road company to carry freight without the payment of canal tolls, pursuant to the act entitled "An act relating to the transportation of freight on certain railroads," passed May 12, 1847.

Sec. 47. This act shall take effect immediately.

State of New York, } I have compared the preceding with the original law on file in this office, and do certify that the same is a correct transcript therefrom and of the whole of said original.

CHRISTOPHER MORGAN, *Secretary of State.*
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On Tables for Setting out the Width of Cuttings and Embankments on Sidelong Ground; and also Formulæ for Computing the Area of Vertical Section.

By R. G. CLARK, C.E.

The object of this paper is to investigate some simple formulæ, and from thence to construct some tables, to enable the assistant engineer or contractor to set out the widths of cuttings and embankments on sidelong ground; and also to calculate the solid content of any portion of the ground. The subject may be resolved in the following proposition:—

Given the $\angle$ of inclination of ground, the depth (from field-book, &c.) of ground to the centre of balance or formation level, and the ratio of the slopes; to determine where they will meet the ground at surface.

Let H A F B D (fig. 1.) be a vertical section of the ground; A B the formation line, represented by $2b$; the given angle of inclination of ground H D with the horizon by θ ; the given depth O F from the stake O perpendicular to centre of formation level denoted by a .

Fig. 1.

1. We will proceed first, to determine a formula for O D. Let it be x ; draw D K perpendicular to A B produced; O f parallel to A B K. Let D B be the given slope m base to 1 perpendicular; draw the vertical B C.

Let D f = y ; then O c = F B = b ; e f = $m y$; also by similar triangles, C e = $m a$. $\therefore$ O f = $b + m a + m y$.

Now, by triangle $O f D$, right angle at f , we have

$$1 : x :: \sin \theta : y. \therefore y = x \sin \theta.$$

$$\text{Again, } 1 : x :: \cos \theta : b + m a + m y.$$

$$\therefore x \cos \theta = b + m a + m y.$$

Eliminating y , then $x (\cos \theta - m \sin \theta) = b + m a$;

$$\text{therefore, } x = \frac{b + m a}{\cos \theta - m \sin \theta} \dots \dots \dots (1)$$

From the factor, $\frac{1}{\cos \theta - m \sin \theta}$ of the above formula, the Table No.

I. is computed from 5° to 20° .

2. To find an expression for $O H$ measured from O on the descent.

Draw $H M$ (fig. 2) perpendicular to $A B$ produced. Let $H A$ be

Fig. 2.

the given slope, ratio as before. Let $H M = y'$; then will $A M = m y'$.

Therefore, $H G = N F = b + m y'$ also $O g = a - y'$.

By the triangle $H g O$ we have $1 : x' :: \sin \theta : a - y'$;

therefore, $a - y' = x' \sin \theta$; and $y' = a - x' \sin \theta$.

Again, $1 : x' :: \cos \theta : b + m y'$.

Eliminating y , we have $x' (\cos \theta + m \sin \theta) = b + m a$;

$$\text{therefore, } x' = \frac{b + m a}{\cos \theta + m \sin \theta} \dots \dots \dots (2)$$

From this expression, Table No. II. is calculated by the factor

$$\frac{1}{\cos \theta + m \sin \theta}.$$

3. We shall now investigate an expression for the area of the vertical section; the inclination of ground, depth, breadth of formation level, and lengths x , x' , and also the ratio of slope, being all given.

Fig. 3.

Through centre O (fig. 3), draw $P e$ parallel to $A B$; then $P O = b + m a$. $\therefore$ area of trapezoid $P A B e = (2 b + m a) a$;

area of triangle $P O H = \frac{1}{2} \sin \theta \cdot x' (b + m a)$;

and area of triangle $D O e = \frac{1}{2} \sin \theta x (b + m a)$.

Consequently, the whole area of trapezium or vertical section = area
 $P A B e + \text{area triangle } D O e - \text{area triangle } P O H =$

$$(2b + ma) a + \frac{1}{2} (b + ma) (x - x') \sin \theta \dots \dots \dots (3)$$

The first column of the table gives the angle of inclination of the ground, and the adjoining column the nat. sines to three places of decimals, to facilitate working out the area, as in equation (3). We shall now commence with the following Rules.

I. *To find the two lengths O D and O H*:—RULE. Add the half-breadth of formation level to the product of the slope and given depth; then multiply this sum by the corresponding tabular number, then will each product be equal to each length required.

II. *To find the area of section II A B D*:—RULE. 1st. Add the formation level to the product of the ratio and depth, and multiply this sum by the depth. 2ndly. Add half the formation level to the product of ratio and depth; multiply this sum by the difference of the two lengths, and again by nat. sine of angle. Add these two products, and their sum will be the area.

Example 1.—Given the angle of inclination of ground 18° ; slope, 1 to 1; depth, 45 feet; and breadth of formation level, 30 feet. To find distances of centre stake, area of section, and cubic content, when 100 feet in length.

Here $b + a m = 15 + 45 = 60$; $m = 1$; $\theta = 18^\circ$; its nat. $\sin = .309 \dots$
 $1.557 \times 60 = 93.429 = O D$. $.799 \times 60 = 47.940 = O H$.

By formula (3) we have $(30 + 45) 45 + \frac{1}{2} (15 + 45) (45.48) \cdot 309 = 75 \times 45 + 30 \times 45.48 \times .309 = 4099.5$ area required.

Cubic content = 409950.0.

Example 2.—Given angle of inclination of ground, 20° ; slope, $1\frac{1}{2}$ to 1; depth, 50 feet; and breadth of formation level, 30 feet. To determine distances and also area.

Here $a = 50$; $b = 15$; $m = 1\frac{1}{2} = \frac{3}{2}$; $\theta = 20^\circ$; its nat. $\sin = .342 \dots$ $b + a m = 15 + 75 = 90$.

Now, $2.344 \times 90 = 210.96 = O D$. $.781 \times 90 = 70.29 = O H$.

By formula (3) for area we have

$$(30 + 75) a + \frac{1}{2} (15 + 75) (140.67) \cdot 342 = 7174 \text{ area required.}$$

Example 3.—Given the inclination of ground, 18° ; slope to be 2 to 1; depth from field-book, 20 feet; breadth of formation level, 30 feet. To find area and distances.

Here $b = 15$; $a = 20$; $\theta = 18^\circ$; $m = 2$. $\therefore b + a m = 55$.

$$55 \times 3.000 = 165 = O D. \quad 55 \times .641 = 35.25 = O H.$$

By formula (3) we have

$$(30 + 40) 20 + \frac{1}{2} (15 + 40) (129.74) \cdot 309 = 2505 \text{ area required.}$$

Remark.—If the ground should ascend and descend, as in the adjoining diagram (fig. 4), then Table No. II is to be used to find the distances. Table No. I will in like manner be required for ground descending from centre, as in fig. 5.

Fig. 4.

Fig. 5.

The tables will likewise do for embankments—No. I. for the ascent from centre stake, and No. II. for the descent.

We shall now discuss the equations (1) and (2). Put them respectively under the following forms. T, T' , being tabular numbers, $A = b + m a$.

$$X = T.A; \text{ and } X' = T'.A.$$

Divide by T, T' , respectively; then $\frac{X}{T} = \frac{X'}{T'}$, A being eliminated.

Therefore the two distances, x and x' , are to each other as their respective tabular numbers; consequently the distances can be proved by a second operation. The Tables might have been carried up to 45° , but then they would require a greater number of places of decimals to insure greater accuracy.

Fig. 6.

In taking the angle of inclination, the clinometer or common theodolite might be used; but if the spirit-level should be used, then we have only to measure from O downwards *any* distance, $O r$, (fig. 6), and then take the height with instrument; and then will the sine of angle of inclination $O d s = r O d = \frac{\text{height}}{\text{distance}}$.

Angle.	Nat. Sin.	TABLE No. 1.—For O D.			TABLE No. 2.—for O H.		
		1 to 1	1½ to 1	2 to 1	2 to 1	1½ to 1	1 to 1.
5°	·087	1·100	1·156	1·217	·854	·881	·926
6°	·105	1·124	1·193	1·273	·832	·868	·910
7°	·122	1·148	1·230	1·323	·802	·851	·895
8°	·139	1·175	1·280	1·404	·780	·835	·885
9°	·156	1·203	1·328	1·496	·761	·820	·873
10°	·174	1·233	1·380	1·570	·752	·804	·856
11°	·191	1·265	1·437	1·666	·736	·790	·850
12°	·208	1·279	1·500	1·778	·700	·780	·844
13°	·225	1·330	1·566	1·902	·705	·763	·841
14°	·242	1·372	1·655	2·055	·696	·752	·826
15°	·259	1·414	1·731	2·230	·676	·740	·818
16°	·276	1·459	1·825	2·463	·663	·727	·800
17°	·292	1·506	1·930	3·600	·645	·717	·801
18°	·309	1·557	2·050	3·000	·641	·710	·799
19°	·326	1·613	2·186	3·040	·630	·698	·787
20°	·342	1·673	2·344	3·913	·611	·680	·781

Improvement in Railway Sleepers.

The chief objection that has been raised against the employment of sleepers in the construction of railways, is their liability to decay, and the necessity that exists of renewing them from time to time. Kyan's corrosive sublimate, which has been employed for preserving them, has been found in France and elsewhere to be too expensive a process, and crude creosote, different sulphates, and pyrolignite of iron, have all been successively tried, but with results by no means satisfactory. We are therefore glad to introduce Mr. Fred. Busse's invention for constructing railway sleepers from a certain compound cast around a wooden frame, which he has called "*terresin*." The following is his own description of his invention:—

"My sleepers are manufactured by hand, just on the spot where they are wanted. These sleepers have been tried on the Leipsic and Dresden, and the Dresden and Silesia lines, and combine all the advantages which are reasonably to be expected from a good sleeper. They are easy to make, are cheap and solid, and promise a duration for a period of time not to be calculated; supposing only thirty years, it greatly exceeds that of wooden sleepers. I have cast sleepers, according to my invention, 8 ft. long, 14 in. broad at the base, at an outlay amounting to less than 1 Prussian dollar (3s.) the piece. The yet good pieces out of the old worn sleepers may be advantageously cut for frame top pieces. The principle of my invention is to inclose a frame of entirely dry, well-seasoned wood, air-tight, in a substance which is not affected by the influences of wet and air, it being the result of experience that under such circumstances, the wood will not be destroyed at all, or at least will last by far longer. The method after which I build and compose the said sleepers is as follows:—I take two pieces of wood, dried to the highest degree by artificial heat in a stove. Immediately after drying, I dip those pieces in a boiling compound of 10 lb. of brimstone, and 100 lb. of coal tar, to which I add 80 lb. of very fine powder of caustic lime. This done, I scratch or take off with a knife the superfluous compound, leaving only a thin coating on the wood. The pieces of wood thus prepared are now brought anywhere along the line of the railway where coarse gravel is to be found; it may be taken out of the soil or from a river. The latter is to be preferred, as containing less earthy matter. The gravel mixed with fine or coarse sand, or small stones—the latter till to an inch diameter—ought to be dried, or rather heated before used. The wooden frame is placed, the topside to the bottom, in a conical iron or wooden mould—the latter material is to be preferred—which is to be filled up with the compound which I call "*terresin*" and which is prepared as follows: I take an iron vessel, large enough to hold a quantity of *terresin*, sufficient to cast three sleepers; I melt 10 lb. of brimstone, add 75 lb. of stiff coal-tar, and mix it by stirring with 100 lb. of fine powder of well-dried fresh-burnt caustic lime, which is slaked in the air or with a little water. Where powdered chalk or plaster are cheaper, these materials may be used as well. The exact

quantity of lime, chalk, or plaster, for a given quantity of brimstone and coal-tar is dependent upon the quality of the said materials, and the choice of the right proportion must be left to the best judgment of the manager. In case the tar should not be of good quality, a little resin and grease may be added. To this compound add, always stirring and turning the mass over a gentle fire, 10 to 12 cubic feet of that before-mentioned dried or heated gravel, and fill or rather ram the thick hot compound into the moulds in which the frames are placed. The moulds must before-hand be well coated with clay, and afterwards sifted over with fine ash, to prevent the compound adhering to the mould. Before the compound is cooled, it is advisable to pierce one or two holes through the top part of the sleepers, vertically to the bottom, with an iron bar. By these means the sleepers and rails may be levelled or balanced as accurately as possible, by pressing dry sand into the holes, which will leave the sleeper spreading under the bottom part. The sleeper being completely cooled, it is taken out by overturning the mould. The top pieces, where the rail or the chair is to be screwed (which is by far the better process) or nailed down, must be left free from the compound, and are only coated with the thin hot compound, without the gravel, which may be repeated after having fastened the chair, to secure the top pieces against the influence of air and water.

By this contrivance we get a very cheap sleeper, as hard as stone, and extremely heavy—400 lb.—without losing the elasticity which is wanted to a certain degree, and allows, what is a matter of importance, that the rails or chairs are situated directly on wood. Here I feel obliged to remark that we have found it in Germany a good practice to support the sleepers only on the two extremities, leaving the gravel or sand loosely underneath the middle part, an experience undoubtedly made likewise in England. It is a matter of importance that any kind of wood may be employed, and that the construction of the frame and the size of the sleepers may be altered according to circumstances. The sleepers may be made much wider with a proportionate small increase of expense. The thin *terresin*, without gravel, can be used with great advantage to cover the surface of the wooden sleepers already laying, which after that preparation, will last longer. In case of using the *terresin* for this purpose, I expect a commission of £1 for every 1000 pieces thus covered, and if it is employed for covering roofs, bridges, viaducts, houses, pavements, floors, &c. 2d. for the square yard. For those different purposes it is advisable to add about 3 to 10 per cent. of animal grease, tallow, train-oil, &c. For floors, pavements, &c. the same compound is used as for sleepers, without any grease.

Regarding the resistance against pressure, it is to be observed, that sleepers on the Leipsic and Dresden Railway have undergone, without the least alteration, the pressure of the heaviest trains, with 20 ton locomotives. Their firmness and compactness is beyond all doubt, and their cohesion so great, that it was only with great difficulty that a sleeper of this kind could be broken up with iron chisels and hammers.

The Artizan.