

ROAD-MAKING IN THE HILLS.

PRINCIPLES AND RULES,

HAVING SPECIAL REFERENCE TO THE

NEW ROAD FROM KALKA VIA SIMLA

TO

KUNAWUR AND THIBET.

BY

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CONTENTS.



I.—PRINCIPLES OF CONSTRUCTION,.....	1
II.—RULES FOR ESTABLISHMENT,	11
III.—PRESCRIBED FORMS,	15

ROAD-MAKING IN THE HILLS.

NO. I.—PRINCIPLES LAID DOWN BY MAJOR J. P. KENNEDY,
FOR THE GUIDANCE OF ALL PERSONS ENGAGED IN CON-
STRUCTING THE ROAD FROM KALKA, THROUGH SIMLA, TO
KUNAWUR AND THIBET.

Every road should have its line as level, and its surface as hard, smooth and non-elastic, as circumstances under the most scientific management will allow.

The subject of road-making may be divided into two general branches :—

First.—The laying out of the line.

Second.—The construction of the road.

LAYING OUT OF THE LINE.

When the grave charge of initiating the improvement of a district of country, by the construction of roads, is committed to a man of judgment, his first care will be to consider the features of the country, not only within his immediate charge, but far beyond those limits.

He should divide his road projects into three distinct classes. The first and most important containing the lines of general intercourse; the second containing the roads for merely local objects, and communicating with those of the first class; and the third containing the farm roads communicating with those

of the second and first. He should not, upon any account, permit the perfection of his roads of the first class to be in the slightest degree injured for the benefit of those of the second or third classes. His great lines of intercourse must be laid out solely with reference to the general levels of the country, and to the permanent markets, to which producers may afterwards have to convey their goods. If he think only of his own little district at this point of his operations, he will materially injure it, as in that case his general lines will probably not be such as to invite general traffic, and the mercantile interests of his district will be proportionally impeded. The co-operation of the circumjacent neighbourhood is essential to the improvement of any given spot of country, and must be earnestly sought for. Keeping these considerations constantly in view, we may now proceed to the rules applicable to all branches of laying out, viz :—

1st. That the line must never rise or fall unnecessarily ; it must go round, or cut through impediments.

2nd. That the quantity of ascent or descent, when such is unavoidable, should be divided uniformly over as long a distance of the line as the nature of the ground will permit, and thus the inclination at each particular part will be reduced to the smallest possible rate.

We should recollect that the loads carried along roads must be small in proportion as the inclination of the hills is great ; that the steepest hill, in fact, regulates the load.

We must never forget, in laying out a line of road, that on an inclined plane or hill, of which the surface is hard and smooth, when any power holds a heavy body in equilibrium, the power exerted will have the same proportion to the weight as the height of the plane or hill bears to its length ; and secondly, that whilst the effect of the load increases, the power of the animal employed to draw it diminishes in proportion as the degree of inclination increases. These two facts should never be absent from the road-maker's mind.

When this subject is fully understood, it will be evident that the ignorance of a person who undertakes to lay out a road may, and very often does, make the transport of commodities amount to many times what it should cost. There is little doubt that the greater number of the hills we generally find on roads might have been either wholly avoided, or their inclination very much diminished, by judicious laying out ; and the greatest evil is ; that the only wise remedy for such blunders is to make a new piece of road where they exist, and if they are numerous, to change the entire line. The common mode of correction is to cut down in some degree the hill, and to fill up a little the hollow ; but this method

rarely reduces the inclination as low as the natural features of the ground would allow ; and it generally costs much more than would be necessary to put the road in its right place by laying it out afresh.

The correction of hills on old roads has been alluded to here, to show the importance of extreme accuracy and sound principles in selecting an original line. Every Superintendent will now understand that if an error be made, it cannot be thoroughly remedied without abandoning that portion of the road where it exists, and taking up a new line, thereby losing the capital already invested, and injuring the speculators whom the road may have brought there ; but if there be an error of construction, as for instance, the use of soft materials instead of hard, or the like, all this can be set right without abandoning the old line. The power of getting level roads by cutting through hills and filling up hollows is not disputed ; and in laying out a line of railroad this method must be adopted, because the velocity of the steam-carriage will not allow of such rapid curves as a road must take which follows the natural inflexions of our hills ; but the expense of such cuttings and embankments is so enormous, that to think of them for the ordinary roads would be quite out of the question. Our necessities frequently require that farm roads should be made, that roads for approaching minor villages, &c., should be made, and that extensive districts of almost unexplored countries should be intersected by numerous lines of general communication. If a costly kind of road be attempted in such cases, the necessary results cannot possibly be produced, because the necessary funds could not be provided ; still it is essential that as accurate a regard should be paid to their laying out, as if they were to be immediately constructed on the most perfect models, and that the levels be the very best that the nature of the country will admit of. We must provide from the commencement that every successive operation shall tend to bring them ultimately to a state of the very highest perfection, and that nothing shall ever have to be undone.

False ideas of economy and inadvertence frequently lead to the employment of men who do not understand the principles of these essential operations, although they attempt to execute them, and hence the eternal toiling up and down hill to which they, their neighbours, the public, and future generations are condemned. Most amateur artists are time-killers and money-wasters, but of all the amateurs in the world, the road-maker is the most mischievous ; there is no method of avoiding his ingenious contrivances to harass the weary traveller and reduce the profits of industry.

The first thing to be done, when it is determined to open a road between any two points, if they be distant, is to get the maps of the adjacent country, and to become thoroughly acquainted with

every inch of the intervening ground in all directions, particularly the course of rivers.

If it be a hilly country, the greatest possible attention must be given to choose the most convenient passes of mountains with reference to their height, and the highest passes of valleys, which in all cases, must be considered as obligatory points of the line. The selection of these, therefore, is to be considered the first and most important point of laying out, and nothing short of *mathematical proof* of their superiority to all other points ought to satisfy the Superintendent that he has selected the right points.

It is much to be regretted that the Survey Department of India has not furnished the public with that most important class of information, a contour delineation of the hills; the want of which must be remedied by increased industry in all those who are engaged examining the country with a view to the selection of the line.

The most disadvantageous circumstances under which it can be required to lay out a line of road is, where the direction runs at right angles across a line of hills, to the passes of which there are no convenient approaches by means of under-features; this obliges us to resort to the expedient of zig-zags. There is no difficulty in laying out such a road to any required degree of inclination; but when done, it is always dangerous, as it is not possible to avoid very acute angles, which on a declivity, are most objectionable. If an animal run away with a carriage in descending such a road, the first turn he reaches will probably finish the mortal career of the whole party.

The rule in such a case must be, to make as few turns as possible; and in general, there need not be more than one on each side of the mountain.

Having obtained a knowledge of the relative heights, as above described, both from maps, and by taking lines of section with the level, and having thus selected all obligatory points, we may now proceed to the operation of marking out the exact line between all the points thus selected. This is done by fixing up pickets with flags attached, in the required slope, by means of either the plummet-level or a spirit-level, having a graduated vertical limb. These flag-pickets may be placed at intervals of about one hundred yards, more or less, according to the bends in the hills, taking care that one is put at every projecting and every retiring angle of the ground, and that from each picket the one on either side is distinctly visible. We proceed thus until the whole line is picketed off, observing to correct this line, if requisite; and it rarely happens that the pickets can be placed precisely in their right permanent position at the first trial.

Having got the long pickets accurately placed, the ground should be distinctly marked at each picket by cutting a cross, or some other convenient sign; and the second operation must be commenced by placing short pickets with the boning rods at intervals of about eight yards between the long pickets.

Third operation. Having placed the short pickets, long lines are then laid to the foot of the pickets, taking care that the lines run round all obstacles, and not over them. When these lines are fixed, some expert laborers, accustomed to the work, may be placed to cut out the lock-spitting exactly to the level of the line.

This operation should be done with great accuracy, that there may be no necessity for correction afterwards, and handy men, accustomed to the work, should be employed in lifting the lines and laying them again, as the lock-spit cutters proceed. This lock-spitted line being the sole regulator of the levels, must be examined, and re-examined to ascertain that in every part it has been accurately cut. The person charged with such a work must not spare himself at this point upon any account. Let him then bring every one whose opinion is worth having in the neighbourhood, to visit and criticise what he has done; let him reflect that, by any idleness or stupidity on his part, he passes sentence upon countless generations to suffer inconvenience and unnecessary toil for his omissions. The lock-spitted line, when completed, is not to be considered as any thing but a gauge for the general level of the surface of the road. It is not the centre, as some suppose, although, upon a general principle, the nearer the centre line comes to it, the cheaper will be the forming of the road, and the more we diverge from it, the more costly it will be where the features of the country are of a hilly character.

With the completion of the above described lock-spitted mark, neatly cut along the whole length of the projected road, we shall consider the business of laying out the line to have been executed; and in order the more clearly to separate this most important operation from all others, we shall consider the subsequent picketing, ruttings and marking off the details, as appertaining to the subject of construction.

The average cost of cutting this gauge-line or lock-spit, independent of the preparatory surveying and superintendence, ought not to exceed four or five shillings per statute mile—that is to say, for the actual pay of the laborers employed to execute it; and when completed, it ought to exhibit a perfect level or a perfectly uniform incline, between every two of the obligatory or main points, and following every horizontal inflexion of the ground, it ought to stand the test of any instrument, and be pleasing to the eye. The want of accuracy in the laying out of public undertakings, is the

source of that constant doing and undoing, or playing at blind-man's buff with the work, which we so often see ; doubling or quadrupling the proper cost, and leaving most discreditable results. The economy and perfection of the work will be in proportion to the judgment and accuracy applied in the laying out and making of this gauge-line, as it gives us the key by which to regulate with the utmost precision, every subsequent effort of every laborer we employ, and to point out where every spadeful of excavation is to be dug, and permanently deposited with the smallest amount of exertion. We shall next proceed to the subject of

CONSTRUCTION.

As soon as the lock-spitted gauge-line shall have been well considered and criticised, and all necessary corrections completed, it may be widened into a 5-foot track. The next operation is to fix the pickets for the centre of the road.

This will regulate first the cost, and second, the appearance of the work when complete. We must avoid objectionably sharp turns ; but we must also studiously avoid heavy cuttings and fillings, and we must make our curves regular. These three points can generally be combined ; and they must be combined, otherwise, the Superintendent cannot be qualified for his charge. He should never have his eye off the gauge-line, and as each picket is placed, it should be accompanied with a mental calculation as to the quantity of cutting and filling, and consequent cost it will require to bring the road at that point to its proper width, and to the level of the gauge or lock-spit. He will bear in mind that as often as he can place a picket exactly at the lock-spit, without infringing on a principle, he should do so, as then the forming of the road will cost the least possible sum ; unless when he has to deal with rock which requires blasting. He must at all times think of his finances, taking care that the amount of money or labor estimated for the work shall be made to complete it, and he will be justly culpable if it fall short, as this consequence is very rarely attributable to any other cause than unfitness in the Superintendent. The wrong placing of a few pickets may cause a piece of work to cost double or tenfold, nay, a hundred times more than it should cost ; and it is clear that the man who can perform the most perfect work at the cheapest rate, must at all times earn character in proportion. It is evident that there may be a very great variety of curves made for rounding off the angle which the lock-spitted gauge-line forms in passing a valley or ravine, and that the more the curve is carried out from the angle, the better will be that particular part of the road, but it must be recollected that the slight improvement thus effected on one spot, is attended with

most disproportionate cost ; and, if a man deficient in judgment be placed in direction of such works, he may use very fine arguments as to the utility of gradual curves, and the like, but the result will be, that instead of succeeding to fulfil the object of his employer, by opening in its full length a useful line of intercourse, he will find all his money expended on two or three fantastical embankments. He will leave the district as closely sealed up as he found it, and his employer will be justly disgusted with such costly enterprises. If he desire to serve himself, and to be useful to his neighbours, he will follow, as nearly as possible, the natural features of the ground ; unless when there is the most indisputable reason against this ; and keeping a watchful eye upon the money chest, he will never sacrifice the general result to any chimera whatever. This cutting and banking mania is the grand source of wasteful expenditure in the construction of our roads.

If, instead of going uniformly along the side of a hill, and making our road with the minimum of cutting and filling,—if, instead of this, we seek to torture it into straight lines, still keeping to certain predetermined levels, the line of road must be a succession of deep cuttings and high embankments : costly at first, and costly to the last, from their liability to dilapidation.

As soon as the centre line shall have been cautiously picketed out, all the side lines must be measured from it and distinctly ruttéd out upon the ground, taking care to lift the several shear-sods. These lines will show the verges of the road, the inside and outside of the fences when such are made on the road, and the width of the water-tables, as well as the position of the catch-water drains. Accurate *bonings* must be put in at every picket in the centre line, which will thus be level with the opposite points of the lock-spit gauge, and a correct longitudinal section must be made up between these pickets.

Cross section lines should likewise be made up to the intended level of the road at every 100 yards, showing the precise fall that the road is to have from the centre to each side, when formed. But in making up longitudinal and transverse sections, it is necessary to observe whether the soil be of such a nature as to answer for the soling, or whether it be of so defective a quality as to require a superstratum to prepare it to receive the broken stones or surface gravel ; and a corresponding distinction should be made as to the height to which the section lines should be raised in different places. If the natural soil be of the right quality for soling a road, it would be an unpardonable waste to require that more of the same description of material should be excavated elsewhere, and brought upon it, although we have known such surprising extravagance set forth in specifications. The cross-slope

given to a road should vary according to circumstances. If its maintenance and repair be carefully provided for, on level ground a fall of one in twenty-four from the centre of the sides will be sufficient. If there be any doubt as to the future care, the best precaution is, to increase the cross-slope as a security against surface water, and in all cases it is well to make the cross-slope somewhat greater on declivities than on the level ground, in order that the path of all surface waters may be directed in the shortest lines to the water tables; under these different circumstances, the cross-slopes may be made to vary from one in twenty-four to one in twelve, and they should be accurately proved by the section level.

It is well to know that some authorities on this subject have recommended the cross-slope of roads on declivities to run the whole way from the outside verge to the inside, whilst others advise just the reverse, and not from the centre to each side. The chief object of the first recommendation is, to prevent the corrosion of the outside verge by the surface water, and that of the second to prevent any accumulation of water in the water tables, but they both appear to be most objectionable in practice, as they necessarily throw every carriage off its level, and bring an unequal portion of the load on the wheels of one side. They also give a longer run to the surface waters on the road. No professional man should permit so serious an inconvenience to be inflicted on the public. His ingenuity ought to provide a remedy of a different kind. As soon as the longitudinal and cross sections have been made up to the right level, the work may be considered in a state to employ large forming parties, who after this preparation, can scarcely commit errors, if there be any degree of activity in the overseers.

When the road is constructed upon level ground, it is desirable to make two side fences with water-tables outside of these; when it is on sloping ground, one side fence will suffice, the cut face of the bank forms the other.

It is evident that on sloping ground, the Superintendent, who desires to execute his work with economy, must use every exertion to provide that the quantity of cutting shall, as nearly as possible, agree with the amount required for filling, that he may not be obliged to carry materials either to or from the place where he works.

The materials used for fences, retaining embankments, &c., will depend upon the nature of the soil in a great measure; and the best proof of skill, in this or any other art, is the power of making the most possible out of the circumstances in which we are placed. The man who cannot supply himself from his own vicinity, would fail, if he had Guernsey granite and mines of gold at every perch of his progress. When the soil is stony the fences and faces of

embankments would naturally be made of this material, and, when built dry, they should have a slope of one-fourth of their height. If sod work be used, the slope should be increased to one-third of the height, and when a bank of earth or other material is faced without being supported, the slope will depend on the quality of the soil, observing to give the greatest slope to the most friable soil, and it is for the Superintendent to observe the natural slope at which each kind of earth will continue. The best soil that we can meet with in constructing roads is gravel; because, in the first place, it has natural drainage; secondly, when the road has been formed in such a soil, it is both soled and metalled unless the traffic be of a very heavy description.

In making a road through any spongy or soft soil, it is well to let the work season after the general drainage and forming have been effected before proceeding further. When embankments are filled up, a considerable allowance must be made for sinking, and after allowing them to season, they should be again levelled up. If these points be not attended to, or if the work be hurried over, it will look well at first, but afterwards it will show many inequalities and defects that might have been avoided.

The liberal use of a heavy roller is an excellent way of consolidating the surface of a new road, preparatory to opening it to the public, and the difference in the quality of both gravel and stones should be well understood by every road Superintendent. Some stones can be broken with more profit to the workmen at one anna per ton, than others at six annas, and where heavy carriages are in use, the low priced stone is, in general, the more costly in the end. We must recollect that the price of breaking the stone forms but a portion of the cost of metalling a road, and the most durable material to be had within any rational limit, as to cost, is at all times the most desirable. Contracts for stoning, therefore, should always specify the precise kind of stones required, and from what quarries they are to be taken; and no one can be considered properly qualified for superintending such works as we are now considering, unless he have acquired a thorough knowledge of the several varieties of rock common in the country, with the different qualities and properties peculiar to each.

When we estimate the cost of a new road, we should divide the whole into three very distinct general heads. The first may include all the expenses of surveying, laying out, forming, draining, fencing, soling, gravelling, and all else preparatory for the stoning. The second head should show the cost of the stoning or metalling, and should detail minutely the quality of the stones required,

and the quantity per perch ; allowing a larger dimension to the broken stones in the bottom, and a small dimension at the surface. The third, the cost of the masonry, bridges, pipes and tunnels if any.

It is extremely essential to separate thus the great heads of expense, in order to enable *all persons* to understand the way in which the total cost is made up on different descriptions of work, and, as it were, to get rid of that professional mystery which is generally made to envelope every thing relating to the expenditure of money.

The details here included under the first head are such as are required, with but little variety as to their application, in all projects for new roads, and their cost may be made to vary from 100 to 600 rupees a mile, according to the peculiarities of soil in which we are working. The second head, or metal-ling, may be either wholly omitted in certain cases, or it may be adopted to any degree that the circumstances render necessary. For instance, three tons of tender stone, at one or two annas a ton, may be thought applicable for the exigencies of one case, when in another it might be indispensable to apply twelve tons to the perch of the hardest stone to be had, at a cost of perhaps six or eight annas per ton ; thus making the rate for this branch of cost vary, from three or four annas, to 100 annas the perch, according to the means applicable for the construction, and the intensity of the traffic to be expected. The third general head, including pipes and masonry, is also capable of being effected in various degrees of excellence, and at proportional rates of cost, which can only be regulated by comparing the necessity of the work with the funds applicable for its construction.

J. P. KENNEDY, MAJOR.

SIMLA :
June 15th, 1850. }

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## No. II.—HINDOSTAN AND THIBET ROAD.

*Rules for Superintendents, Overseers, &c. &c.*

Officers employed on the survey of the line are to send in reports of their observations, at least once a week, addressed to Major Kennedy at Simla: these reports to be accompanied by sketch plans and sections. The plans to be on a scale of two inches to one mile. The section horizontal scale to be likewise two inches to one mile, and the vertical section 200 feet to one inch.

2. The maximum incline is not to exceed 3 in 100 or 1 in  $33\frac{1}{3}$ ; and every exertion must be made to keep the inclines as much as possible *below* this maximum.

3. The whole line is divided into Superintendent's divisions, and each division to be designated by a letter.

4. The point from which all measurements are to be taken is marked by a picket sunk opposite Mr. Vivian's house in the Simla bazar.

5. The 1st division, commencing southward, is denominated the A, or Krole division; the 2nd B, or Simla division; the 3rd C, or Mahassoo division; the 4th D, or Muttiana division; the 5th E, or Kotegurh division; the 6th F, or Teranda division; the 7th G, or Chini division; and so on to the end of the line northward.

6. All reports to be made on foolscap paper, and marked at the head of the report with the divisional letter, to which the portion of the line it refers belongs, as well as the territory. It will be folded in four, and docketed on the back by the Officer who sends it, with the divisional letter and the substance of the report.

7. All Officers will be expected to keep copies of their reports, plans and sections, for the convenience of future reference.

8. All Officers employed in surveying the line as well as Officers in charge of divisions, and Overseers in charge of sections, and also Assistant Overseers, will be required to make themselves thoroughly acquainted with the printed paper containing the "Principles of laying out and constructing the works," that a uniform practice may obtain throughout.

9. The working parties are to be kept under the superintendence of their respective mates; and each Sapper Overseer is to be appointed to his distinct and separate charge, consisting of one or more mate's parties, according to the strength of the whole party as shewn in the following table:

Composition of an Overseer's party for working a section of 10 miles of the line.

Two or more Overseers' sections to constitute a superintending Officer's district.

| SAPPERS.                       |                                      | MATES AND LABORERS.        |           |               |           |               |           |                   |           |                    |           | REMARKS. |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|--------------------------------------|----------------------------|-----------|---------------|-----------|---------------|-----------|-------------------|-----------|--------------------|-----------|----------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Overseer in charge of Section. | Assistants in charge of sub-Section. | When Working single force. |           | Double force. |           | Triple force. |           | Quadru-ple force. |           | Quintru-ple force. |           |          | Sextruple force. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                |                                      | Mates.                     | Laborers. | Mates.        | Laborers. | Mates.        | Laborers. | Mates.            | Laborers. | Mates.             | Laborers. |          | Mates.           | Laborers.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1                              | 1                                    | 1                          | 50        | { 1<br>1      | 50        | { 1<br>1      | 50        | { 1<br>1          | 50        | { 1<br>1           | 50        | { 1<br>1 | 50               | <p>This composition of the working parties will enable one Sapper Company to furnish Overseers for ten Divisions, extending over about 200 miles. It gives us the power to employ efficiently under them from 2,000 to 12,000 men a day.</p> <p>Until the line is opened to 6 feet wide, the pickets shewing each man's working ground must be placed when working in clay, or gravel at seven yards a part, and in rock at two yards apart.</p> <p>A party working in double force would thus cover upwards of 1½ mile in clay, or about ½ mile in rock work, and it is probable that the double force would in the first operation be better looked after than a more extensive party. Working our 10 divisions at double force would give us 4,000 laborers. When the widening of the road to its full extent commences wall building, &amp;c., then the larger forces may be called in with profit.</p> <p>One of the Assistant Overseers should always be a miner.</p> |
|                                | 1                                    | 1                          | 50        | { 1<br>1      | 50        | { 1<br>1      | 50        | { 1<br>1          | 50        | { 1<br>1           | 50        | { 1<br>1 | 50               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 1                                    | 1                          | 50        | { 1<br>1      | 50        | { 1<br>1      | 50        | { 1<br>1          | 50        | { 1<br>1           | 50        | { 1<br>1 | 50               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 1                                    | 1                          | 50        | { 1<br>1      | 50        | { 1<br>1      | 50        | { 1<br>1          | 50        | { 1<br>1           | 50        | { 1<br>1 | 50               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 1                                    | 1                          | 50        | { 1<br>1      | 50        | { 1<br>1      | 50        | { 1<br>1          | 50        | { 1<br>1           | 50        | { 1<br>1 | 50               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                | 1                                    | 4                          | 200       | 8             | 400       | 12            | 600       | 16                | 800       | 20                 | 1000      | 24       | 1200             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



13. Before the parties are dismissed in the evening, every mate must be informed of the precise point where his squad is to assemble on the following morning.

The distribution of the men, by assigning to each a regular portion of work, marked off by pickets, and sufficient to occupy him for the day, is the most important duty of the Overseer and his Assistants. By this method a fair principle of task work can be established; and there is no other remedy against idleness, and consequent waste of the public resources. The omission of this practice frequently makes public works cost from 10 to 20 times the proper amount, and every Superintendent and Overseer employed in the present works, will be held strictly responsible for the execution of this essential rule.

14. The breaking of tools is entirely attributable to the carelessness of the Superintendents and Overseers, by allowing the weaker tools to be applied to the work of stronger ones. The pickaxe and the hoe are frequently destroyed by attempting to remove heavy stones with them; a labor which ought to be reserved for the crowbar, the sledge and wedge.

15. The present deficiency of crowbars, sledges, mining tools, &c., will gradually be remedied. In the meantime, Overseers must employ the weak tools at the clay and gravelly portions of the work, where after a 5-foot track has been completed, with convenient passing places 12 feet wide, the width of the road may then be generally increased to 12 feet, with passing places of 18 feet wide at salient and re-entering angles of the ground, and at other convenient places.

16. The ultimate width of the road may be considered at 18 feet throughout, with the exception of difficult cliffs, where the width of 12 feet will suffice. In every part of the road, a retaining wall, on the side of the precipice, will be requisite to completion, with a parapet raised two feet three inches above the road level. Small weep holes, four inches square, to be constructed under the parapet, for the escape of the surface water, at every 50 feet.

17. At every re-entering angle of the ground, and at distances not exceeding 100 yards, substantial cross drains must be made under the road, of ample dimensions, to carry off all the water that can be expected in the heaviest rains, and, in no case, are these drains to be of smaller dimensions than four feet high on the outside, and two feet wide, which is sufficient to admit a man to clean or repair them.

18. Great care must be taken in preparing sound foundations for all walls which, when built dry, as retaining walls on the outside or precipice, should have a slope of one-fourth of their height, and a thickness, at their foundation not less than one-fourth of the height,

plus two feet six inches. These retaining walls it is not desirable to make generally more than four feet high, exclusive of parapets although many emergencies will render much higher walls occasionally requisite.

19. In opening the first 5-foot track, where very difficult cliffs occur in the line, temporary tracks may be made either above or below the proper level, as the nature of the case may permit, taking care, after passing the obstacle, immediately to regain the proper level. By this means an immediate passage can be obtained long before the permanent passage could be made in its proper position. And it is desirable that such temporary passages should be above rather than below the proper level, because, in that case, the progress of the permanent track in its proper position along the cliff, will not be impeded by persons passing on the temporary track. These temporary tracks should be suitable for the passage of mules, and they may, in many cases, be made to occupy either the brow of the cliff, which shall ultimately be worked down to the road level, or the foundation of a wall to be subsequently built up to that level.

**J. P. KENNEDY.**

SIMLA :  
*June 15th, 1850.* }







## FORM OF REQUISITION FOR TOOLS AND MATERIALS.

Required for use at the Tunnel on the Hindostan and Thibet Road,

5 seers Steel,  
4 seers Iron,  
1 Dubba Oil.

W. NAPIER.

Simla, 25th September, 1850.

(Approved)

J. P. KENNEDY.

Received the above articles,

W. NAPIER.

## FORM OF BILLS FOR TOOLS AND MATERIALS.

DR. THE HON'BLE E. I. COMPANY.

*For materials on account of the Hindostan and Thibet Road.*

|                   |           |   |   |   |
|-------------------|-----------|---|---|---|
| 5 seers Steel @   | per seer, | 0 | 0 | 0 |
| 4 seers Iron @    | per seer, | 0 | 0 | 0 |
| 1 Dubba Oil @     | per seer, | 0 | 0 | 0 |
| Total Rupees, . . |           | 0 | 0 | 0 |

September 25th, 1850.

(Signed) A. B., *Merchant.*

Certified that the above weights and prices are correct.

(Signed) T. GRAHAM, *Accountant.*

September 25th, 1850.

Received the amount of the above Bill in Co.'s Rs. — Annas —  
Pies —

(Signed) A. B., *Merchant.*

Certified that the above sum was paid in my presence.

September 25th, 1850.

(Signed) C. D.

