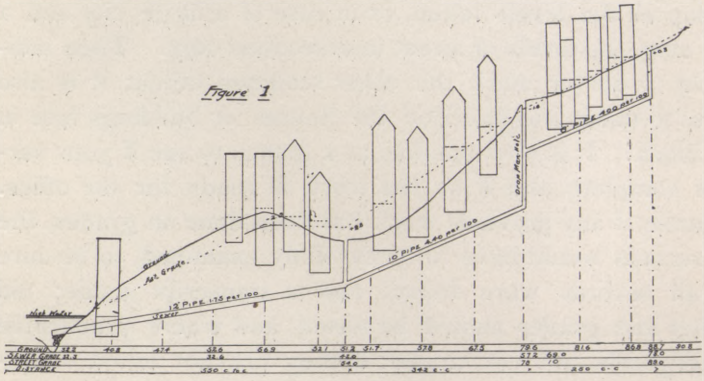
structures, at residence lots materially affected, rows of trees, unusual irregularities, railroad or other tracks, covers of manholes, and inverts of sewers, as well as noting the depths of water, gas and other pipes, or underground work; and in these days of the camera, a photograph of a difficult point is often of great service, especially when working out the details in an office, perhaps a thousand or more miles away.

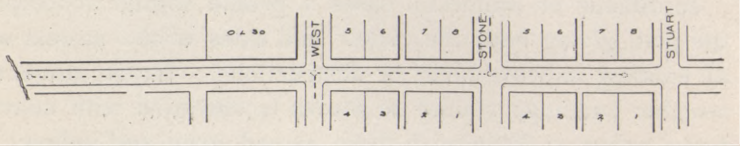
Having completed the survey, the next step is to place on the map all the levels taken, or in case of a large city and a small map, the levels of street intersections only. Then indicate by a dot or mark the other readings taken; it is also helpful to mark the direction the houses or buildings face in each block. It is now possible at a glance to see if your survey is complete, and if so, the work is ready for the office. Of course, if any previous work has been done on grades, the City records would have to be carefully examined, to be sure that all records were found, and a transcript made; old benches and grades should be tested, and where practicable and adaptable, left unchanged; if they are not found adaptable they should be repealed by an official action of the city government.

In difficult or important cases a profile should accompany the plat, giving both the center and sides of the streets with all existing improvements or obstructions. Brick, stone, and wooden buildings should be shown in elevation with conventional colors to distinguish them, as red, grey, and yellow. In considering existing improvements, wooden structures are generally regarded as temporary, and brick, stone, or metal as permanent; but the degree of permanency must be settled by the judgment of the engineer. These profiles should be made on regular profile paper, say Plate A, and on a scale of about 40 feet to the inch horizontal, to 4 feet to the inch vertical, as shown in Fig. 1. For purposes of record a smaller scale can be used and the profiles made in sheets with four or five blocks to the sheet.

The factors to be considered in determining the grades depend very much on circumstances. In looking up the

practice of various cities and engineers many different ideas are found. An engineer in one of the larger cities writes that the grades of their streets are determined by the grades of their sewers; another that high water in the river controls; and another seems to lay particular stress on ease of hauling. But it is safe to say that no one factor should predominate to the exclusion of all others, and it is not the idea of the author





to give a set rule, but rather to show existing rules for various conditions so that the predominating feature may be selected, and all other necessary considerations taken into account. Sewerage should always be considered as a leading factor, as the sewers require a certain amount of fall to keep themselves clean, and under certain circumstances if too steep may run dry and wear out. The street grade should be from ten to fourteen feet above the sewer, according to circumstances. In arriving at this, take the elevation of the under lip of the "Y" on the sewer pipe, the amount of raise to the wall of the building to be connected, allow for the

sewer coming in one foot below the cellar, and then add the depth of the cellar; the total will give about the proper height of the street grade above the sewer. This point is illustrated in Fig. 1. Again, in a flat or level district, a sewer may start at low water, and the rise required to give it sufficient flow may soon carry it too close to the surface of the ground, in which case the sewage will either have to be pumped or the surface of the ground raised. If the area must be filled eventually, then let the required grade for the sewer govern the grade of the street.

If the city is subject to the rise and fall of the tide, or high water in a river or other floods, these become very important considerations that must be taken into account and studied carefully. As a rule in such cases the grade should be established above high water unless the expense and damage to existing structures is prohibitive. If the grades are not established above the height of floods, the sewage, at times at least, may have to be raised by pumping. A careful estimate of the cost of filling the area and of pumping, should be made to decide which method to adopt. The modern sand pump dredge, which handles such large quantities of sand quickly and cheaply, has simplified the problem of filling.

In localities such as indicated by the above conditions the streets may constitute dikes or levees. When this is the case the serious damage or total destruction of the street and paving in case the grade is a foot or two below instead of a foot above high water should be kept in mind.

Whether for ease of hauling, or effect on the existing property, the preference will depend on the street and locality. On a business street with much long distance hauling, it will usually be best to lower the rate of grade. It would be poor policy for the sake of perhaps a few thousand dollars damages to property to adopt high rates of grades and compel the spending of many times more money by the public who have to use them. Again, in a purely residential district, with little through travel, much steeper grades and less cut or fill is advisable.

The drainage of the lots is to be considered as one of the factors, especially where the separate system of sewers is in use. The rain-water drains from the roofs and lots to the streets, and in some cases the whole volume of storm water is carried by the gutters. The grade system then must have the additional care and study made necessary by this problem of storm drainage.

The limiting per cent of grade should next be taken up. Six prominent and experienced engineers have given the following figures: For maximum, 5, 8, 10, 12, 16, 20 per cent. For minimum, 0, 0, 0, .55, 1, 0 per cent. This is a large difference of opinion, but investigation indicates that each was probably influenced by his locality. In cities with topography like that of Kansas City, Duluth, Burlington, or Dubuque, a limit of grade of 10 per cent. would in some cases almost amount to confiscation of abutting property. Grades as high as 16 to 18 per cent have been used, and by careful work made serviceable, but it is safe to discourage them, and 20 per cent or over may be regarded as practically prohibitive to traffic. For business traffic 5 to 6 per cent should be the maximum and the minimum may be zero on the center line, where a fall can be given to the gutters.

For permanent country roads the author is averse to anything over 7 per cent and in most cases a relocation would pay better than excessive grades.

It is a well known fact that a pavement on a grade wears faster than on a level, and that the calks on the horses' shoes cut and loosen the surface as they "scratch" up hill. There is also an added strain on the harness and vehicle, a loss in time and in the amount of loads hauled, all going to make up the item or factor known as the "Cost of Operation" of a grade, which is the difference between the cost of hauling a load on a level and the cost of hauling the same load up a grade. This feature is often neglected by the engineer in figuring grades but it is of vast importance and value and its neglect a direct money loss.

Experiments and observations have been made by various engineers in this line with the following results:

1. Up to 3 per cent on a paved surface the difference in cost and time is inappreciable for ordinary distances.

2. Different classes of pavements and surfaces affect directly the cost of operation on grades, and for this reason a pavement that would answer on the level would often not be appropriate on a grade. For instance, it has been found that the traction of a load on a level on an iron road is ½ of 1 per cent of the weight of load; on gravel 4 per cent, and sand 20 per cent; so that a load that would go easily on an iron rail or on asphalt pavement up a 5 per cent grade would be moved with difficulty on a rougher surface. On the other hand it is found that the kinds of pavements are limited by the grade. Sheet asphalt or extremely smooth cement grouted brick should not be used on grades of over 5 per cent; ordinary brick or wooden block on grade of over 5 to 7 per cent; stone block, macadam and Telford, 7 to 10 per cent; and from 10 to 15 per cent grades should have especially designed Telford with chamfered stone block or round cornered brick.

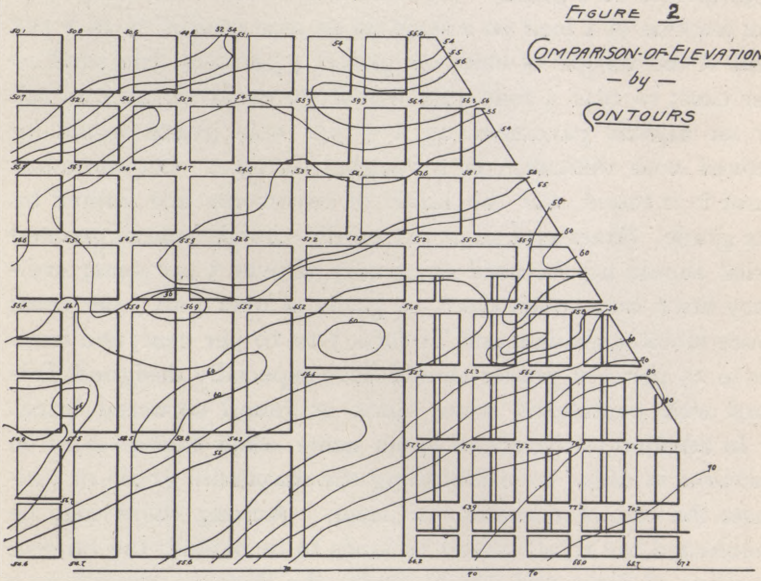
In addition to the above items many other factors must be included in order to establishing the maximum grade or estimate the cost of operation on same. Among these may be mentioned the total number of loads to be hauled; the relative number of light and heavy loads; the distance around by a more circuitous route having easier grades over which the heavier loads could be hauled.

The problem of determining the amount of money which may be spent to reduce or avoid a heavy street grade includes the consideration of so many indefinite and undetermined factors that it is not capable of exact mathematical solution. However, one can have more than mere guess to guide him. Many formulas based on reasonable assumptions but more or less empirical in nature have been published by their authors and these should be employed in assisting the engineer to the solution of such problems.

General practice limits the grade across intersections and

on sloping side hill pavements to 3 per cent, and time has demonstrated the wisdom of this limit.

We will now consider that we have enumerated all of the more important features governing the selection and fixing of grades and will take up the work. Returning to the consideration of the topographical map. It is the practice with some engineers to work out the grades directly from the



figures on the map giving the elevations, but if the map is contoured it is safer, and in most cases will so facilitate reaching the final conclusions as to more than pay for the extra labor. Fig. 2 illustrates how contours show the character of the ground.

Contours will at a glance picture the natural sub-divisions of the territory relative to slopes, inclinations and drainage, and it is often advantageous to divide the area into districts according to these natural sub-divisions, considering them first in relation to each other, and then in detail for each district. Where practicable it is a good plan to place trial figures on the survey map in light pencil, or on a second map.

In a fairly level town it is not difficult to decide on trial grades, and nearly all the work can be done from the map.

In rougher ground the profile must be resorted to.

In using this it is a great help in adjusting the grades to stick pins at the trial points selected and stretch thread over them. The trial grade is thus shown at a glance, and by shifting the pins any degree of adjustment is obtainable. Of course both parallel and intersecting streets should be borne in mind at the same time.

In extremely difficult cases and where the work is to be passed on by a city council, board of public works or other body of laymen, a relief map will often illustrate and explain the work and the reasons and benefits thereof where nothing else will convince. These may be made with comparative ease and facility and as accurately to scale as an ordinary profile. In the opinion of the author they should be more frequently resorted to.

Where a street has abrupt changes, particularly in the residence portion, the use of vertical curves and reversed curves is recommended as greatly improving the appearance. There are no limiting conditions that demand a perfectly straight grade line from one intersection to another, either for sewerage, drainage or traffic. But it is very seldom that curves are found in use, though in residence districts they can be utilized to great advantage to the property. Very full data of the work on curves should be given and recorded, or they are liable to be ignored and the grade taken in the old fashioned straight line.

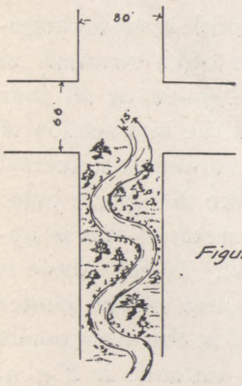


Figure 3

Reversed curves have been used on steep grades with good results. At Burlington, Ia., Mr. Steyth when City Engineer very prettily solved the grade of a steep hill in this way and the vacant spaces between the paving and curb were parked.

By this system, although the road is somewhat lengthened, the amount of grade per foot is, of course, correspondingly reduced. Fig. 3 shows an arrangement by reversed curves.

Each street should be figured as far as possible to carry its own surface water. It is a great temptation with a ravine handy to dump the water into it, and this plan is generally favored by councils and laymen, but the Nemesis is sure to come when the property is improved and the street paved, for the water will run off so much faster that congestion and flooding will result. For the latter reason, convergence in grades should be avoided, and the drainage split as much as possible.

In most of our older cities where the grades have been established from time to time as each street was improved, this condition exists. The grades have been established for the convenience of the moment and for a particular locality. As other streets are improved their water is thrown into some new channel and the result is that there is a choice of either costly damages, a change in grade, or an expensive storm sewer to carry off the water.

One of the most important parts of the work is the arrangement of street intersections, and this has often resulted in much confusion. The grades should be given at all four corners of the intersection and not alone at the intersection of the center lines. It has been a common and almost universal error in the smaller cities and towns to make the grade point the intersection of the center lines. The result of this is apparent when two streets cross on a side hill. If the grade is taken strictly as it reads, to "the intersection of the center lines," there will be two grades established at the same points at each corner of the intersections. For instance in Fig. 4, we have an east and west street, A B, having a grade at B of 89, at the intersection of the center lines of 90, and at the west end A of 91. The north and south street, C D, has a grade of 100 at C, and 80 at D. From A to B is 1,000 feet, from C to D is 600, width of paving is 50 feet. Then the grade of the northeast corner, at the intersection of curb lines

on the street C D, would be 90.83 and on A B at the same point 89.95—a difference of 0.88. The difference between the high point at the northeast corner and the low point at the southeast corner, 1.66 feet.

The above example is taken from practice. The street had been curbed on the grade of A B and cement walks laid to correspond. Later a contract was let to pave both A B and C D, and also to build cement walks on C D. All curbs, walks and center of paving were to be put in at grade. The

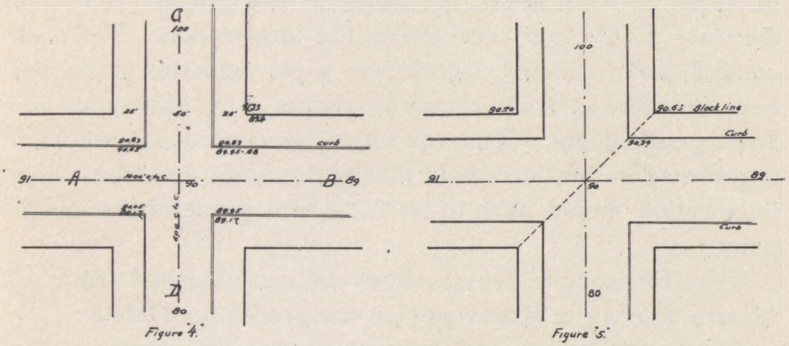


Figure 4. Figure 5.

engineer solved the problem as best he could by averaging the curb grades, but the result was a law suit. The court admitted the impossibility of following the ordinance, and recognized the discretionary power of the engineer, and as his interpretation was impartial it was not disturbed; but a severe criticism was made on the man who drew the original ordinance.

In another case arising from a similar cause, but in which the arrangement was somewhat different, the Supreme Court held that the city and the engineer, in seeking to remedy a defect by raising the paving, were at fault and the paving had to be lowered.

In several cases where the grades have been established in this manner, they have been rectified by amending the grade ordinance so that the grade of the corners will be the average of the grade of the intersecting streets on that line as in Fig. 5. This is probably legal, but a better way would be

to refigure the whole system anew, establish the corners, repeal the old ordinance, and enact a new one.

Recent Supreme Court decisions have shown that the only safe way to give grades is by establishing them at the intersections of the street or property lines for the four corners of the intersection, and any desired intermediate points must be given and established at the same time.

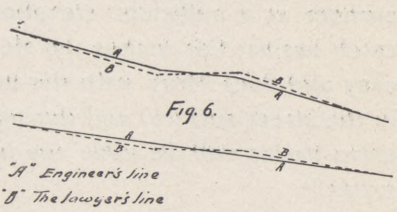
In many cases in the general practice of the past it has been the custom on streets having grades of over 8 per cent to 10 per cent, to break the grade at the property line and decrease it to 3 per cent across the intersection. For such conditions this is well, but below 3 per cent the grade has been established from center to center in a continuous line and so staked out. This the courts have said is not a legal interpretation, but have held that in the latter case the whole intersection would have to be flat at the grade of the center point.

Take for instance the excellent and much quoted report of Messrs. Hering & Rosewater on the grades for Duluth:

"Upon all streets and avenues in the city except in the business section, the curb grades should be unbroken between intersecting curbs. In the business section of the city the lines of curb grades, when exceeding 8 per cent, should be broken at the street or property line. All street crossings from the curb on one side to the curb on the other, irrespective of location, should be designed on the basis of a 3 per cent slope, except when the slope of the intersecting streets or avenues is less, in which case the grades shall be continued unbroken over the crossings."

Now to an engineer the meaning and intention of this is perfectly clear, but it is liable to lead into an error of mode in expressing the purposes which may be interpreted by the courts entirely different from what was intended. If the continuous grade, of 3 per cent or less, is established by figures given at the four corners of each intersection, both in relation to the leading street and the side street, the work will hold good; but if for convenience the grade is given from center

to center, then the court holds that the *whole* intersection must be of the grade of the center point, i. e., flat, which of course the engineer did not intend; also, unless otherwise especially provided for in the grade ordinance or by-laws of the corporation, the establishing of two or more parallel streets establishes intersecting streets between which, in the case of continuous grades, would lead to the conflict shown in Fig. 4. In Fig. 6 is shown a diagram illustrating the above decision.



Another consideration affecting the intersection is the arrangement of catch basins, and in this connection are quoted the following comments by Mr. W. J. Yoder, in which he concurs with the author's paper read before the Western Society, by saying:

"In reference to street intersections, the arrangement of grades is one of the most important parts of the work. In this connection I would like to contrast the methods of draining an intersection as generally in use in Chicago and other places where the streets are level, or nearly so, and that now used by the South Park Commissioners of Chicago. The usual practice is to locate the catch-basin at the four corners of intersection, thus in time of storm sending the greatest amount of water by the cross walks where there should be the least amount. Then to obviate this difficulty, false gutters are used which soon become stopped with debris causing the water to rise, and often making the cross-walks impassable. Another very objectionable feature of the false gutter is that it requires a hump in the side of the pavement which is neither pleasant to the eye nor to ride over. In the method which is now employed by the South Park Commissioners in Chicago, four more catch basins are required than by the other plan, but it seems to me the many advantages more than justify the extra cost. By this plan the catch basins are generally placed about 25 feet back from the street

lines. This shortens the distance to the summit giving a better fall in the gutters. Summits are then made at the four corners at a sufficient elevation to give a good fall to the catch basins; this makes the step from the curb to the street easy and does away with the usual pond of water and hump in the street surface, and during an excessive rainfall the four extra basins will be none too many to properly care for the water."

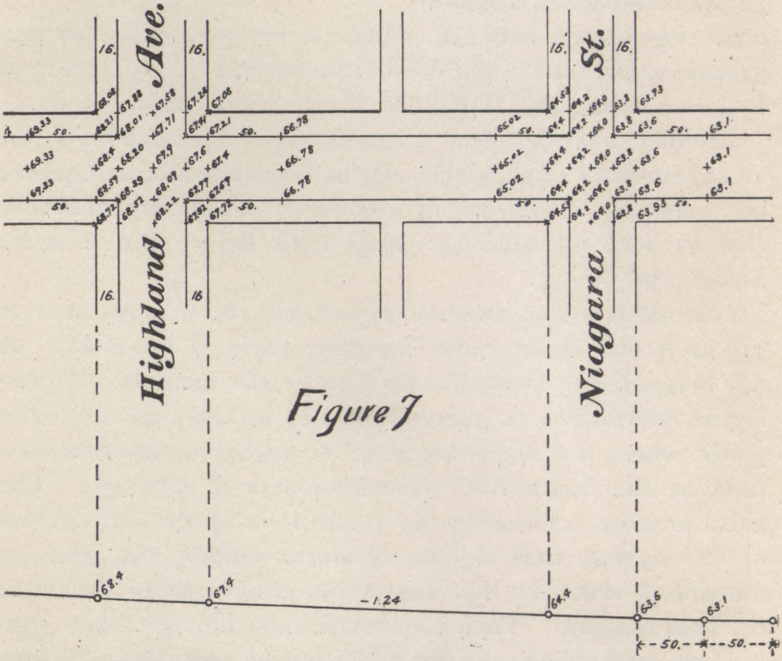


Figure 7

For convenience in the office work, it is easiest to figure the grades first on the center lines and from this skeleton diagram the block corners and other points to be established can be worked out. Taking then the center of the street as a base, and figuring the slope of the intersection at 3 per cent rise, from the curb to walk at ¼ inch per foot, slope of walk ¼ inch per foot, we have the rise to each corner. The sum of these divided by two will give the average grade for block corners, and by repeating for the other sides the best average

for the intersection will be obtained. Figs. 7 and 8 illustrate the two cases above referred to.

In the location of summits between streets, considerable ingenuity has been displayed in elaborate formulæ for the location of the summit to a nicety, but to a man of experience the rule of one of our prominent municipal engineers seems to be admirable. His rule is, "Give me an accurate map, a profile and a look at the ground, and I will put my finger on the proper summit," and this, it seems, is the best. Locate it when the field work is done.

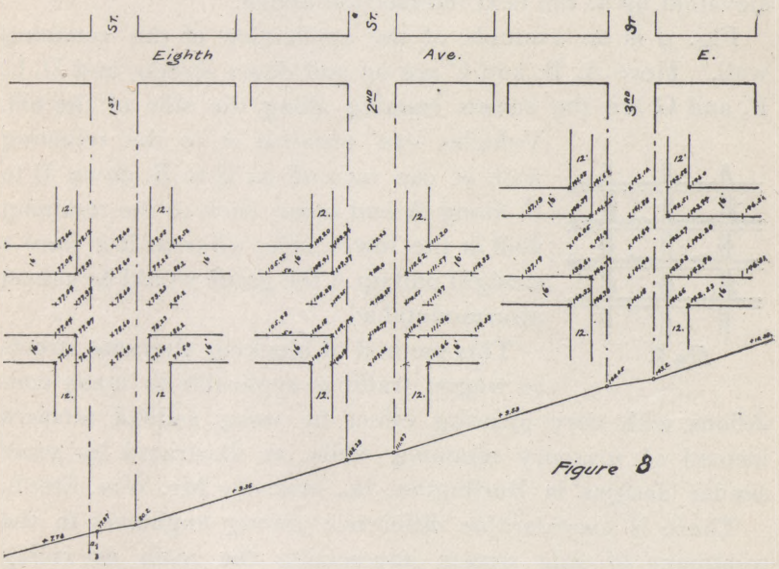


Figure 8

If the summit is to be on a curve the elevation of the curve should be worked out and given on the profile at least every twenty-five feet or oftener if the curve is sharp.

In the arrangement of side hill streets and terraced streets, the engineer has a good opportunity to display his ingenuity and any latent artistic taste which he may possess. The practice of raising the up-hill curb and giving the road-way a fall to the center, or making it all of the same slope to the down-hill curb, is a good way of overcoming this difficulty, and with care some pretty effects can be obtained from an "out-

rageous cut." Some engineers have discouraged this arrangement because of throwing the water to one side; but this is not a valid objection, as it is easy to provide for the water.

The amount of slope from the uphill to downhill side of the road-way between curbs should not exceed 3 per cent. Various methods have been suggested and used to reduce the steepness of grade for side hill streets, most of them are however not of general application but result from special conditions. One system is that of building retaining walls in every other block of the up and down streets, thereby keeping the elevation up at the next intersection above.

Fig. 9 is an example of the application of the retaining wall. Here A, B, and C are up and down streets and D, E, F, and G are the streets running along the side of the hill. Vehicles can traverse A to the retaining wall, or can turn off on E to B, down B to F, along A and come back to the retaining wall at the lower side, whereas if it were a straight pull up A the grade would be almost insurmountable.

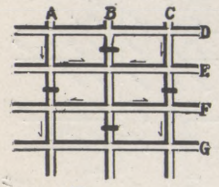


Fig. 9.

This method of blocking alternate streets to wagon traffic is applicable to many conditions with very pleasing effect by using sodded terraces instead of masonry retaining walls, as illustrated by some similar designs in Burlington, Ia., made by Mr. Wm. Steyh.

There is considerable difference among engineers in the treatment of side streets intersecting the main or ruling streets. Some establish the grade of the side and ruling streets at the same time, while others do not. Right here is a frequent cause of error. The engineer establishes the grade of his ruling streets, and ignores the side streets, thinking not to establish the grade of side streets at that time. But Supreme Court decisions say that "where not otherwise especially established, the establishing of the ruling street establishes the intersecting streets at the same grade."

As an example the following case is cited, illustrated by Fig. 10. The grade of streets A and B had been established

for some years as 100 at the intersections A C and B C. Jones bought a piece of property on C street and made improvements thereon according to the grades established on A and B. Later the grade of A at C was lowered to 92 and C street was excavated to meet the new grade. Jones brought suit against the city for damages by reason of the change of grade. The city claimed that the grade of this street had never been established. The Iowa Supreme Court held that the grade of street C had been established by establishing the grades of streets A and B; that the change in A was a corresponding change in C and therefore damages were awarded. Similar cases in several other states are given. This is cited as an example, similar conditions existing in several other cities, where the grades of cross streets are not supposed to be established, and because it is a very common error.

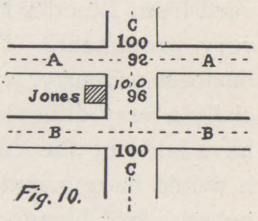


Fig. 10.

Much trouble in grades could be saved by a careful consideration of future grades in laying out additions or new towns, and by following the natural lay of the land, instead of chopping the ground up into lots and blocks, cornfield style; better gradients could be obtained and much expense saved both to the city and abutting property.

Mr. D. W. Mead, in commenting on an earlier paper by the author touching the subject, expressed agreement by saying, "The question of grades should be considered in the laying out of a city. If that can be done, the grade question will be comparatively simple. Unfortunately in this country, our very desirable system of rectangular public land survey has led to the adoption of a very undesirable rectangular system of streets, which, though convenient for dividing property into the greatest number of rectangular lots upon which can be built the greatest number of rectangular buildings, has little else to recommend it from any point of view. Traffic, sewerage and surface drainage should naturally follow the slope of the country, and any attempt to deviate from this

soon becomes a very serious financial question in the building of a large city. Most of our larger cities are finding this out in a very expensive and consequently impressive manner. The attempt in Chicago at present to open a diagonal boulevard from Lincoln Park to Union Park, has made this point very prominent. The cutting of streets through valuable business property, which has long since been built up, is financially a very difficult problem; whereas, if it were possible to have laid out the city with the necessary or diagonal streets it would have greatly facilitated traffic and at a minimum expense. In Chicago the question of drainage has not entered into this grade question in so important a manner, but in a great many other cities where the land is very irregular in contour, the result of not following the drainage valleys with streets has led to a very great expense in the construction of storm sewers, as well as in street construction and other constructions which have been necessitated simply by the failure to follow out so obvious a plan as to follow in Nature's footsteps and place our streets, which are and should be the natural drainage lines of the city, in the natural drainage valleys."

As curb grades are almost inseparably connected with the general street grade, their consideration is pertinent here. The curb grade is often given as a certain fixed amount above the street grade, but this is a poor rule. While it should always be uniform the height can often be varied in different localities with benefit. Of course it should be established at the same time as the street. On a side hill slope the uphill curb may be perhaps 8 inches above the pavement while it is but 6 on the lower side, the difference is scarcely noticeable. Jogs in the curb are objectionable and should not be tolerated.

Not long since, in an article on grades, the statement was made that the curb was to be set on the established grade, and that the center of the street was to be lowered to give the desired crown. This would be illegal in most states, as it is generally held by the courts that the grade is the top of the pavement in the center, and that at this point it must cor-

respond with the ordinances, by-laws, or other official records of the corporation wherein the grade is defined. If, however, the state law and the laws of the city allow of the above arrangement it would be permissible; but in the majority of cases it is more practical to have the roadway fixed and vary the curb. In this relation attention is called to the fact that in repaving it has been held that a change in the shape of the crown and of the gutters was not a change of grade.

Local conditions of surface drainage and convenience generally govern the depth of the gutter and height of curb to be exposed, and when not restricted by rules of the corporation, are subject to the discretionary power of the engineer. In a comparatively flat town where there is not much choice, it is generally sufficient to establish the curb grade at the four corners of the intersection; but in some cases it is necessary to go back a short distance, 50 to 75 feet, and make a secondary point; of course this break is not pretty, but is often necessary. If a vertical curve is used a better appearance is made. In a majority of cases the depth of the gutter is equal to the crown of the pavement and the curb is exposed that amount; but this cannot be set down as a rule and there will be hardly a city where a variation of this will not be beneficial to the work.

Walk grades can either be taken with the general grade or separate, according to circumstances. In business districts and well built up localities it would be best to settle them at the same time. In curb grades, no fixed rule should be given to cover the walk grades for the whole city.

In residential sections where the walks proper are comparatively narrow the minimum slope of the unpaved portion from the walk to the curb is almost universally ¼ of an inch to the foot and may well be fixed at that; the maximum has no limit.

In the business districts it would be well to settle as to whether the walks, when they extend to the curbs, shall be even with, or above and projecting over them. No set rule will govern all cases. But average common practice gives

the walk a minimum of ¼ inch and a maximum of ½ inch slope to the foot towards the curb. At walk corner intersections, the elevation of the inner corner should be the average of the outside opposite corners, if greater than ¼ inch to the foot slope, and if less than ¼ inch to the foot, the average, plus enough to make the slope ¼ inch to the foot.

In residence districts when the height of the lot grade is more than four feet above the curb the walk grade should be raised above the curb until either the slope from the walk to the curb becomes too steep to maintain or becomes dangerous to the public. It is the author's opinion that this should not be arranged until it is thoroughly talked over with abutting property owners; but the engineer should insist on uniformity, and compliance with the laws of good practice. A few blue prints showing the manner of arranging walks, grades and terraces will be of much aid in illustrating how these features can be arranged, as will also photographs of the solution of similar problems as illustrated in Plate I and II.

Outside of business districts the ruthless slaughter of trees is vandalism, and unless positively necessary can be prevented by the courts, contrary to the general supposition that "the city can do as it pleases." In some cases long rows of trees are cut down because they come in the line of walks. It usually develops that the trouble has been that in establishing the first grades and walk lines only a few blocks were figured on instead of the whole city, and the trees were sacrifices to somebody's blunder or lack of careful study of the whole situation.

Very few of our cities have an established "building grade;" this would be a desirable innovation, and it is a thing to be hoped for. There seems to be no reason why our business houses should not have the same elevation above the street throughout, and if not desirable to make them uniform, a maximum variation could be prescribed and a regulation made that no building should be put up without ascertaining the building grade. As to what would constitute the placing of a building at grade the Supreme Court of Iowa has ruled

that "Property is at the established grade when it can be comfortably, conveniently and safely used for the purpose to which it is devoted." From this it will be seen that no rule could cover all cases, and of course it would not be practical to attempt it, but some regularity and uniformity should be striven for.

The laws and decisions in regard to grades vary somewhat as to the mode to be used for different States, but the decisions as to the essentials are practically the same in America and England. Before beginning on a grade system the engineer should always look up or have some lawyer examine the State law for him to see that the ordinances of the city are in harmony therewith, and govern his work accordingly.

When all the various steps heretofore mentioned have been considered and all parts of the work covered, the figures are ready for presentation, and this is best done in the form of a report with the plans and profiles accompanying. As in most cases this report is to convey definite information to those not familiar with technical matter, it should be clear, brief and as free from technical terms as possible.

The author does not believe in allowing the engineer's work to have final judgment passed upon it by the property owners or by the council, as to its appropriateness. If there is any doubt, either in the minds of the council, the citizens or the engineer, a consulting engineer or board of engineers with experience in this line should be called in, and their decision abided by.

The report should then be followed by legislative action of the city council in the form prescribed by the State law or charter of the city. This is generally by an ordinance (in many States an ordinance is mandatory) which should take up the grades as recommended in the engineer's report, in a systematic and regular order, stating the grade of each street in a separately numbered section, so that in case of any subsequent changes as to any one street, it would be necessary to repeal or change only the section pertaining to the particular street in question. The ordinance should also mention and

include by reference the engineer's profiles, plans and maps of the work.

See that this ordinance is regularly passed, signed by the requisite officers, and recorded in the city records in strict accordance to law. In most cases publication of the ordinance, either in a newspaper or by posting up, is also necessary, and in this case proof thereof should be made and entered in the proper city records right at the time. It generally devolves on the engineer to see that it is printed correctly, as a person unacquainted with technical work would not readily detect errors.

FORM OF ORDINANCE.

The following form of ordinance is given as a guide for those new in the work. Comparison should always be made with the prescribed form of caption for the individual city and changed accordingly. The principle features and advantages are:—The index, and dividing the ordinance into sections for each street and subject.

AN ORDINANCE establishing the grades of the streets, avenues, roads, highways, lanes, alleys, and block intersections of the City of.....in the State of.....

INDEX.

1.—Bench marks and City Datum,
2.—Explanation of figures and terms,
3.—First Avenue Grade,
4.—Second Avenue Grade,
5.—Iowa Avenue Grade,
6.—Main Street Grade,
7.—Muscatine Road Grade,
8.—(Etc. for of balance streets, avenues, &c.)

* * * * * * * * *

197.—Grade of intersecting streets,
198.—Explanation of grade points,
199.—Official Bench Marks, Location and Description,
200.—Plans, profiles and maps included,

201.—Conflicting ordinances repealed,

202.—When to take effect.

Be it ordained by the City Council of the City of....., in the State of.....:

(This caption to be changed to suit city's adopted form.)

Section 1. That for the purpose of establishing grades in the streets, avenues, roads, highways, lanes, alleys, and block intersections in the City of....., in the State of....., the following named point shall be taken as a base or starting, to-wit:

A point one hundred (100) feet below the top of the stone sill of the basement door of the Southwesterly corner of the County Court House, marked as follows: ( ) said building being situated on Strong's Avenue, between Mill and Court Streets in said City of..... The same base being.....feet above sea level.

Section 2. That whenever any point is given by numbers as a grade point, it shall mean such number of feet and one-hundredths of a foot above the "Base" established in and by section 1 of this ordinance, and the grade of any street, avenue, road, highway, lane, alley or block intersection of said City of....., between grade points, as hereinafter established, shall be on a plane between such points from intersection to intersection, the terminals being at the intersections; excepting points in blocks especially established, where the grade shall be a plane between such special points; excepting, also, streets where the grade line shall be on a vertical curve, where the grade shall be given by the engineer's plans and as herein given; excepting, also, other streets, avenues, roads, highways, lanes, alleys and block intersections or other places, where no grade points are hereinafter given, at such intersections or at other places herein especially excepted, in which case the grade shall not be hereby established nearer such intersections and railway tracks (where no grade points are given) than the last grade point given on each side of such intersection or other especially excepted location.

Section 3. That the grade at the black line of First Avenue at the intersections of the streets, avenues, and public square as hereinafter named, shall be as follows:

At the	northwest	corner of	Dixon St.	and	1st Ave.	138.5
"	northeast	"	"	"	"	140.5
"	southeast	"	"	"	"	143.0
"	southwest	"	"	"	"	142.0
"	northwest	"	Madison Av.	"	"	151.0
"	northeast	"	"	"	"	161.5
"	southeast	"	"	"	"	153.0
"	southwest	"	"	"	"	153.5
"	northeast	corner	public square			168.0
"	southeast	"	"			168.5
"	southwest	"	"			168.0
"	northwest	"	"			168.5
"	center of the		public square			169.0

* * * * * * * * * *

Section 197. That the grade of all streets, avenues, roads, highways, lanes, alleys and block intersections, crossings or intersecting any of the above named streets, avenues, roads, highways, lanes, alleys and block intersections, shall be the same for such streets, avenues, roads, highways, lanes, alleys and block intersections thus crossing or intersecting at such crossings or intersections, as the above named.

Section 198. That the grade points herein above given and hereby established, at the intersections of the streets, avenues, roads, highways, lanes, alleys and block intersections above specified, shall apply to and establish a grade of the elevation given at that point, and all other points in the intersection not herein especially excepted shall be figured as the average pro rata of grade points given, except that nothing herein given shall be construed as fixing the grade of the top of the curb, or the bottom of the gutter.

Section 199. That the points hereinafter named are hereby established and adopted as "bench marks" or "reference points" in said city, to-wit:

1.—
2.— } Describe accurately.
3.—Etc.

Section 200. The notes, maps, plans and profiles of the civil engineer on file are by reference hereby included and made a part of this ordinance.

Section 201. All ordinances or parts of ordinances conflicting herewith are hereby repealed.

Section 202. This ordinance shall take effect and be in force from and after its passage and publication as required by law.

Passed.....19..

.....
Mayor.

.....
City Clerk (or other proper officers.)

NOTE:—Proof of publication should be entered of record as soon as made.