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The strength of cement under different conditions

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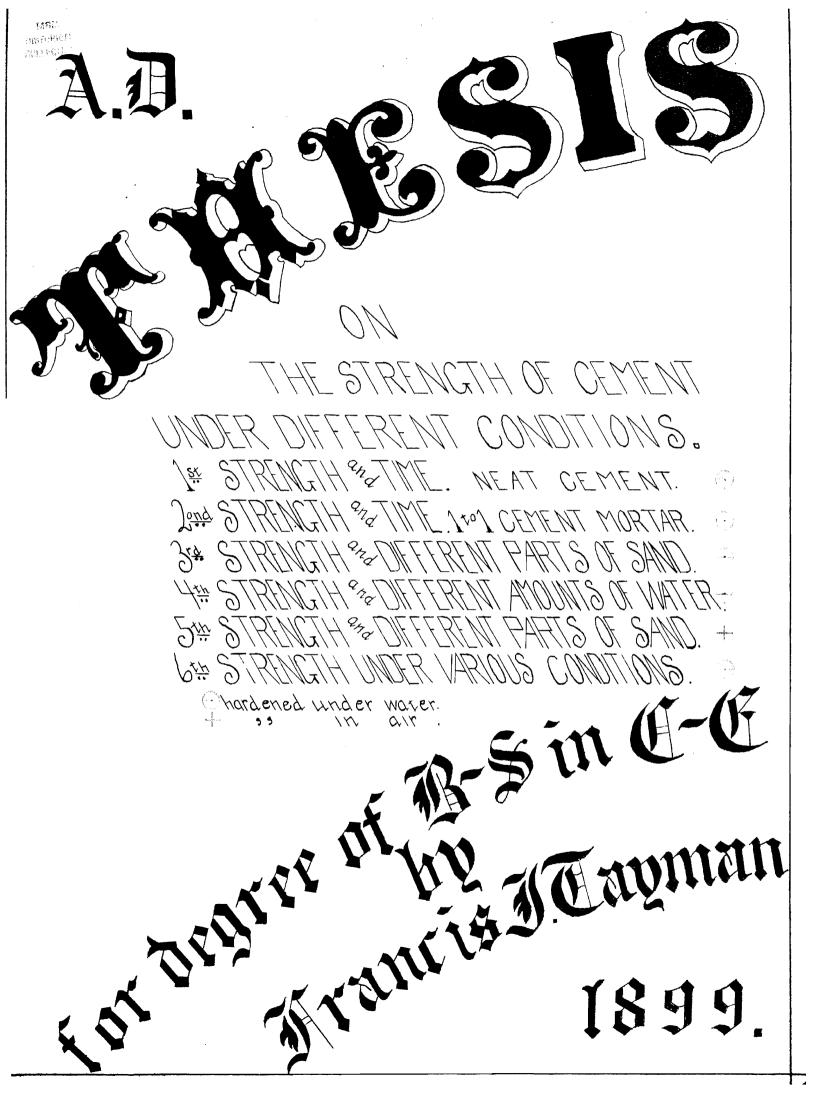
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12-8 gr Starter west start

THESIS ON THE STRENGTH OF CEMENT UNDER THE DIFFERENT CONDITIONS.

- 1st. Relation between Strength and Time (neat Cement) in water.
- 2nd. Relation between Strength and Time (of one Gement, to one sand) in water.
- 3rd, Relation between Strength and proportion of sand(in water)
- 4th. Relation between Strength and quantity of water (neat dement).
- 5th. Relation between Strength and proportion of sand (out of water)
- 6th. Strength under various conditions.

Object:-

Derivation of some Empirical Formulae, showing relation between breaking strength, and various functions which enter into Cement testing.

We find a great deal of experimental work done in Cement testing, also some curves plotted, but there are but few equations fitted to these curves, this, then, is the object of the present work.

In this work a great many interesting points have been made manifest, most of them are of no practical value but merely of interest in themselves. The work has been on several of the most important ones, to be given subsequently.

On these and a few others is the foundation of Cement testing, as given by all writers on the subject.

This work is entirely on the tensile strength, as that is the most important, so that all the experimental data show relations existing between breaking strength in pounds per square inch, and the

other functions which may enter in the experiments.

Apparatus.

The following is a list of the Apparatus used in this work:

1st. Testing Machine.

2nd. Moulds.

3rd. Sieves,

4th. Trowels.

5th. Others of minor importance, such as thermometers, scales, glass, water, etc.

The testing machine was of Rheile's make and capable of registering a breaking strength from 0 to 1000 poundw.

The moulds were Tinius, Olsen & Co's. "Standard Type."

Sieves. They were of "Standard mesh" used to get various sizes of sand, and remove any foreign products which may happen to be present, and also in testing the fineness of the Cement.

Sand.

The sand used was not Standard sand, nor as good a quality as desired, but it was the best at hand. It was not analyzed but apparently had some material in it, such as chert, which injures its quality as a material for cement mortars.

It was dried and cooled to the temperature of the room before using.

materials.

Cement, Sand and Water were the materials for this work.

The Cement was the best quality of Portland Cement that could be obtained. Sufficient quantity was taken from the barrel at a time for each experiment, which comprised from one hundred to one hundred and fifty briquettes.

This quantity was placed in a box and thoroughly mixed, the object of mixing being to have all the material in each briquette as nearly an average as possible. For instance, if the cement was used directly out of the barrel we might get cement of different quality for the different briquettes, due to the conditions of packing the cement, and also the difference between outer surface of barrel and center.

preliminary Tests.

I used cement from two different barrels, that is, in experiment I and II cement was used from one barrel, and in experiments III, IV, V; VI cement was used from another barrel.

The following are the Preliminary tests made upon these barrels.

Fineness of first barrel:

Cement depends greatly upon fineness of grinding for some of its good qualities, hence tests for fineness are usually made.

The sieves used for the test were, viz.

No. 50 (2500 meshes to square inch)

No. 80 (6400 meshes to square inch)

The average results of the cement of the first barrel in experiments I and II were as follows:

Of two hundred (200) grams taken there were rejected from

No. 50 sieve = 3.6 grams = a

No 80 sieve= 15.04 " = b

so that total rejection of No. 80 was a+b=18.64

Rejected from No. 100 sieve = 21.5 grams = c

Hence total rejection from No. 100 was a+b+c=40.14 grams.

Therefore

200-40.14 = 159.86 grams passed through all the sieves. Soundness:- of first barrel.

This test is made to determine whether or not the cement will bulge or crack.

The test was made by the usual method, that is, one fourth part of water and three-fourths part cement (neat).

The pats made from the cement goave no sign of bulging or cracking.

Setting.

This test was determined by the aid of two wires, one of which had a point finer than the other, the latter having a larger brass (weighted) ball on the end than the former, The lighter ball containing the thicker wire was used to determine the time of beginning of setting, that is, when the pat of cement held the lighter ball "setting had commenced", and when it held the finer wire with the larger ball it was completely set.

The following are results from first barrel:

On March 1st. 1899 at 11.40 c'clock A.M. I made a mixture of cement and one quarter water,

It held wire No. 1 (or began to set) at 1.0'clock P.M.

It held wire No. 2 (or was set) at 6 o'clock P.M.

Mineness: - of second barrel.

Of 200 grams taken there were rejected from

No. 50 sieve = 2.7 grams = a

No. 80 "=14.00 "=b

so that the total rejection of a+b=16.7 grams rejected from No.100 sieve = 20.01 grams = c, making a total of a+b+c=36.71 grams.

Hence

200-36.71 = 163.29 passed all sieves.

Soundness of second Barrel.

I could see no signs of bulging or cracking.

Setting for Second Barrel.

I made up pats under the same conditions as first.

It was made up March 22nd. at 6 o'clock, A.M.

Held No. 1 wire at 7.55 o'clock A.M.

Held No. 2 wire at 2 o'clock, P.M.

Mortars.

The sand and cement were weighed instead of taking parts of volume, and water was first measured in a graduate before using. The temperature was also noted.

After weighing out the desired amount for conditions of each mortar, the sand and cement were thoroughly mixed before being made into briquettes.

The proportions used will be given in the details of the different experiments.

Experiments.

The experiments will first be briefly stated and explained in a general way.

The object of each experiment was to find, if possible, a ralation between breaking strength and some one of the various functions, such as time, quantity of sand, quantity of water, etc., keeping all other conditions constant.

The temperature of the room and water was always recorded before mixing a batch of briquettes.

Experiment No. 1.

Strength and Time (neat cement).

The object of this experiment was to find a relation between tensile strength per square inch, and time after mixing.

paving mixed cement with water I noted the quantity of cement, quantity of water and temperature of room and of water.

The quantity of cement and water were the same for each lot of thirteen.

The amount of water used was 375 grams to 1500 grams of cement, or 25% was water.

For this experiment I made up thirteen batches of eleven briquettes. Each batch required 1500 grams of cement and 375 grams of water.

Each batch was allowed to set 24 hours in air (after being made. They were then placed uder water to harden and there remained until time for breaking.

In breaking I took one from each batch at the end of first day after mixing and breaking it, and the average gave me one point for a curve. I repeated this at end of second day, also fourth day, etc. This was continued until all the points were obtained, which enabled me to plot my curve, the record and discussion of which will be given later.

Experiment No. 2.

Strength and Time of a 1 to 1 cement mortar (in water).

This experiment was to determine the relation between breaking strength per square inch, and time after mixing of a 1 to 1 mortar, all other quantities being constant as in experiment No. 1.

In this experiment I used 1500 grams of mixture, that is,750 grams of Cement and 750 grams of Sand and 250 grams of water.

The sand was passed through a No. 20 sieve to remove pebbles, stones, etc.

The sand and sement were weighed separately, thoroughly mixed before moulding and then treated as in the previous experiment.

This time I had an average of twelve briquettes instead of thirteen as in the first experiment.

I let them all set for twenty-four hours in air, just as in the previous experiment before putting them in water. Then as before explained I tested one from each lot at the end of certain times, such as first day, second day, etc. and obtained my average from the different points of the curve (which will be discussed later).

Although a 1 to 1 mortar was used, it is rational to suppose that for the same conditions any other mortor as 1 to 2, or 1 to 3, etc. should follow the same law, the only difference being in the constants involved in the equations.

Experiment No. 3.

Gement with different proportions of Sand(in water).

Here the ratio of the constituents in the mortar varied, all other things remained constant.

The mortar varied from a neat cement to all sand, giving thirteen points for the curve.

The method of making and breaking the briquettes was as follows:

In order to get the best average, the lot was made up of one batch at a time, making conditions for the average the same as in experiments I and II.

The temperature of room and of water used were recorded.

The quantity of water used was 250 grams to 1500 grams of the mixture of sand and cement.

In this experiment the briquettes were allowed to set for three days before putting them in water as some of them contained much sand and appeared very wet, and by this means had time to dry and to set thoroughly

Experiment No. 4.

Strength of Neat Cement by Varying Amount of Water for Mixing. (let harden under water).

In this experiment the weight of cement, time, etc. remains constant, but the quantity of water varies.

In this experiment it is necessary that the different batches, or lots be made up without loss of water.

The moubds rested on glass, (as in the other experiments) and were sealed around the edge on the lower side with oil to prevent the cement, (which was almost liquid in some cases) from escaping.

The mixture of cement was as usual 1500 grams but the quantity of water varied from 50 grams to 1000 grams, giving eleven points for the curve.

In this experiment the briquettes were allowed to set two days in air before placing them under water.

Experiment No. 5.

Strength with Different Proportions of Sand (out of water).

In this experiment the preliminary discussion is the same as for experiment No. 3. as all the conditions, etc. are the same except in this case the briquettes are allowed to harden in the air, instead of under water.

In this experiment batch No. 62 (where the mixture is all sand) is the same as batch No. 32 of experiment No. 3, as I took six briquettes from it, as it is also all sand.

Experiment No. 6.

Neat Cement Briquettes, Hardening under Water for Various Purposes.

The objects of this experiment are as follows:

1st. Strigth at six months. All to varify or prove

2nd. Strength at one year. the results obtained from

3rd. Strength in five years equation of curve in

experiment No. 1.

4th. Time required to break the briquettes under some percent of the average maximum load, that is, suppose than ten (10) of these briquettes are broken at one year, and by this means get an average, then, I load a briquette up to 75% of this average maximum load and wait for it to break, continuing this process and at different percentages of the maximum loading I get (by this means) some relations that are yet to be obtained.

The briquettes for this experiment are finished but the limit of time is so great that it will not be possible for me to put any of the results in this thesis, but the conditions, such as making them up, quantities of cement and water, temperature, etc. are just the same as in Experiment No. 1.

Some general remarks upon the different Experiments.

I used two barrels of cement for this work. The first barrel was used up on Experiments No. 1 and No. 2.

The second barrel was used for the rest of the experiments.

The water used was well and cistern water, obtained from those of the Missouri School of Mines at Rolla, Missouri.

In all these experiments the cement was sieved through a No. 30 Sand sieve to get rid of all foreign particles.

In experiment No. 2, and No. 3, the sand was sifted through a No. 20 sieve to remove pebbles etc. Then the sand was thoroughly dried and cooled to the temperature of the room before using, as hot dry sand may evaporate some of the water added in mixing.

In experiment No. 1 Sets G. and I. were mixed on a cold, freezing day, and as a result cracked and had to be thrown out as the results were so bad. Hence only had eleven in a set for an average instead of thirteen as stated before.

In all the data where parentheses (---) appear are places where results were so bad that they were disregarded.

In all cases the moulds were oiled and placed upon glass, so that they could be easily slipped in order to prepare them for further moulding.

described a theles for testing to setting the continue small Ball & thick wire) is

Ball weighs 113.3 grams, and trans to testing compete setting) is

No2 (Large ball & fine wire for testing compete setting)

Ball = 453.3 grams, and insureter of wire = 1/2 and to all

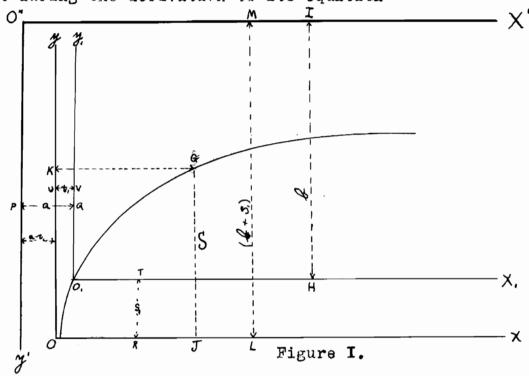
Discussion of Curve No. 1.

Results of my first experiment are given on page from which the data given on page (/) were obtained by taking the average results of one day, two days four days, etc.

From this data the curve on Plate I was plotted, strength per square inch being plotted as ordinates and time as abscisses.

A curve drawn through these points resembles that of an Equilateral Hyperbola whose asymptotes are parallel to the axes.

The curve is shown in Figure I and all reference will be made to it during the derivation of its equation



Let us assume the general equation of an Hyperbola which is

x y = c

c being a constant.

Let O' X' and O'Y' be asymptotes of the curve.

Since the curve does not pass through the origin take some know pointo, for reference, this is referring the curve to a new axis, and in this case the origin is the first point on the curve, hence we have 0, X, and 0, y, as the new axis and the coordinates of the new origin are S, and t,

Hence the equation of the curve with reference to the asymptotes is $X^{*}Y^{*}=C=--1$

The problem is to get a constant value of C.

Take any known or average point on the curve as G.

S=JG=average strength in pounds per square inch after mixing it is also equal to the distance of the average point from the old X axis.

b = HI = distance of new X, axis from asymptotes O" Y'

b+S, = distance of Old X. axis from asymptote 0" Y'

t = KG = time in days after mixing before briquettes were broken, also distance of average point from old Y axis.

a = PQ = distance of new Y, axis from the asymptote O"Y"

S₁ = RT = average strength of eleven briquettes of one day after mixing.

t, = UV = Time (one day) of breaking of first lot after mixing.

Now again let X_i and Y_i pass through O_i and now we use this as origin.

Now to get values of X^{*} and Y^{*} in terms of $(t--t_{*})$ and

(S -S.) hence we have from figure

$$X' = (X, -a)$$

$$Y^{1} = (b - y_{1})$$

c = ab Hence for any point

Now x of first point is a

y of first point is b hence solving for C. we get from (2)

 $bx_1-x_1y_1 + ab-ay=ab$

 $bx_1-x_1y_1-ay_1=0$ Now to solve for a and b as c=ab.

$$(b-Y_1)x_1 = ay_1$$
 divided by x_1 and y_1

we get
$$\frac{b-y_1}{y_1}=\frac{a}{x_1}$$

$$\frac{b-1}{y} = \frac{a}{x}$$
 didived by $\frac{1}{a}$

$$\left(\frac{b}{a} \times \frac{1}{y}\right) - \frac{1}{a} = \frac{1}{x}, \text{ divided by } \frac{b}{a} \text{ or multiplied by } \frac{a}{b}$$
and we have
$$\left(\frac{1}{y}, -\frac{1}{b}\right) = \left(\frac{a}{b} \times \frac{1}{x}\right) \text{ this is equal}$$

$$\frac{1}{y}$$
, $=\frac{1}{x}+\frac{a}{b}$ $\times \frac{1}{x}$ but $y = S - S$, and $x = t - t$.

$$\frac{1}{\left(\frac{1}{S-S}\right)} = \left(\frac{1}{b}\right) + \left(\frac{a}{b}\right) \left(\frac{1}{t-t}\right) \qquad ----- \qquad -(3)$$

In which $\frac{1}{h}$ is the intercept and $\frac{a}{h}$ is the slope of line.

Now multiplying by b we get

$$\frac{b}{(s-s)} = 1+ab \left(\frac{1}{t-t}\right)$$
. $ab = \frac{b}{(s-s)}(t-t) = c$.

If this assumed equation is the right equation to the curve they by plotting

 $\frac{1}{S-s}, \qquad \frac{1}{t-t}.$ Shown on plate I which proves our statement.

Let us now investigate the meaning of the constants involved in this equation.

From the intercept on the $\frac{1}{3-s}$ axis the value of $\frac{1}{b}$ taken from the plot is 0016. from which b = 625.

Likewise $\frac{a}{b} = \tan(-\frac{8}{9.25}) = .8648$.

and from the value of b = (625) we find that a = b tan = 540.5.

S, and t. are other constants that enter but whose values are given in the tables.

Having these constants determined we may simplify equation (3) by putting in their values.

 $S_{\bullet} = 17.7.$

t. = 1.

a = 540.5

b = 625.

Hence equation (3) becomes

$$\left(\begin{array}{c}
\frac{1}{8-17.7} = \left(\begin{array}{c}
1\\625
\end{array}\right) + \left(\begin{array}{c}
540.5\\625
\end{array}\right) = \left(\begin{array}{c}
1\\t-1
\end{array}\right) \text{ from this}$$

$$S = \frac{1}{\left\{\frac{1}{625} + \frac{540.5}{625} \frac{1}{t-1}\right\}} - 17.7$$

EXBEHINENT NOT.

Bach	rempt	of Room 200
A	Pempr	of Water 22
Ne	Nime in Days	Strength in # Per Sq. inch.
\	\	50
2	2	208
3	4	299
4	7	382
. 5	14	383
6	21	6/7
7	30	553
В	40	677
_ 9	60	634
10	90	664
	e des recipios de la composición de destructura de la composición de la composición de la composición de la co Transferencia de la composición del composición de la composición del composición de la composición de la composición de la composición de la composición	Addition of the company of the control of the contr
Bach	Tempt	of Room23
		of Room23 of Water17
Васн		of Room 23° of Water 17° Strength in #Per Sq. inch
Васн В		
Васн В		og Water-17 Strength in #Per Sq. inch
Bach B No 1	Templ Time in Days	of Water-17° Strength in #Per Sq. inch
Bach B No 1 2	Templ Time in Days	of Water-17 Strength in #Per Sq. inch
Bach B N 1 2 3	Templ Time in Days 1 2	of Water-To Strength in #Per Sq. inch. 20 110
Bach B N 4	Temple in Days 1 2 7	of Water-17 Strength in #Per Sq. inch 20 211 352
Bach B N 9 1 2 3 4 5	Temple in Days 1 2 4 7 14	of Water-17 Strength in #Per Sq. inch 20 110 2111 352 542 606 (436)
Bach B N 9 1 2 3 4 5	Temple in Days 1 2 7 7 14 21	of Water-17 Strength in #Per Sq. inch 20 110 2111 352 542 606 (436) 682
Bach B N 9 1 2 3 4 5 6	Temple in Days 1 2 1 7 14 21 30 40	of Water-17 Strength in #Per Sq. inch. 20 24/ 352 542 606 (736) 682 738
Bach B N 9 1 2 3 4 5 6 7 8	Temple in Days 1 2 7 14 21 30 40	of Water-17 Strength in #Per Sq. inch 20 110 2111 352 542 606 (436) 682

B 5 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -		
Bach	Rempt	of Room 23
C	Remiet	of Water 182
No	Prime in Days	of Water 182 Strength in * Per Sq. inch.
\		36
2	2	153
3	4	280
4	7	372
5	14	550
6	21	638
٦	30	562
ゎ	40	677 .
9	60	746
10	90	679
		!
7)	Templ of	Room = 123°
7)		Room = 124°. Water = 122°.
Bach		
Back D		Room = 123° V ter= 122° Strength in ** Per Sq. inch.
Back D		W ter= 122 Strength in # Per Sq. inch.
Back D No	Pempt of Pime in Days	V ter= 122 Strength in # Per Sq. inch.
Bach D Ne 1	Pempt of time in Days . /	V ter= 122 Strength in #Per Sq. inch.
Bach D No 1 2 3	Pempt og ' Pime in Days · / 2	V ter= 122 Strength in # Per Sq. inch.
Bach D No L L 3	Pempt of Vime in Days · / 2 4 7	Veter= 122 Strength in # Per Sq. inch. /7 266 371 364 56/
Back D No 1 2 3 4 5	Tempt of Time in Days · / 2 4 7 /4	V ter= 122 Strength in # Per Sq. inch. // 266 371 364
Bach D No 1 2 3 4 5 6	Tempt of Time in Days · / 2 4 7 /4 2/	Veter= 122 Strength in # Per Sq. inch. /7 266 371 364 56/
Bach D No 1 2 3 4 5 6 7	Tempt of Time in Days 1 / 2 4 7 14 21 30 40	Veter= 122 Strength in # Per Sq. inch. // 266 371 364 56/ 638
Bach D No 1 2 3 4 5 6 7 8	Tempt of Time in Days 1 / 2 4 7 14 21 30 41	Vere 122 Strength in # Per Sq. inch. // 266 371 364 56/ 638

Back	Tempt of Room = 123°		
E	Tempt of	Water = 123°	
No.	Pime in Days	Water - 124° Strength in #PCT. Sq inch.	
/	/	9	
2	. 2	6.2	
3	4	777	
4	7	4/7	
5	<i>i.f</i>	782	
6	21	620	
7	30	680	
8	4,0	r /	
7	50	580	
10	90	783	
11	The state of the s		
T			
Bach	Tempt of	Room = 16°	
Bach		Room = 16° Water = 15°	
		1	
F		Room = 16° Water = 15° Strength in *Per. Sq. INCH.	
F		Water = 15° Strength in *Per. Sq. INCH	
No. /	Tempt of Pime in Days	Water = 15° Strength in *Per. Sq. INCH_	
F. No. /	Tempt 13 Time in Days	Water = 15° Strength in #Per. Sq. INCH	
F. No.	Tempt 13 Time in Days	Water = 15° Strength in *Per. Sq. INCH. // 63	
F. No. / 2 3 3 5 6	Tempt 17 Time in Days 4	Water= 15° Strength in *Per Sq. INCH. 3 287 376	
F. No.	Tempt 17 Time in Days 2 4 7 /4	Water = 15° Strength in *Per. Sq. INCH. // 3 287 376 657	
F. No. / 2 3 3 5 6	Tempt 33 Time in Days 2 4 7 /4 2/ 30 40	Water = 15° Strength in *Per Sq. INCH. 3 287 376 657 6/3	
F. No.	Tempt 17 Time in Days 2 4 7 14 2/ 30 40 60	Water = 15° Strength in *Per. Sq. INCH. // 63 287 376 657 6/3 570	
F. No.	Tempt 33 Time in Days 2 4 7 /4 2/ 30 40	Water = 15° Strength in #Per Sq. INCH. 3 287 376 657 613 570	

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BacH	Pempt of	Room 16°
G	Pempt of	Water 15° Strength in #Per.Spince
No.	Days	#Per Spince
/	/	7
2	2.	7)
3	-	2.76
4	7	. 77
	11	37.)
6	21	620
7	30	64,5
8	10	(170)
7	60	7:53
,)	70	808
11		
//		
Bach	Pempt of	Room = 144°
	Pempt of	Room = 144° Water= 132°
Bach	Pempt of Pempt of Time in Pars	Room = 144° Water= 132° Strength in # Per. Squinch
	Pempt of Pempt of Pime in Days	Water 132 Strength in # Per. Sq inch.
Bach	Pempt of Pemit of Time in Days	Room = 144° Water= 132° Strength in # Per. Sq inch.
Bach J No	Pemit og Pime in Days	Water- 132 Strength in # Per. Sq inch.
Bach No	Pemit og Pime in Days	Water: 132 Strength in # Per. Sqi inch. //
Bach No	Pemit og Pime in Days	Water: 132 Strength in # Per. Sq inch. // //
Bach No	Pemit og Time in Days	Water: 132 Strength in # Per. Sqi inch. // // 223
Bach No / / / / / / / / / / / / /	Pemit og Time in Days	Water= 132 Strength in # Per. Sqi inch. // // // // // // // //
Bach No 3	Pemit og Time in Days	Water= 13½ Strength in # Per. Sq inch. // // // // // // // // // // /// ///
Bach No / / / / / / / / / / / / /	Temit of Time in Days 2 1 2 1 2 1 2 1 2 1 2 30	Water= 132 Strength in # Per. Sqi inch. // // // 223 320 320
Bach No 1 S	Temit of Time in Days	Water= 132 Strength in # Per. Sqi inch. // // // // // // // // // // // // //

Bach	Tempt of	Room - 132°
K	Tempt of	Water=122°
Na	Pime in Days	Water=1220 Strength in * Fer Sq inch.
		6
2	2	36
3	4	227
1/		337
5	14	470
6	21	551
1	30	572
8	-0	662
7	60	664
10	70	1 1
11		
AMERICAN PROPERTY AND ADDRESS OF THE PARTY ADDRESS OF THE PARTY AND ADDRESS OF THE PARTY ADDRESS OF THE PAR	Market Company of the	A CONTRACT OF THE CONTRACT OF
T) 1	Pempt of	Room=1534°
T) 1	Tempt of V	Room=1534 Vater=134
T) 1	Pempt of V Pime in Days	Room=153° Vater=134° Strength in * Per Sq inch
Bach	Tempt of V Time in Days	Room=153° Vater=134° Strengthin * Per Sq. incu
Bach L No	Tempt of V Time in Days	Vater = 134 Strength in ** Per Squincy
Bach	Tempt of V Time in Days	Vater = 134 Strength in ** Per Sq. incu
Bach L No	Tempt of V Time in Days	Vater = 134 Strength in ** Per Squincu
Bach No 3	Tempt of V Time in Days	Vater = 134 Strength in ** Per Sq incu
Bach No 2 3 4 5	Tempt of V Time in Days	Vater = 134 Strength in ** Per Squincu
Bach No 2 3 4 7	Tempt of V Time in Days 4 7 14 21 30	Vater = 134 Strength in ** Per Sq incu // /// /// /// 594 594
Bach 1 2 3 4 5 6 7 8	Tempt of V Time in Days 4 7 14 21 30 40	Vater = 134 Strength in ** Per Sq incu // /// /// 594 470
Bach No 1 2 3 5 6 7 8 9	Tempt of V Time in Days 2 4 7 7 7 7 9 9 60	Vater = 134 Strength in ** Per Sq incu // /// /// /// 594 594
Bach 1 2 3 4 5 6 7 8	Tempt of V Time in Days 4 7 14 21 30 40	Vater = 134 Strength in ** Per Sq incu // /// /// 594 470

Васн	Ta	1 150
	•	Room = 17°
	Tempt .	g Water= 15½ Strength in # Per. Sq inch.
No.	Pime in Days.	
		\3
2	2	73
3	4	290
H	7	373
5	14	538
6	21	619
7	30	596
8	4/0	709
9	00	558
10	90	
Bach	Pempt of	Room =
Bach	Temps of	
	Temps of	
No	Pernet of Tempt of Time in Days	
	Temps of	
	Temps of	
No.	Temps of	
No. 1	Temps of	
No. 1	Tempt of Time in Days	
No. 1 2 3 1 1 5 5 7	Tempt of rime in Days	
No. 2 3 / 5 7 8	Tempt of Fime in Days	
No. 1 2 3 1 1 5 5 7	Tempt of Time in Days	
No. 2 3 / 5 7 8	Tempt of rime in Days	

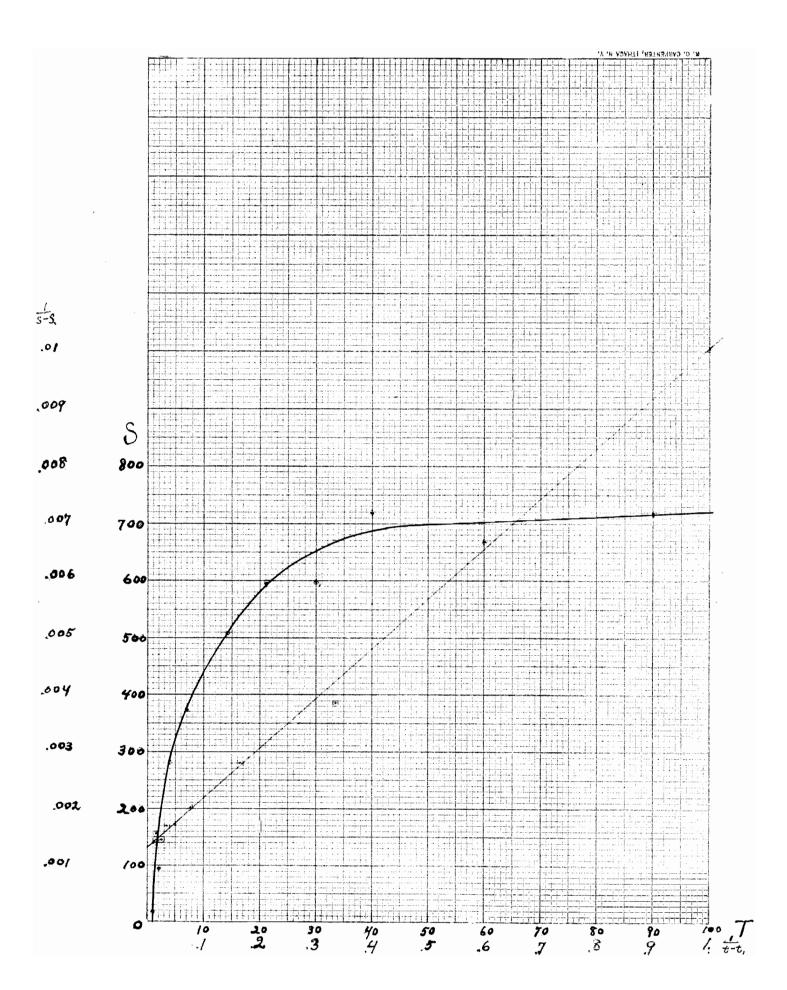


PLATE.I.

		AC	. A 7.		
	2	3	4	5	6
Average	Time in	S-3.	t-t.	<u>1</u> S-3.	$\frac{1}{t-t}$
ef 10-or-11 Briguettes	days after mixing	S minus strength at one day	t.minus	3.3,	
17.7		<i>O</i> .	0		
93.8	2	76./	/	.01314	
282.4	4	2647	3	.00378	.33⁄3
375.	The second secon	3573	. 6	.0028	166
507.2	11	489.5	/3	.00204	.077
594.9	21	577.2	20	.00173	.05
598.2	30	580.3	29	.00170	.0344
7/8.3	40	700.6	39	.00143	.0256
660.5	60	6.12.8	5?	.00155	.0170
715.4	90	697.7	89	.00143	.01/23
		ann gagaphdephonomen a lein a dhèiri a t- a 100 - 100 Chilliann a 13 (100 Chilliann a		and the state of t	

Discussion of Curve No. II.

This curve is shown on Plate II page 25 and when plotted it has the appearance of being of same type as curve No.I.

Hence we are justified in assuming a similar equation as in first case, the derivation of which is the same, and need not be repeated.

If we use an equation similar to (3) of curve No.1, but introducing the values obtained for this second curve we will obtain a line and if it is straight our second assumption is correct. The values of these quantities of second curve are given in Plate II. page (± 6) .

The results of this plot is shown on Plate II. A straight line apparently satisfies all the points. Therefore our assumption in Experiment No.I also holds good for this second experiment.

The symbols S, t &tc. involved in the following discussion, are strength, time, etc. as before explained, the equation then is.

The constants for this equation are determined as they were in previous discussion.

 $\frac{1}{b}$ the intercept on the $\frac{1}{s-s}$ axis is =.0028 from which b=357.1.

Now $\frac{a}{b} = \tan$.B = slope of line and = $\frac{22}{28} = .857$.

 $a = b \tan \beta = 357.1 \times .857 = 306.035.$

Combining these values (b and $\frac{a}{b}$) we get =306.035.

b+S, gives the strength that the briquettes would reach at an infinite time. b+S' being the distance of old X axis to X' axis. X' axis being one asymptote of the curve. This is also shown directly from the equation by making t= 2 thus

$$\frac{1}{s-s_1} = \frac{a}{b} \frac{1}{t-t_1} + \frac{1}{b}$$
 becomes

$$\frac{1}{s-s_1} = 0 + \frac{1}{b}$$
 from which

$$b = s - s$$
, or $s = b + s$, $= b + 9.29 = 357.1 + 9.29 = 366.39$

To determine the other asymptote (which is Y') may be done in either of two ways. First, by knowing the value of a and t taken from the plot, Second, by making $s = \infty$ in equation of the curve.

The equation then becomes

$$\frac{1}{\infty - s_1} = \frac{a}{b} \left(\frac{1}{t - t_1} + \frac{1}{b} \right)$$

or
$$0 = \left[(a) \left(\frac{1}{t - t} \right) + 1 \right]$$
 dividing through by $\frac{1}{b}$

and multiplying out gaves:- t = t' - a = 1 - 306.035 = -305.035.

The curve fully drawn shows that for any time after the curve crosses the X axis that the strength is very negative but apparently has no physical meaning.

The equation in its reduced form obtained by the substitution of the known values of the constants is

$$S = \frac{1}{\left(\frac{1}{b} + \frac{a}{b} \left(\frac{1}{t-t}, -s\right) - s\right)} = \frac{1}{\left(\frac{0028 + .857}{t-1}\right) - 9.3}$$

Bym making S=0. t becomes equal to 11 hours 20.4 minutes which shows that same thing holds true in this experiment as in experiment No.1. viz. that it takes a certain time after mixing before cement sequires any strength.

This gives a means of determining the time of setting of cement mortars (allowing this time to be what we call time of setting) which cannot be accurately done by arbitrary means, used for neat cements,

the most common being the wires and balls as previously explained.

It will be noticed in this experiment that the values of the time when S=0 is greater than in experiment No.I. This seems rational from the experimental data, viz. that it requires a longer time for a briquette of morter to reach a given strength than one of neat cement.

From this it is rational to conclude that as proportion of mortar increases the time of setting also increases, that is a mortar of all sand would require and infinite time to set in order to give any strength. This interesting point gives material for further investigation, viz. to determine relation that exists between amount of sand and cement used and time of setting, also the relations that exists between strength and different proportions of sand in the mortar. This latter is considered in next curve discussed.

By making S = 0 we get t = 11 hours and 20.4 minutes which shows from calculation, and also from plot that there is a certain time after mixing before cement acquires any strength.

This being the case it seems allowable to call this time to at which cement began to show strength.

From plot the time t'=21 hours.

The curve shows that strength approaches an infinite limit in an infinite time.

This finite value is $= b + s_1 = 357.1 + 9.29 = 366.39$ pounds per square inch, hence our curve becomes a horizontal line after a comparatively short time.

RESIGNITS OF EXPERIMENT Nº2.

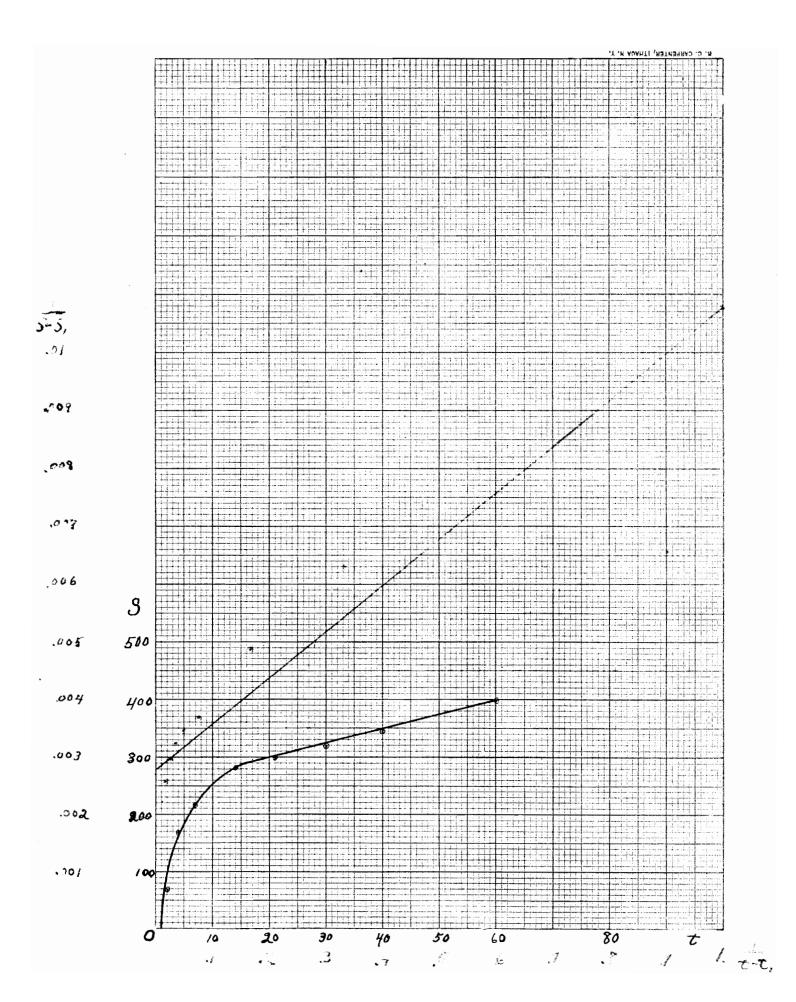
Bach	Pempt of	FRoom Mi
N	Tempt of	Water 212
No.	Mini-In Days	Strength in *Per. Sq inch.
/		7
2	2	57
3	4	/22
4	F	2/9
5	, 1	242
_6	2/	249
7	30	248
8	40	37/
9	60	374
10	80	
//		,
	The second section of the section	graphy and the control of the contro
	Pempr of	i Room = 175°
		Koom=172° Waxer=162° Strength in #Per Sqinch
Bach		Water = 162° Strength in #Per Sqinch
Bach No.		Water = 162° Strength in #Per Sq inch
Bach No.		Water = 162° Strength in #Per Sqinch
Bach () 10. / 2 3	Tempt of Time in Days	Water = 162° Strength in #Per Sq inch
Bach () No. / 2 3 4 5	Tempt of Time in Days / / / / / / / / / / / / / / / / / /	Waxer=162° Strength in #Per Squinch /0 78 , S2 /23
Bach () No. / 2 3 4 5	Tempt of Time in Days	Waxer= 162° Strength in #Per Sq inch /0 78 /23 270 273
Bach () No. / 2 3 4 5 6 7	Tempt of Time in Days / 2 // 2 // 3)	Waxer= 162° Strength in #Per Sqinch /0 78 , S2 /23 270 270 278
Bach () No. / 2 3 4 5 6 7	Tempt of Time in Days	Waxer=162° Strength in #Per Sqinch /0 78 , 52 /23 270 273 378 346
Bach () 10. / 2 3 4 5 6 7 8	Tempt of Time in Days	Waxer= 162° Strength in #Per Sqinch /0 78 , S2 /23 270 270 278
Bach () No. / 2 3 4 5 6 7	Tempt of Time in Days	Waxer=162° Strength in #Per Sqinch /0 78 , 52 /23 270 273 378 346

		en ja var en
Bach	Pempt o	8 Room = 172°
P	Parak a	2 Maxor - 184°
1	Time In	Strength in # Per 3y inch
No	Days	# Per 37 inch
	executive Principles	/0
, e .	2	72
2		The state of the s
3	Z ·	168
4	7-7	220
5	17	254
0	2/	338
7	30	382
8	40	3 42
	00	378
10	80	
	T.	
// Bach	Nemat o	00 Fragu - 19°
Bach	Tempt of	of Front = 19°
Bach	Tempt of	of Maker=17° Strength in
Bach	Tempt of Tempt of Time in Days	of Maker=17° Strength in # Per.Sq inch
Bach	Tempt of Tempt of Time in Days	of Maker=17° Strength in # Per.Sq inch
Bach Q No.	Tempt of Tempt of Days	f Water=17° Strength in # Per.Sq inch
Bach Q No. /	Tempt of Tempt of Days	Strength in # Per.Spineh
Bach Q No. / L 3	Pempt of Prime in Days	Strength in # Per. Sq inch
Bach No. / 2 3	Tempt of Time in Days	f Waker=17° Strength in # Per.Sq inch 70 174 244
Bach No. / 2 / 3	Pempt of Days	Strength in Per.Sq inch 70 174 244 296
Bach No. 1 2 3 1 5	Tempt of Days	Strength in # Per.Sq inch 8 70 174 244 296 273
Bach No. / 2 / 3 / 5 6 7	Tempt of Time in Days	f Water=17° Strength in # Per.S.; inch 8 70 174 244 296 273 304
Bach No. 1 2 3 1 5	Tempt of Time in Days 44 40	F Water=17° Strength in Per.Sq inch 70 174 244 276 273 304 340
Bach No. / 2 / 3 / 5 6 7	Tempt of Time in Days	f Water=17° Strength in # Per.S.; inch 8 70 174 244 296 273 304
Bach No. / 2 3 / 5 6 7 8	Tempt of Time in Days 44 40	F Water=17° Strength in Per.Sq inch 70 174 244 276 273 304 340

Bach	Tempt of	F Room=19/2°	Bach	Rempt of	Room=20°
R	Memps of	Water=172		Tempt of	Water=202°
No.	Time in Days	Strength in # Per Sq. inch	No.	Time in Days	Water=202 Strength in # Per. Sq. inch
/		// "	/	/	8
£	2	59	2	2	76
3	4	185	3	4	/77
4	77	224	4	7	2/6
5	++	302	5	, 7	3/7
6	2/	339	6	2,	308
	3)	328		30	348
<u> </u>	40	348	8	40	324
7	60	378	7	60	436
,0	80		,0	80	
1			1/		
		La carriera como con servicio de la como con esta esta esta esta esta esta esta esta	1-2-1	dia campa	la transfer de la companya della companya de la companya della com
Bach	Tempt of	Room-20°_	Bach	Tempr of	Room = 1830
S_	Tempt of	Room-20° Water=182°	Bach	Tempt of	Room=1834 Waxer=1934
S	Tempt of	Waxer=182°		Tempt of Tempt of Time in Days	Room=1834 Water=1934 Strength in #Per. Sq. inch
S	Tempt of	0	Bach V	Tempt of Tempt of Time in Days	Room=1839 Water=1939 Strength in #Per. Sq. inch
S	Tempt of	Waxer=182°		Tempt of Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch
S No. /	Tempt of	Water=182° Strength in # Per Sq. meh		Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch
S No. / .2	Nempt of Time in Days	Water=18½° Strength in # Per Sq. meh 63	No.	Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch 11
S No. / Z 3	Nempt of Time in Days	Water=18½° Strength in # Per Sy meh 63	N o.	Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch // /2
S No. / 2 9	Tempt of Time in Days	Water=18½° Strength in # Per Sq. meh 63 770 222	No.	Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch // //2 /62 /// 214 306
S No. / Z 3	Nempt of Time in Days 1 2 4	Water=18½° Strength in #Per Sq. meh 63 170 222 322	No. 2 3 4 5	Tempt of Time in Days / / / //	Water: 134 Strength in #Per. Sq. inch 11 72 162 111 214 306 348
S No. / 2 9	Tempt of Time in Days 1 2 4 14 21 30 40	Water=18½° Strength in #Per Sq. Inch 9 63 170 222 248 308 308	No. 2 3 4 5	Tempt of Time in Days	Water: 134 Strength in #Per. Sq. inch 11 72 162 171 274 306
S No. / 2 3 // 5	Tempt of Time in Days 2 2 14 2 14 30 40 60	Water=18½° Strength in # Per Sq. meh 9 63 170 222 322 248 308	No. 2 3 4 5	Tempt of Time in Days / // // // 2/ 30 40 60	Water: 134 Strength in #Per. Sq. inch 11 72 162 111 214 306 348
S No. / 2 3 // 5	Tempt of Time in Days 1 2 4 14 21 30 40	Water=18½° Strength in #Per Sq. Inch 9 63 170 222 248 308 308	No. 2 3 4 5	Tempt of Time in Days 1 2 4 7 1/1 2/ 30	Water: 134 Strength in #Per. Sq. inch // /62 /11 214 306 348

Bach	Rempt of Room = 1/1/2			
	Rempx ox	Waxer= 184		
No.	Pime in Days	Waxer= 1834 Strength in # Per Sq. inch		
_/	/	. 15		
2	9	74		
3	4	164		
1	7	218		
5	14	215		
É	21	270		
F?	30	3/3		
8	70	347		
1	60	390		
,0	80			
. /				
Bach	Tempt of	Room=\630		
Bach W	Tempt of	Room=\640 Water=172		
Bach W No	Tempt of Tempt of Time in Days	Room=164° Water=172° Strength in # Per. Og. inch.		
<u> </u>	Tempt of Tempt of Time in Days	Water=172 Strength in # Per. Og. inch.		
No. 1 2	Tempt of Tempt of Time in Days	Water=172 Strength in # Per. Cy. Inch.		
No. 1 2 3	Tempt of Time in Days / 2	Water=172 Strength in # Per. Og. inch. 8 67 /66		
No. 1 2 3	Tempt of Time in Days	Water=172 Strength in # Per. Sy. inch. 8 67 /66 262		
No. 1 2 3 4 5	Tempt of Time in Days / 2 4 7	Water=172 Strength in # Per. Sylinch 8 67 /66 262		
No. 1 2 3 4 5 6	Tempt of Time in Days / 2 4 7 14 21	Water= 172 Strength in # Per. Sq. Inch. 8 67 /66 262 258 278		
No. 1 2 3 4 5 6	Tempt of Time in Days / 2 4 7 /4 2/ 30	Water=172 Strength in # Per. Sq. inch. 8 67 /66 262 258 278 376		
No. 1 2 3 4 5 6	Tempt of Time in Days / 2 4 7 /4 2/ 30 40	Water= 172 Strength in # Per. Sq. inch. 8 67 /66 262 258 278 376 375		
No. 1 2 3 4 5 6 7 8 9	Tempt of Time in Days / 2 4 7 /4 2/ 30 40 60	Water=172 Strength in # Per. Sq. inch. 8 67 /66 262 258 278 376		
No. 1 2 3 4 5 6	Tempt of Time in Days / 2 4 7 /4 2/ 30 40	Water= 172 Strength in # Per. Sq. inch. 8 67 /66 262 258 278 376 375		

	T - 2230 0 - 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
Bach	Mempr .	8 Room = 162
X	Tempt of	W.xer=162
No.	Time In Days	Water= 162 Strength in #Per. Spin-
		6
Z	2	62
	4	194
The second control of	7	222.
5	14	253
6	21	315
7	30	278
8	40	310
7	60	432 ·
,0	8 0	
	According to the contract of t	7 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
Bach	Tempt of	Room = 16
J	Tempt of	Water= 16.
No.	Pime in Days	Water= 16 Strength in # Per Sqj. inch
		9
2	4	70
3	2	48
4	Authorities (Name of Control of C	222
<i>5</i>	17	272
Ь	C : .	325
	21	JAJ
F-,	30	307
5	30 40	307
, 5 9	30 40 60	307
5	30 40	307



Z.37K_/A

	٠ گ	3	4	5	b	
Average	t Time in	5 - 5.	t-t.	$\frac{1}{S-S}$	\(\frac{1}{t-t.}\)	
	DaysAgrer		7 minus One Day		(0,	
929	/	0	0		-1/2/2/2	
68.4	1	59./	1	.01776	/.	
/67.6	4	158.3	3	.00631	334	
2/5.2	7	205.9	6	.00485	./66	
281.2	14	271.9	/3	.00367	.077	
199.8	21	290.5	20	.00344	.05	
3/9.	30	309.7	29	.00322	.0347	
343.7	40	334.4	39	.00299	.0256	
398.75	60	389.4	59	.00256	.0170	
	80		79	e de de la composición del composición de la composición de la composición de la composición del la composición del composición del composición de la composición de la composición de la composición de la composición del compos	9/26	
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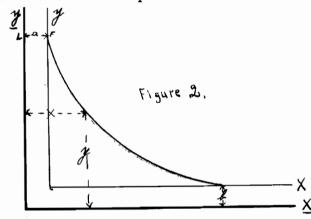
Discussion of Curve Number III.

The results of the third experiment are as given on page (29) from which the data on page 33 were obtained by taking the average of eleven briquettes.

From this data the curve on Plate III was plotted, with strength as ordinates and parts of sand as abscissae.

This curve gives results which seems to justify the assumption of an equation to an equilateral hyperbola referred to its asymptotes (X Y) as axis.

The derivation of the equation is as follows:



Let us assume that the equation referred to X Y as axis is

Let S average strength of ten briquettes in pounds per square inch.

p = proportion of sand.

a and b = distance between y Y and x X respectively.

s = 0 F (fig. 2) = strength of neat cement (properly slacked)

Let us now take point F for reference.

Let B be any point on the curve whose coordinates are \mathbf{x} and \mathbf{y} referred to XY axes.

Now A B
$$\leq X \leq p + a$$

$$B C = y = s + b$$

Substituting in equation (1) we get.

$$(p+a)(S+b)=K$$

To find the value of K in terms of known constant S' and unknown constants a and b, consider the point F on the curve. The x and y of this point are a and b +S' respectively.

Then K for this point F = xy = a(s' + b) putting this value in (2) we have.

$$(p+a)(s+b) = a(s^2+b)$$

$$S = \frac{a(s^2-s)}{p}$$
multiplying and reducing we get

If our assumption is correct, by plotting s and $\frac{S^{*}-s}{p}$ we get a straight line.

a = slope and b = intercept on s axis.

The points were so scattered in parts of the plot that the line could only be drawn approximately.

This line is shown on Plate III page (33).

The value of b = -65 and $\frac{b}{a} = \tan d = \frac{2}{5} = .4$ $\alpha = \frac{\frac{f}{4}}{4} = \frac{-65}{4} = -/62$. The values of a and b having been determined equation (3) may be writ-

ten

$$s = \frac{-162.5 \times 600 \quad 65}{p \quad (-162.5)}$$

By making S=0 we get p 23.1 proportion of sand that would give a zero breaking strength.

By making $S = a_0$ we get the value of p which located the X axis = a.

Thus
$$S = a \left(\frac{s^2 - s}{p} \right) - b$$

ps = as' - as - pb.

$$s(p+a) = as^{*} - pb$$
 from which

$$p+a-\frac{As^2-pb}{s} \qquad \frac{As^2-pb}{s} = 0$$

By making $p=\infty$ we locate X: thus

$$S = a \left(\frac{s! - s}{p} \right) - b = a \left(\frac{s! - s}{\infty} \right) - b$$

EXEEBINENT No.3.

5	ta	an annual residence of the consequence of the con-	and the second of the second o
Barn	Mer	npt of	Room=12°_
20.	Mer	npt of	Water = 123° Strength in # Per Sq.inch
No.	Geme	nt Asand	strength in # Per Squinch
1	1 -	Cement	4 0 0
Ĺ),)	"	299
J	11)1	274
4	"))	244
5).	1)	338
6	, 2)	"	441
7	رر	>>	346
8	>,) <i>)</i>	366
9))	7)	382
10	2)	The statement of the state of the statement of the statem	352
//	"))	442
Bach	Ne	mpk o	& Room = 142°
21.			
No.	Pro Ceme	P. of ntaSand	Mater = 132 Strength in # Per Sq inch
	4C	to 18	317
2	11	\$1)) mm.docentristmont/2014 - 2 d.c. (1989)21	572
9	-		
3	11		515
4)1		515 506
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<i>4 5 6</i>);)))))) N))	506 512 551
4 5 6 7))))))))))))))))	506 512 551 474
4 5 6 7 8))))))))))))))))))))))))))))))))	506 512 551 474 512

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Васн	Per	nPł	of	Room = 140
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No	Pro Cem	P. c	os ESand	Water 13° Strength in #Per Sq. inch
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2	13	יי))	476
3))	1))1	462
4	1)))))	50 L
5))	л	11	490
6)1	71	31	485
7)1))	ונ	383
8)	/1	1)	476
9))))))	471
10	11		7. T. C.	434
4	<i>)</i>))))	428
Bach	Ne	mp)	t of	Room = 133°
23	Ne.	mΡ	t of	Water=132°
No.	Bro' Cem	P. o ente	S and	Water-13½° Strength in #Pcr. 3 j. itizh.
* 1807/234-00-7	10	to 1	8	304
2))))))	34/
<i>3</i>))))))	390
4)) m))	"	402
5))))	J)	252
6)1	[)))	345
7	.))	"	")	350
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8))	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,))))	3 95
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Pai		- 10
Bach		Room= 132°
24	(empt of	Water= 132°
No.	Prop. of Cementa Sand	Water= 132° Strengthin * Per Sq. inch
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2)) 1) 11	2//
3)) 1,))	207
4	11)1 17	228
5)))) 7	237
6))))))	194
7))))))	208
8))))))	241
9))))	2.52
10	11 2))1	208
11)))) 0	223
Fach	Rempt of	Room=132
25	Rempt 00	Water 133°
No.	Prop of Cement & Sand	Strength in *Per. Sq. inch.
	1C to 3 &	132
2	,, ,,))	156
3)1)))1	132
4	1)))))	137
5	1))1 1)	152
6))))))	146
7)1 >> >)	155
8))))))	/36
9)) I)))	170
10))))	162
//))))	157

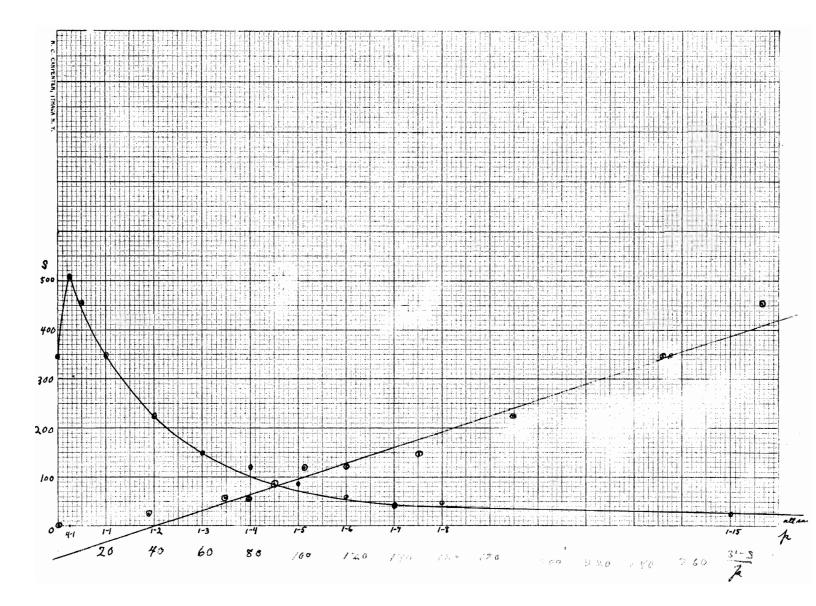
Bach	Ne	m	Pt os	3 Room = 15°
26				
No.	Bro	P. G	id Sand	Water= 14° Strength in * Per. Sq. Inch.
1			48	
1	"	IJ))	125
3]1)1))	148
4))	"	13	128
5))))))	129
6	n	"	"	120
7))	1)))	105
8	"))	3)	101
9))	3)))	115
10))	,,,	"	134
//	,,	•-		98
The second secon		"))	98
Bach		A THE PERSON NAMED IN	managery first in a managery was a managery and a m	and the second s
The second secon	Ne Ne	MP.	PX 08	Room = 15°
Bach	Ne Ne	MP.	PX 08	Room = 15°
Bach 27	Prot Cen	MT MP	PX 08	Room = 15°
Bach 27	Prot Cen	MT MP	tos tos tosand	Room = 15° Vater = 14½° Strength in *Per. Sqinch.
Bach 27 No.	Protent 1C	MAT MP Lent	tos tos tesand	Room = 15° Water = 14½° Strength in * Per. Sq.inch.
Bach 27 No. 1	Prof Cen 1C	thit the ien to 3	tos tos tasand	Room = 15° Water = 142° Strength in Xt Per. Squinch. 81 69
Bach 27 No. 1 2 3 4 5	Proficers /C ""	thir thir ien' to 3	7 08 1 5 5 5 5 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	Room = 15° Vater = 14½° Strength in APer. Sq.inch. 81 69 92
Bach 27 No. 1 2 3 4	Profession IC	thiren's	7 08 1 7 08 1 1 2 3 0 4 5 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Room = 15° Nater = 14½° Strength in Her. Squinch 81 69 92 75
Bach 27 No. 1 2 3 4 5	Prof Cem /C	thiren's	7 08 1 5 Sand 5 3	Room = 15° Vater = 14½° Strength in *Per. Sq.inch. 81 69 92 75 81
Bach 27 No. 1 2 3 4 5 6 7	Profession IC	thiren's	7 08 1 5 08 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Room = 15° Vater = 14½° Strength in * Per. Sq.inch. 81 69 92 75 81 103
Bach 27 No. 1 2 3 4 5 6 7	Prof Cem /C	thiren?	7 08 1 7 08 1 1 2 3 5 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	Room = 15° Vater = 14½° Strength in ** Per. Sq.inch. 81 69 92 75 81 103 96
Bach 27 No. 1 2 3 4 5 6 7	Profession IC	thire !! !! !! !! !! !! !! !! !! !! !! !! !!	27 08 1 7 08 1 10 5 08 1 10 7 10 10 10 10 10 10 10 10 10 10 10 10 10	Room = 15° Vater = 14½° Strength in ** Per. Sq.inch. 81 69 92 75 81 103 96 70

	4	
Васн	Tempt of	Room 142°
28	Remps of	Strength in # Per Sq. inch
N	Prop. 08	Strength in
No.	Cementasan	#Per Sq. inch.
	1C to 68	61
2)1))))	64
3	» (1))	58
4 .	1))) 1)	65
.5)))) I)	59
6)) /)))	59
7))))))	54
8))))))	52
9))))))	51
10	וו וו (נ	72
)))) //	58
Bach	Tempt og	A com-
99		1100
<u> </u>	Prop of	VVater=
No.	Cement + Sand	Water= Strength in #Per Sy inch
1	10 to 7 S	a de la companya de l
2	1))) ()	
3	. 11 21 21	
4))))))	
5))))	
6))))))	
7)\))	
8	رر ((۱۱	
9))),);	
10)))) \s	
	2) 21 21	

Bach	Rempt of	Room=
30	Rempt of	Waxer=
No.	Prop. 08 Cement + Sand	Water= Strength in #Per Squinch
	10 to 88	The state of the s
2),))))	
3	ני ני וו	
4	ני ני ול	
5))))))	titling on an Advantage of the Control of the Contr
6))) ₁) ₁	
7))))))	
8	1/))))	
9))))))	
10	n n n	
//	ע ני וו	
Васн	Tempt of	Room-142°
31		
No	Prop. og Cement & Sand	Water= 134 Strength in #Per Sq.inch
The second control of the control of	1C to 15 &	<i>ذ</i> ؟
2	1) 1))\	20
3	ול וו זו	30
4	1)))	21
5)1 1;);	26
6	ול מי ע	21
7))))))	23
8	21 21 11	21
1	11 11 11	30
10	2) 11))	21
11)) 1) ₎₎	23

Bach	() em	Pt. 08	Room= 14°
32	le m	? <u>¥</u> .°§	Water= 142° Strength in *Per. Sqinch.
Mo.			* Per. Sq inch.
1	AII	Sand	O
2	**))	0
3))))	0
_4)\))	0
5))))	0
_6))	15	0
_7)))	0
8)))	0
9))))	0
10))	>>	0
//	71)	0
		- 一次中 ¹⁹ MacManggang yello makkan (Edy, on Maghilla) - Manggay - Maghillag (1 によらいに _も Me) - Maghi	
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FIL 47/F III.

	$A \mathcal{O}$	A 7	
1	2	3.	4
S .	/	S'-S	S'-S
Average Strength of	Parte of Cement & Sand	Strength of	The state of the s
1/Briquettes	Clment & Sand	Strength of neat briguettes minus S	
343.8	All Cement	256.2	<i>2</i> 7
507.0	40 to 18	93.	372.
453.5	20 to 18	146.5	2930
347.2	10 to 18	252.8	252.8
221.3	10. to 28	378.7	187 3
148.6	10 to 3 S	451.4	./50.4
119.3	10 to 48	480.7	./2:2
84.8	10 to 58	515.2	135.0.
59.3	10 to 68	540.7	7 /
41.8	10 to 78	558.2	79.7
47.6	10 to 88	562.4	67.05
232	10 to 158	576.8	33.4
0	All Sand	600.	9

Discussion of Curve No.IV.

The results are given on page (35). from which the data on Plate IV. page (38) is obtained and from this data we plotted the curve shown on Plate IV., using breaking strength as ordinates and amounts of water as abscissas.

equation for it, so that all I can conclude from the curve is that it rises gradually until it reaches a certain height, about 520 pounds and then remains constant regardless of amount of water used, provided the experiment is conducted as we preformed it, that is, be sure and keep putting cement in the moulds until they are completely filled or packed and allowing all excess of water to flow off.

It is also reasonable to suppose that strength decreases as water (added) decreases, and that it finally reaches zero when there is not enough water added to slack the cement, or cause setting.

RESULTS OF EXPERIMENT NOIT

		The Co. I have been a supplied to the control of th
Bach	Rempt of	Room = 14°
39	Nempt of	Waxer = 15°
Mo.	Time in Days	Waxer=15 Strength in * Per. Sq.inch.
1	60	322
2	")	400
3	>)	292
4	ال	448
5)1	345
6	<i>)</i>)	460
7))	466
8	»	507.
9)1	458
10))	503
)	445
Bach	Pempt of	Room = 14°
40		Waxer= 1334
No.	Pime in	Strength in # Per. Sq. inch
	60	435
1	2)	248
3))	322
4	1)	410
5))	321
6))	414
7))	468
8))	438
9))	377
10))	338
//))	389

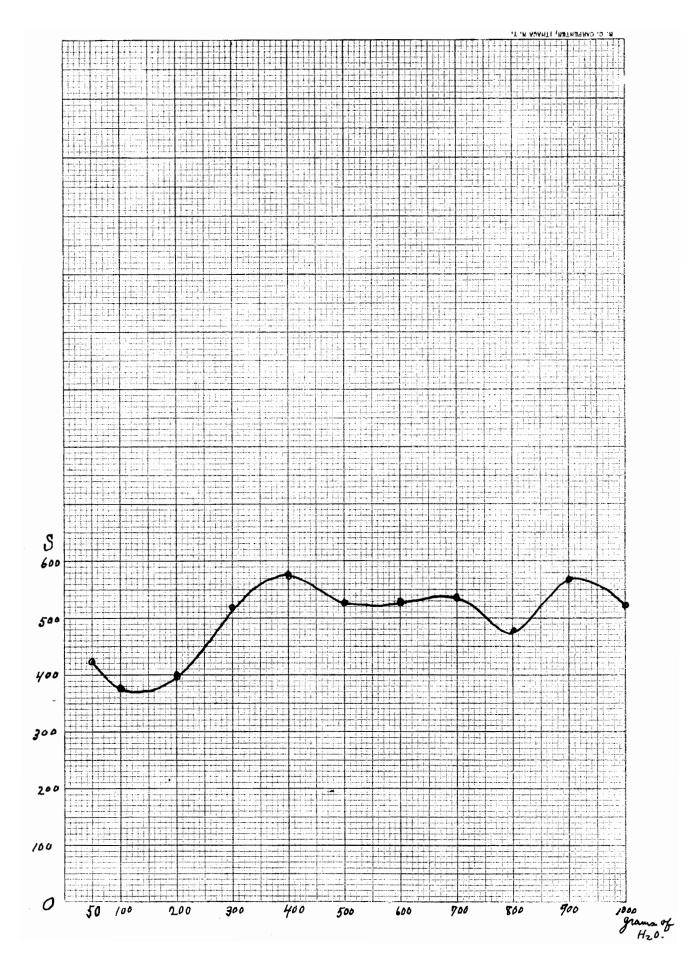
en description and construction of the second section and the sectio	والمراجعة والمراجعة والمستحدية والمراجعين	* 20 00 00 00 00 00 00 00 00 00 00 00 00
Bach	Jempt of T	Room = 12°
41	lempt of	Maxovaly
No.	Time in Days	Strength in A Per. Sq. inch
NAT OF SQUARES AND A STATE OF	60	360
2	11	346
3	11	458
4	ii	412
5	1	370
6	Y	374
7	ų	424
8	4	414
9	ч	467
10	11	344
11	11	1199
//		422
Bach	same occursor in a safe sa a company for a construction	
	Pempt of	Room = 12°
Bach.	Pempt of	Room = 12°
Васн 4 2	Pempt of	
Bach 42 No	Pempt of Pempt of Time in Days	Room = 12° Water= 14° Strengthin # Per. Sq.inch
Bach 42 No	Pempt of Pempt of Time in Days 60	Room = 12° Water= 14° Strengthin # Per. Sq. inch 6/4
Bach 42 No.	Pempt of Pempt of Time in Days 60	Room = 12° Water= 14° Strength in # Per. Sq. inch 6/4 540
Bach 42 No 1 2	Permpt of Permpt of Time in Days 60	Room = 12° Water= 14° Strengthin # Per. Sq. inch 6/4 540 560
Bach 42 No. 1 2 3	Pempt of Pempt of Time in Days 60	Room = 12° Water = 14° Strength in # Per. Sq. inch 614 540 560 493
Bach 42 No. 1 2 3 4 5	Permpt of Permpt of Time in Days 60	Room = 12° Water = 14° Strength in # Per. Sq. inch 6/4 540 560 493 544
Bach 42 No. 1 2 3 4 5 6 7 8	Tempt of Tempt of Tempt of The in Tays 60 "" ""	Room = 12° Water = 14° Strength in # Per. Sq. inch 614 540 560 493 544 418
Bach 42 No. 1 2 3 4 5 6	Pempt of Pempt of Time in Days 60	Room = 12° Water = 14° Strength in # Per. Sq. inch 6/4 540 560 493 544 4/8 499
Bach 42 No. 1 2 3 4 5 6 7 8	Tempt of Tempt of Tempt of The in The	Room = 12° Water = 14° Strength in # Per. Sq. inch 6/4 540 540 493 544 4/8 499 480

Bach	Pempt of	Room 162°
43	Rempt of	Water-15°
No.	Time in Days	Water. 15° Strength in # Per. Sq. inch
1	60	505
2	l l	563
3	((624
4	((645
5	l	646
6	4	581
7	ft .	419
8	(1	624
9	l (1	519
10	lı	652
//	"	X
Dach	"lempx of	Room= 1820
1 1 1 1 1	7	20
44	Rempx os	Water-164
14	Tempy of Time in Days	Water-164 Strength in #Per. Sq. inch
N ₀	Tempy of Time in Days	Water-164 Strength in #Per. Sq. inch
No	Nempx of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03
1 2 3	Nempx of Nime in Days 60	Water-164 Strength in #Per. Squinch 5.03 506 446
1 2 3 4	Nempt of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548
1 2 3 4	Nempt of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548
1 2 3 4 5 6	Nempx of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548 5// 502
1 2 3 4 5 6 7	Nempt of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548 5// 502 575
3 4 5 6 7 8	Nempt of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548 511 502 575 474
1 2 3 4 5 6 7	Nempx of Nime in Days 60	Water-164 Strength in #Per. Sq. inch 5.03 506 446 548 5// 502 575

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Bach	Tempt of	Room=20°
45	Tempt of	Water=18°
No.	Time in	Water-18° Strength in # Per Sq. inch
The control of the co	60	520
2	lt.	527
3	tı	465
4	. [1	<i>53</i> 6
5	11	<i>57</i> /
6	11	545
7	ч	551
8	1	528
1	ц	501
10	· t(536
//	(r	538
Bach	Pempt o	g Room=214°
46	Jemrt of	Water = 202
No.	Time in Days	Water=202 Strength in #Per. Sq. inch.
/	60	421
2	(1	525
3	***	518
4	(1	498
5	(1	479
6	4	503
7	ď	570
8	и	566
9		621
10	FF	645
//	4+	584

Bach	No.	R 105°
117		Room-102
7.	Time in	Vyaxer=182 Strength in # Per. Sq.inch
No	Pays	
	60	494
2	(1	440
3	(1	490
4	tı	502
5	ч	508
6	ř.	492
7	(t	500
8	ų	465
9	çt	498
10	41	. 376
11	11	510
Bach	Rempt of	
Васн 48	10	Room 15/2
Васн 48 No.	Tempt of Tempt of Time in Days	Room 15/2
Bach 48 No.	Tempt of	Water-162 Strength in # Per. Sq. inch
148 No.	Time in Days	Water-162 Strength in
148 No.	Pime in Days	Water-162 Strength in # Per. Sq. inch
1 2 3	Time in Pays 60	Water-162 Strength in # Per. Sq. inch 599 562
1 2 3	Time in Days 60	Water-162 Strength in # Per. Sq. inch 599 562 523
148 No.	Time in Pays 60	Water-162 Water-162 Strength in # Per. Sq. inch 599 562 523 620 561
1 2 3 4 5 6	Time in Pays 60	Water-162 Strength in # Per. Sq. inch 599 562 523 620 561 490?
1 2 3 4 5 6	Time in Days 60	Water-162 Strength in # Per. Sq. inch 599 562 523 620 561 490?
1 2 3 4 5 6	Time in Pays 60 "" "" "" "" ""	Water-162 Strength in # Per. Sq. inch 599 562 523 620 561 490? 607 570
1 2 3 4 5 6 7 8	Time in Pays 60 "" "" "" "" "" ""	Noom 15/2 Water-16/2 Strength in # Per. Sq. inch 599 562 523 620 561 490? 607 570 638
18 No. 1 2 3 4 5 6	Time in Pays 60 "" "" "" "" "" "" "" "" "" "" "" "" ""	Water-162 Strength in # Per. Sq. inch 599 562 523 620 561 490? 607 570

	the same of the sa	May construe agreement with the control and the second
Bach	Tempt of	Room= 142°
49	Pempt of	Water 15t
No.	Time in	Water= 152 Strengthin *Per. Sq. inch
/	60	501
2	((470
3	4	503
4	¢¢.	574
5	U	530
6	41	624
7	ч	507
8	11	555
9	1(542
10	11	508
11	te te	X
Mary Aller of Action of Street Action of the Control of the Contro	The second secon	The state of the s
	en in 1992-freitstettettettet fleik besætsette ett ender til og visse telefore	North Control of Contr
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1 to 1 to 2 to 1 to 1 to 1 to 1 to 1 to	The state of the s	
and the second s		
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40	2
Quantity of water	Average Strength of
in Grava.	11 Briquettes
<i>5 0</i> .	422.4
100.	378.2
200.	399.2
300.	5/0.9
400.	577.8
500.	5-26.9
600.	5289
700.	539.1
8.00	479.6
900.	5-68.2
1000.	531.4

Discussion of Curve Number V.

The results are shown on page 41 and data on page 45 from which the curve shown on Plate V was obtained.

Now this curve is similar to that of No.III and all the conditions that fulfill No.III likewise fulfill this curve, therefore the discussion are exactly similar and need not be repeated here. The only difference between this Experiment and Experiment No.III is, that the briquettes in this experiment were allowed to harden in air instead of under water. The constants involved are the only things that differ.

S', S a,b, etc. have similar meaning to those of Curve No.III.

$$S^* = 590$$

$$b = -25$$

$$\frac{b}{a} = \tan \beta = \frac{2}{10} = \frac{1}{5} = .2$$

$$a = \frac{-25}{2} = -125$$
.

$$s = \frac{s'a-b}{a+p} = \frac{590 \times (-125) + 25}{-125 + p}$$

Similar

$$p = -a$$
 and $S = -b$

The following conclusions may be drawn:

As amount of sand increases the strength decreases. Hence curve has two finite limits, one being strength with zero amount of sand, and the other being pure sand with zero strength.

It can also be noted that the more sand used the honger it takes to set (in order to gain strength) From this we conclude that a pure sand briquette must set for an infinite time in order to obtain strength or set, this however has no physical meaning.

FXPERIMENT Nº5

Bach	Rempt 00	132°
50		Vater = 132° Strength in
No.	Time in Days	Strength in # Per. Sq. inch
	60	314
2	11	249
3	((269
4	((2/0
5	16	156
6	rt.	204
7	ŧ1	309
8	· (199
9	. ((232
10	11	218
	11	252
Bach	Jemph of	Room - 19°
51	Tempt of	Water= 16 Strength in
No.	with the second of the second	# Fex. Spinch
And the second s	60	4/4
3	rr rr	474
4		575 502
Fr. 1 St. AMERICAN PROPERTY IS NO. 1970	(1	parameter in agreement or in the case of t
5	1	446
17	((<u>489</u> 461
8	(1	5/0
9	1	459
10	(1	464
//	***	478

	Name of the second seco	and the second s
Bach	Jempt of	Room 192°
52		Maxer-
No.	Tempt of Tyme in	Strength in # Per Spinch
1	60	. 440
Z	11	393
3		357
# # ***	((395
5	CL	338
6	(1	341
7	(409
8	((132
9	(ı	414
10	(1	415
	4	387
Bach	Jempr of	Room=18°
53	JETHPK OS	. Wazer= 12°
No.	Nime In Days	Water-12° Strength in Her Sq inch
	6 Ó	244
2	1(267
3	(1	221
4	4	299
5	((298
6	11	270
7	[]	264
8	4	261
9	(1	358
10	tt	273
[[46	274

Bach	Rempx of	P - 18"
54	Compx oc	Maxex 1934
No.	Pime in	Water= 124 Strength in # Per. Spinch
Will State of the	60	196
2	/(135
.3	((219
4		199
5	CC	162
6	((205
7	q	144
8	((160
9	L(158
10	4	155
li	50	161
The rate of the second second second	THE COURT OF SERVICE SERVICES AND THE CONTRACT OF THE COURT OF THE COU	2. J. Carrieron, Physics and A. Santa, 1991, 1992, Republic 27, 1781 (1991). Physics at Machine Street, p. 1782, pp. 1781.
Васн	Tempt 08	Room 20°
Васн 55		Room LO° Water 162°
		Room Lo° Water 162 Strength in # Per Sy inch
55 No. 1	Memrt of Mime in Days	Water 162 Strength in # Per Sy inch 115 83
55 No. 1 2 3	Memrt of Time in Days 60	Water 162 Strength 197 # Per Syllich 115 83 116
55 No. 1 2 3 4	Nemrt of Time in Days 60	Water 162 Strengthin # Per Syllinch 115 83
55 No. 1 2 3 4 5	Nemrt of Time in Pays 60	Water 162 Strength 197 # Per Syllich 115 83 116
55 No. 1 2 3 4 5	Nemrt of Time in Days 60	Water 162 Strengthin 115 83 116 155
55 No. 1 2 3 4 5 6	Nemrt of Time in Days 60	Water 162 Strength hin 115 83 116 155 114 160
55 No. 1 2 3 4 5 6 7	Nemrt of Time in Days 60	Water 162 Strength 17 115 83 116 155 114 160 170
55 No. 1 2 3 4 5 6 7 8	Memyt of Time in Days 60	Water 162 Strengthin 175 83 116 155 114 160 170 151
55 No. 1 2 3 4 5 6 7	Nemyt of Nime in Days 60	Water 162 Strengthch 115 83 116 155 114 160 170 151

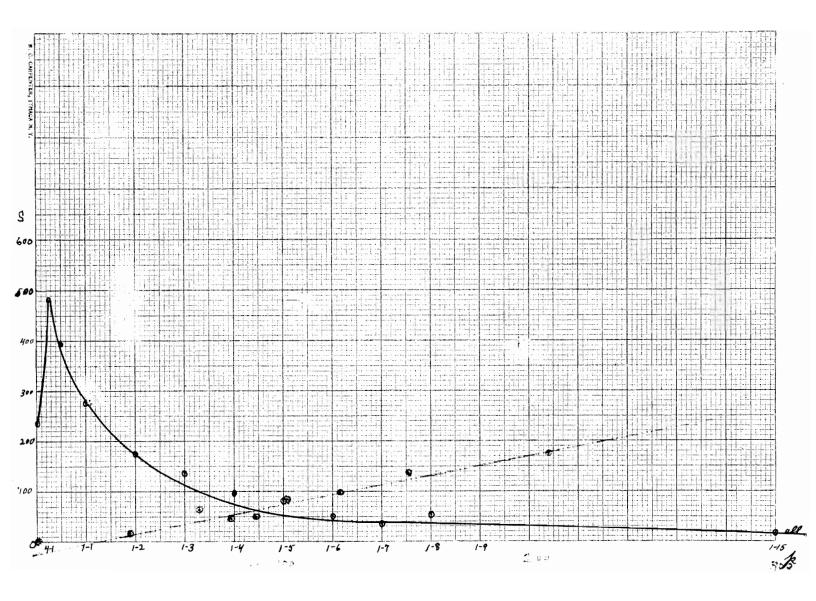
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Bach	REMPT OF	Room=21°
56	M max ac	Water= 192° Strength in # Per. Sq. Mich
A .	Time in	Strength in
No	Days	# Per. Sq. Mch
		109
2	/1	73
. 3		80
4	"	118
5	N	110
6	(1	75
7	(r	9/
8	'(132
9	41	88
10	t ₁	98
//	lı.	102
Bach	Mempt os	Koom-12°
No	Time in Days	Water 19° Strength in #Per. Sq. lich
1	60	65
2	Cl	7/
3	A standard for effect of the change of the standard standard section of the standard standard section of the standard section	56
4	(1	102
5	- 41	106
6	· · · · · · · · · · · · · · · · · · ·	90
7	Ç.	82
8		60
9	N	61
10	4	103
//	٠,٠	99

F	The second section of the second seco	Control of the Contro		
Bach	Tempt of	-Room = 152°_		
58				
No.	Mime in Days	Water-112 Strength in # Per. Sq. inch		
	60	46		
2	Ų	47		
3	11	60		
4	Million Control of the Control of th	33		
5	41	48		
6	1(53		
7		3),		
8	u	59		
9	u	50		
10	le .	60		
11	1	69		
Bach	Pempt of Room - 82°			
59	Mempt of	Water 11/2		
No.	Time in	Strength in # Per. Sq inch		
	60	31		
2	11	. 24		
3	11	37		
4	4	40		
5	ų	34		
6	II	37		
M	Į.	40		
Secretary of the second	u	70		
7	Ч	35		
	The state of the s	ann sa i sagis en		
8	11	35		

En					
Bach	Mempt of	Room= 20°			
60	Jempt of	Water=19°			
No	Time ind	Jempt of Water= 19° Time in Strength in Days #Per. Sq. mch			
1	60	6/			
2	"	55			
3	"	57			
4	4	52			
5	(62			
6	ď	62			
7	((56			
8	lr	37			
9	l ₁	57			
10	U	55			
//	lt	X			
Bach	Tempt of	Room-20°			
(6)	Pempt of	Water= 19° Strength in # Per. Sy. inch.			
No.	Mime in Days	# Fer. Sy. inch.			
	60	n filmi ingaliyang galaga kalika kalika kalika kara sa			
L	11	17			
3 #	Y	/3			
		7			
5	fi	15			
6	1)	23			
7	V	16			
8	(I	,0			
9	(f	" 24			
10 [[V	/ // X			
11	(c	X			

Bach	Tempt of Room = 14°			
62	Pempt of Vvater=14/2 Pime in Strength in Days # Per Sq inch			
No.	Pime in Days	Strength in # Per Sq inch		
	60	0		
2	11	0		
3	(t	0		
4	l f	0		
5	10	0 .		
6	ď	0		
7	((0		
8	4	O		
9	q	0		
10	(t	0		
1//	4	0		
No. of the second section of the second second				
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	Propagation Promite Section 1 to 1	Secretary and the second secretary and the second secretary and the second seco
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An engineer of a second se		
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(45)

DATA. 1 2 3 4						
/	2	3	4			
<u>'</u>	þ	S'-S				
Average of	Parts of	Strength of neat Briquettes	<u>S'-S</u>			
// Briquetter	Cement + Sand	minus s				
236,5	All Cement	353.5	ت * ٠٠			
481.1	4C to 18	108-9	4356			
393.7	2C to 18	196.3	3926			
275.3	10 to 18	314-7	314.7			
173	10 to 28	4/7	2085			
/37.2	10 to 38	4528	1509			
97.9	10 to 48	492.1	/23.0			
8/.4	10 to 58	5-08.6	10/.7			
50.6	10 to 68	539.4	89.7			
34. 4	10 to 78	555.6	71.3			
56.7	10 to 88	533.3	66.6			
15.5	1C to 15 8	574.5	<i>33</i> .3			
0	all Sand	590.	0			

Conclusion.

From these experiments it is observed that many experiments could be preformed, as there are other relations that might be discussed, accompanied by many points of interest, hence we conclude that this subject is unlimited in regard to experimental work.