

130
816

THESIS

REGAGED CEMENT MORTARS

H. E. WILCOX W. S. PEDERSEN

1912

THESIS

XX

130

816

This thesis was contributed by

Mr. H. E. Wilcox

under the date indicated by the department
stamp, to replace the original which was de-
stroyed in the fire of March 5, 1916.

T H E S I S

PRESENTED TO THE

By

H. E. Wilcox

W. S. Pedersen.

WISCONSIN STATE COLLEGE

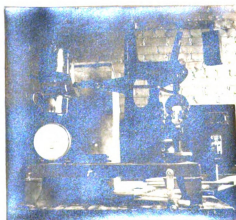
MADISON

1912.

THESIS



Vicet apparatus, vulcanite rings
and Le Chatelier flask.



2000# Olsen Automatic Cement Tester.

This thesis is an investigation to determine the effects of re-tempering cement mortars after the initial set has begun, both as to the time of setting and to the strength, as compared with the same mortar when allowed to set untempered.

DISCUSSION

Probably before launching into an extended discussion it would be best to first explain the terms "gunning" and "retempering".

The term "gunning" as applied to mortars, is the process of mixing the constituents to the proper consistency for use. Consequently "retempering" is the process of returning the mortar to its proper consistency. Hence, it may be noted that the term "retempering" may or may not imply the further addition of water.

In business cement investigations, it is at once evident that a standard is required to determine the proper consistency of the mortar. This may of course, be done at the original mixing, by determining the per cent of water required for a neat cement paste with the Vicat apparatus, and then using the tables prepared by the American Society of Civil Engineers. However, we again find ourselves in a predicament for the table of percentages of water for neat cement mortars has been prepared only for 1:3 mortar. This difficulty was overcome by using Perot's tables which have been recommended by the American Society of Testing Materials until such time as the other mortar may be investigated.

The tables allow us to make a fair and exact picture of a standard consistency, but suppose this was allowed to

set for five hours before remixing. Obviously some of the water has united chemically with the cement and so the mortar will appear dryer.

The problem then confronts us of how we are going to tell the percent of water to use in regaging. It has been found impracticable to use the Vicat plunger when a mortar is being considered, due to the variable action of the grains of sand. However, one apparently possible way remains open, why not regage the neat cement and so determine the added percentages of water that must be used to obtain the standard consistency.

Many things point out that a regaged paste does not act the same as a regaged mortar, foremost among which may be cited previous experiments.

We therefore decided not to attempt to determine the water required for correct regaging, but to regage without addition of water.

METHOD.

Seven brands of Portland cement were selected, samples of which were readily accessible. These samples were so divided between the two of us that any particular brand was carried throughout the test by the same person. In this way the personal equation was eliminated as far as possible.

Each brand of cement was first tested after the method recommended by the American Society of Civil Engineers, for fineness, specific gravity, soundness, tensile strength and time of setting.

The time of setting of the cement as well as that of the mortars, was determined with the Vicat needle. We chose this method rather than that of the Gillmore wires simply

because it is the standard method of the American Society. The method used, however, was imperfect because we dealt with relative values only.

The tensile values were determined from an average of four briquettes. It was originally intended to have the three standard tests, six, seven, twenty-eight and ninety days, but it early became evident that we had not time to wait for the ninety day value and so had to have a sixty day value instead.

All briquettes were broken on a 2,000 pound Tinius, Olsen & Co. standard testing machine, with the shot falling at a rate of six hundred pounds per minute.

PORTLAND.

The three mortars tested were - "1:2", "1:3" and "1:4" proportioned by weight.

SAND.

The sand used was in all cases Standard "30 - 60" Ottawa sand.

PROPORTION.

Enough of each mortar to make seventy-two briquettes and fill six vulcanite rings was prepared. This was mixed one and one-half minutes with the percentage of water as above described. The entire mass of mortar was then divided into six equal portions as nearly as possible by eye. One of these portions was immediately used to make five briquettes and fill one vulcanite ring, the remaining mortar was covered with a damp cloth to prevent evaporation. The briquette made was placed in a moist chamber for twenty-four hours, at the end of which time they were placed under water in the pressure tank.

The vulcanite ring of mortar for determining the time of setting was placed under a damp cloth, and from time to time tested to see when the desired set was reached.

The same procedure was followed with another portion of the mortar in one hour, and so on with the remaining portions. In all cases of recording the process of mixing was done with hands for an interval of one and one half minutes.

CONDITIONS.

The temperature of the room was regulated by thermostats and so kept very nearly constant, varying between sixty-five and seventy-five degrees Fahrenheit. All water used, as well as the storage water was at room temperature. This was accomplished by drawing off several gallons from the tap some time before using, and so allowing it to reach room temperature.

TEST of BEST CEMENT.

Plasticity - - - - - 25% water

Time of setting

Initial - - - - - 1 hr. 31 m.

Final- - - - - 4 hr. 30 m.

Specific Gravity

Dried cement (Lechatelier flask) - - - 3.07

Fineness

Residue on NO. 200 sieve - - - - - 23.5%

Residue on NO. 100 sieve- - - - - 3.55%

Percent of water for mortars.

1:2 Mortar - - - - - 11.6%

1:3 " - - - - - 9.7%

1:4 " - - - - - 9.3%

Soundness tests.

Accelerated, air and water tests -

no cracks or discolorations.

Tensile Strength (Test).

7 da.	28 da.	60 da.
295	470	640
295	460	680
360	540	610
270	490	520
<u>1380</u>	<u>1960</u>	<u>2450</u>

REPORT

1:2 Mortar.

Hours before receiving	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 Hr.	200	315	395	2 hrs. 53 m.	6 hr. 45 m.
	140	305	320		
	110	310	410		
	170	275	420		
	<u>155</u>	<u>308</u>	<u>386</u>		
1 Hr.	220	360	425	4 hrs. 40 m.	7 hrs. 20 m.
	210	360	420		
	190	350	385		
	185	340	410		
	<u>201</u>	<u>353</u>	<u>410</u>		
2 Hr.	195	400	440	4 hrs. 10 m.	7 hrs. 20 m.
	175	360	510		
	170	415	350		
	180	455	---		
	<u>180</u>	<u>415</u>	<u>437</u>		
3 Hr.	190	300	390	4 hrs. 18 m.	7 hrs. 55 m.
	170	365	420		
	180	390	430		
	145	360	295		
	<u>171</u>	<u>353</u>	<u>384</u>		
4 Hr.	240	270	350	3 hrs. 25 m.	7 hrs. 18 m.
	195	310	315		
	170	340	460		
	120	360	395		
	<u>181</u>	<u>315</u>	<u>350</u>		
5 Hr.	200	375	430	2 hr. 53 m.	7 hrs. 28 m.
	180	430	440		
	185	390	440		
	180	350	---		
	<u>186</u>	<u>386</u>	<u>437</u>		

REPORT ON TEST

1:3 Mortar.

Hours before testing	Tensile Strength			Time of setting.	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	35	220	240	7 hr. 10 m.	11 hrs. 40 m.
	50	215	250		
	80	185	260		
	55	165	200		
	<u>55</u>	<u>191</u>	<u>238</u>		
1 hr.	100	170	275	7 hrs. 40 m.	15 hrs. 40 m.
	45	180	240		
	40	185	265		
	70	185	260		
	<u>64</u>	<u>180</u>	<u>260</u>		
2 hrs.	40	210	270	7 hrs. 10 m.	15 hrs. 35 m.
	100	220	245		
	110	170	235		
	95	215	165		
	<u>86</u>	<u>204</u>	<u>229</u>		
3 hrs.	90	150	170	6 hrs. 40 m.	11 hrs. 40 m.
	80	175	200		
	60	155	175		
	70	160	170		
	<u>75</u>	<u>155</u>	<u>179</u>		
4 hrs.	75	150	190	7 hrs. 30 m.	12 hrs. 50 m.
	80	175	200		
	80	120	240		
	70	40	230		
	<u>71</u>	<u>121</u>	<u>214</u>		
5 hrs.	60	220	230	7 hrs. 50 m.	14 hrs. 0 m.
	85	185	230		
	40	150	210		
	--	170	230		
	<u>62</u>	<u>151</u>	<u>235</u>		

BURT COMPANY

1:4 Mortar.

Hours before testing	Tensile Strength			Time of setting.	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	50	50	130	7 hrs. 50 m. 12 hrs. 55 m.	
	45	105	115		
	50	90	165		
	70	86	145		
	<u>54</u>	<u>81</u>	<u>139</u>		
1 hr.	50	100	175	8 hrs. 0 m. 12 hrs. 5 m.	
	50	120	205		
	65	120	160		
	80	110	195		
	<u>61</u>	<u>113</u>	<u>184</u>		
2 hrs.	60	130	195	7 hrs. 50 m. 11 hrs. 25 m.	
	40	130	140		
	40	110	160		
	70	145	175		
	<u>53</u>	<u>129</u>	<u>185</u>		
3 hrs.	60	120	160	7 hrs. 10 m. 10 hrs. 30 m.	
	70	100	140		
	65	100	160		
	60	100	160		
	<u>64</u>	<u>105</u>	<u>143</u>		
4 hrs.	50	90	170	5 hrs. 40 m. 9 hrs. 30 m.	
	50	115	165		
	50	105	140		
	50	110	160		
	<u>50</u>	<u>105</u>	<u>159</u>		
5 hrs.	50	90	140	6 hrs. 35 m. 8 hrs. 30 m.	
	60	90	135		
	45	105	130		
	40	110	110		
	<u>49</u>	<u>99</u>	<u>126</u>		

TEST of PORTLAND CEMENT

Plasticity - - - - - 25.3, water

Time of setting

Initial - - - - - 1 hr. 24 m.

Final - - - - - 3 hr. 15 m.

Specific Gravity

Dried cement (Lechalclier flash) - - - - - 3.17

Fineness

Residue on No. 200 sieve - - - - - 18.4

Residue on No. 100 sieve - - - - - 5.2

Percent of water for mortars.

"1:2" Mortar - - - - - 11.16

"1:3" Mortar - - - - - 9.36

"1:4" Mortar - - - - - 9.13

Soundness Tests

Accelerated, air and water tests -

No cracks or discolorations.

Tensile Strength (net).

7 da.	28 da.	60 da.
460	590	495
480	725	565
495	650	530
470	665	555
<u>469</u>	<u>598</u>	<u>536</u>

TEST of PORTLAND CEMENT

Plasticity - - - - - 25.3% water

Time of setting

Initial - - - - - 1 hr. 24 m.

Final - - - - - 3 hr. 15 m.

Specific Gravity

Dried cement (Lechalatier flash) - - - - - 3.17

Fineness

Residue on No. 200 sieve - - - - - 18.4

Residue on No. 100 sieve - - - - - 5.2

Percent of water for mortars.

"1:2" Mortar - - - - - 11.16

"1:3" Mortar - - - - - 9.36

"1:4" Mortar - - - - - 9.13

Soundness Tests

Accelerated, air and water tests -

No cracks or discolorations.

Tensile Strength (neat).

7 da.	28 da.	60 da.
460	590	495
450	725	565
495	650	530
470	665	555
<u>469</u>	<u>598</u>	<u>536</u>

PAPERLESS CEMENT

"1:2" Mortar.

Hours before requiring	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	290	475	430	3 hrs. 20 m.	5 Hrs. 45 m.
	255	500	500		
	290	510	520		
	245	450	540		
	<u>270</u>	<u>479</u>	<u>498</u>		
1 Hr.	310	480	465	4 hrs. 0 m.	5 hrs. 15 m.
	280	495	515		
	300	445	475		
	300	440	475		
	<u>298</u>	<u>465</u>	<u>485</u>		
2 hrs.	340	435	480	2 hrs. 50 m.	4 hrs. 40 m.
	280	400	475		
	260	420	485		
	260	440	430		
	<u>290</u>	<u>424</u>	<u>468</u>		
3 hrs.	330	430	450	2 hrs. 50 m.	4 hrs. 10 m.
	290	370	500		
	300	390	505		
	345	400	---		
	<u>316</u>	<u>410</u>	<u>485</u>		
4 hrs.	220	480	430	2 hrs. 5 m.	3 hrs. 15 m.
	220	405	415		
	335	385	460		
	290	460	535		
	<u>336</u>	<u>433</u>	<u>460</u>		
5 hrs.	265	390	400	1 hr. 20 m.	3 hrs. 35 m.
	230	360	425		
	260	360	450		
	185	355	400		
	<u>235</u>	<u>361</u>	<u>419</u>		

PROBLEMS - 1918

1:3 Mortar.

Hours before recasting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	140	330	320	1 hr. 44 m.	4 hrs. 50 m.
	170	275	330		
	165	285	310		
	170	310	300		
	<u>161</u>	<u>300</u>	<u>315</u>		
1 hr.	200	310	260	2 hrs. 5 m.	4 hrs. 55 m.
	160	280	260		
	135	255	260		
	180	300	280		
	<u>169</u>	<u>289</u>	<u>263</u>		
2 hrs.	140	260	285	1 hr. 45 m.	4 hrs. 20 m.
	120	255	280		
	120	280	285		
	170	230	280		
	<u>138</u>	<u>249</u>	<u>283</u>		
3 hrs.	140	260	260	2 hrs. 20 m.	4 hrs. 55 m.
	120	230	190		
	145	185	220		
	60	195	260		
	<u>148</u>	<u>219</u>	<u>250</u>		
4 hrs.	60	170	160	3 hrs. 25 m.	4 hrs. 10 m.
	110	210	160		
	120	185	180		
	120	210	165		
	<u>103</u>	<u>194</u>	<u>166</u>		
5 hrs.	120	205	240	2 hrs. 25 m.	3 hrs. 25 m.
	120	205	235		
	140	185	160		
	120	220	175		
	<u>125</u>	<u>204</u>	<u>203</u>		

PORTLAND CEMENT

"1:4" Mortar.

Hours before retesting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	98	150	150	1 hr.	0 m. 4 hrs. 30 m.
	80	155	195		
	70	150	180		
	90	155	190		
	<u>84</u>	<u>153</u>	<u>156</u>		
1 hr.	90	150	180	1 hr.	27 m. 5 hrs. 0 m.
	130	150	210		
	180	200	170		
	80	180	210		
	<u>100</u>	<u>164</u>	<u>193</u>		
2 hrs.	110	140	155	2 hrs.	35 m. 4 hrs. 10 m.
	105	175	155		
	50	155	180		
	50	170	160		
	<u>79</u>	<u>130</u>	<u>163</u>		
3 hrs.	85	150	135	2 hrs.	20 m. 4 hrs. 20 m.
	110	170	140		
	30	120	140		
	110	135	160		
	<u>84</u>	<u>144</u>	<u>141</u>		
4 hrs.	70	100	110	2 hrs.	10 m. 4 hrs. 0 m.
	50	145	100		
	100	110	180		
	110	165	170		
	<u>83</u>	<u>150</u>	<u>155</u>		
5 hrs.	90	95	150	2 hrs.	35 m. 4 hrs. 24 m.
	70	125	170		
	50	140	155		
	80	150	140		
	<u>73</u>	<u>123</u>	<u>151</u>		

TEST of UNIVERSAL CEMENT.

Plasticity - - - - - 25.9% water.

Time of Setting

Initial - - - - - 1 hr. 27 m.

Final - - - - - 2 hrs. 43 m.

Specific Gravity

Dried cement (Lechatellier flash) - - - - - 3.12

Fineness

Residue on No. 200 sieve - - - - - 13.3%

Residue on No. 100 sieve - - - - - 2.4%

Percent of Water for Mortars.

"1:2" Mortar - - - - - 11.78%

"1:3" Mortar - - - - - 9.79%

"1:4" Mortar - - - - - 9.48%

Soundness Tests

Accelerated, air and water tests -

No cracks or discolorations.

Tensile Strength (net).

7 da.	28 da.	60 da.
490	490	540
490	450	560
570	480	455
470	430	570
<u>505</u>	<u>483</u>	<u>531</u>

UNIFORMITY OF SET

1:2 Mortar.

Hours before receiving	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	350	380	430		
	430	435	470		
	395	480	470	0 hr. 33 m.	5 hrs. 25 m.
	270	420	470		
	<u>360</u>	<u>421</u>	<u>473</u>		
1 hr.	355	460	460		
	335	410	450		
	310	440	440	1 hr. 55 m.	5 hrs. 25 m.
	370	400	460		
	<u>345</u>	<u>423</u>	<u>455</u>		
2 hrs.	325	405	440		
	375	450	495		
	365	415	485	2 hrs. 10 m.	4 hrs. 40 m.
	385	470	440		
	<u>365</u>	<u>443</u>	<u>463</u>		
3 hrs.	385	435	485		
	395	440	450		
	370	450	435	1 hr. 50 m.	5 hrs. 15 m.
	170	460	---		
	<u>350</u>	<u>445</u>	<u>445</u>		
4 hrs.	360	430	420		
	375	410	450		
	360	445	455	1 hr. 22 m.	5 hrs. 45 m.
	340	475	435		
	<u>359</u>	<u>443</u>	<u>440</u>		
5 hrs.	315	450	420		
	345	420	420		
	350	410	390	1 hr. 25 m.	5 hrs. 15 m.
	320	440	390		
	<u>333</u>	<u>430</u>	<u>403</u>		

UNIVERSAL CEMENT

1:3 Mortar.

Hours before retesting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	215	270	280	1 hr. 45 m.	5 hrs. 25 m.
	195	270	250		
	215	270	255		
	220	190	220		
	<u>211</u>	<u>225</u>	<u>241</u>		
1 hr.	250	320	335	3 hrs. 0 m.	6 hrs. 45 m.
	275	290	295		
	240	270	300		
	230	305	350		
	<u>249</u>	<u>295</u>	<u>315</u>		
2 hrs.	250	290	320	2 hrs. 20 m.	6 hrs. 20 m.
	220	280	300		
	230	290	300		
	235	290	320		
	<u>234</u>	<u>282</u>	<u>310</u>		
3 hrs.	175	290	260	1 hr. 50 m.	5 hrs. 20 m.
	235	275	300		
	240	300	275		
	175	330	255		
	<u>206</u>	<u>295</u>	<u>235</u>		
4 hrs.	230	250	250	1 hr. 45 m.	4 hrs. 40 m.
	205	250	230		
	220	295	230		
	245	295	215		
	<u>225</u>	<u>250</u>	<u>230</u>		
5 hrs.	180	250	240	1 hr. 40 m.	4 hrs. 10 m.
	190	240	230		
	150	250	210		
	180	230	110		
	<u>175</u>	<u>250</u>	<u>198</u>		

UNIVERSITY OF CALIFORNIA

1;4 Mortar.

Hours before recasting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	180	205	215	0 hrs. 50 m.	8 hrs. 52 m.
	130	190	225		
	50	220	210		
	100	145	180		
	<u>108</u>	<u>190</u>	<u>208</u>		
1 hr.	190	235	250	3 hrs. 45 m.	5 hrs. 0 m.
	160	235	210		
	180	225	250		
	165	215	250		
	<u>174</u>	<u>235</u>	<u>243</u>		
2 hrs.	180	250	270	5 hrs. 15 m.	8 hrs. 0 m.
	165	225	240		
	150	225	260		
	150	230	190		
	<u>160</u>	<u>230</u>	<u>240</u>		
3 hrs.	120	235	250	5 hrs. 15 m.	6 hrs. 50 m.
	140	185	225		
	150	190	210		
	130	190	205		
	<u>135</u>	<u>200</u>	<u>243</u>		
4 hrs.	80	185	250	5 hrs. 5 m.	5 hrs. 50 m.
	120	210	185		
	120	245	200		
	120	240	250		
	<u>110</u>	<u>230</u>	<u>211</u>		
5 hrs.	170	195	250	2 hrs. 50 m.	5 hrs. 25 m.
	160	205	210		
	145	160	215		
	125	210	215		
	<u>180</u>	<u>195</u>	<u>223</u>		

TEST of PORTLAND CEMENT.

Plasticity - - - - - 23.6% water

Time of Setting

Initial - - - - - -2 hrs. 40 m.

Final - - - - - -4 hrs. 35 m.

Specific Gravity

Dried Cement (Lechatelier flask) - - - - - 3.21

Fineness

Residue on No. 200 sieve - - - - - 13.6%

Residue on No. 100 sieve - - - - - 3.1%

Percent of Water for Mortar

"1:2" Mortar - - - - - 11.22%

"1:3" Mortar - - - - - 9.42%

"1:4" Mortar - - - - - 9.16%

Soundness Tests

Accelerated, air and water tests -

No cracks or discolorations.

Tensile Strength (next).

7 da.	28 da.	60 da.
600	630	550
505	510	560
590	630	510
550	660	655
<u>556</u>	<u>608</u>	<u>544</u>

1:2 Mortar.

Hours before recasting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	305	450	545	2 hrs. 57 m. 5 hrs. 23 m.	
	360	490	600		
	300	465	520		
	280	485	460		
	<u>311</u>	<u>473</u>	<u>531</u>		
1 hr.	335	460	560	2 hrs. 40 m. 6 hrs. 30 m.	
	375	455	435		
	315	500	545		
	370	480	480		
	<u>330</u>	<u>474</u>	<u>495</u>		
2 hrs.	360	470	385	2 hrs. 50 m. 5 hrs. 40 m.	
	350	460	495		
	350	440	500		
	340	510	495		
	<u>350</u>	<u>470</u>	<u>489</u>		
3 hrs.	345	530	500	2 hrs. 10 m. 5 hrs. 10 m.	
	350	460	400		
	335	525	580		
	340	455	570		
	<u>345</u>	<u>485</u>	<u>488</u>		
4 hrs.	320	445	490	1 hr. 30 m. 4 hrs. 20 m.	
	280	510	500		
	320	480	545		
	300	480	370		
	<u>305</u>	<u>475</u>	<u>473</u>		
5 hrs.	290	450	465	1 hr. 20 m. 3 hrs. 30 m.	
	270	410	450		
	340	380	510		
	350	360	470		
	<u>313</u>	<u>395</u>	<u>480</u>		

1:3 Mortar.

Hours before testing	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	220	350	355	3 hrs. 3 m.	6 hrs. 30 m.
	210	340	330		
	190	330	325		
	235	305	320		
	<u>214</u>	<u>331</u>	<u>315</u>		
1 hr.	240	370	365	3 hrs. 10 m.	6 hrs. 30 m.
	230	270	410		
	210	320	320		
	200	300	340		
	<u>220</u>	<u>315</u>	<u>359</u>		
2 hrs.	190	365	355	2 hrs. 20 m.	3 hrs. 45 m.
	240	310	325		
	230	325	360		
	235	295	320		
	<u>234</u>	<u>334</u>	<u>345</u>		
3 hrs.	250	270	305	1 hr. 45 m.	4 hrs. 45 m.
	160	330	350		
	190	370	340		
	165	255	360		
	<u>191</u>	<u>304</u>	<u>341</u>		
4 hrs.	210	310	310	1 hr. 25 m.	4 hrs. 0 m.
	165	300	300		
	220	335	350		
	210	255	355		
	<u>201</u>	<u>303</u>	<u>336</u>		
5 hrs.	160	245	325	1 hr. 25 m.	3 hrs. 10 m.
	155	205	290		
	160	255	325		
	140	255	310		
	<u>149</u>	<u>240</u>	<u>313</u>		

1:4 Mortar.

Hours before receiving	Tensile Strength			Time of setting	
	7 ds.	28 ds.	60 ds.	Initial	Final
0 hrs.	110	235	270		
	100	230	265		
	140	240	280	3 hrs. 35 m.	7 hrs. 30 m.
	<u>140</u>	<u>195</u>	<u>270</u>		
	125	235	265		
1 hr.	145	290	280		
	145	240	260		
	165	250	240	2 hrs. 40 m.	6 hrs. 45 m.
	<u>170</u>	<u>230</u>	<u>250</u>		
	155	225	255		
2 hrs.	145	250	250		
	155	250	290		
	150	280	250	3 hrs. 25 m.	6 hrs. 0 m.
	<u>170</u>	<u>215</u>	<u>210</u>		
	155	244	250		
3 hrs.	120	210	250		
	80	140	255		
	140	230	230	2 hrs. 55 m.	5 hrs. 45 m.
	<u>120</u>	<u>175</u>	<u>255</u>		
	115	139	248		
4 hrs.	135	230	280		
	125	265	270		
	140	250	210	2 hrs. 50 m.	5 hrs. 25 m.
	<u>150</u>	<u>235</u>	<u>260</u>		
	135	215	255		
5 hrs.	130	230	235		
	125	255	255		
	165	255	260	2 hrs. 20 m.	4 hrs. 50 m.
	<u>150</u>	<u>245</u>	<u>220</u>		
	148	241	233		

TEST of KLAYOO CEMENT.

Plasticity- - - - - 23.5% water

Time of setting

Initial- - - - - -3 hrs. 5 m.

Final- - - - - -6 hrs. 30 m.

Specific Gravity.

Dry Cement (Le Chatelier flask) - - - - - 3.14

Fineness

Residue on No. 200 sieve - - - - - 20.5%

Residue on No. 100 sieve- - - - - 4.6%

Percent of Water for Mortars.

1:2 Mortar - - - - - 11.2%

1:3 Mortar - - - - - 9.4%

1:4 Mortar - - - - - 9.05%

Soundness Tests

Accelerated, air and water tests -

No cracks or discolorations.

Tensile Strength (neat).

7 da.	28 da.	60 da.
565	570	455
465	525	460
590	590	630
630	745	495
<u>563</u>	<u>510</u>	<u>505</u>

1:2 Part n.

Tensile Strength				Time of setting	
Years before recasting	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	280	475	485	5 hrs. 15 m.	7 hrs. 5 m.
	265	410	385		
	290	430	460		
	<u>310</u>	<u>440</u>	<u>495</u>		
	254	470	440		
1 hr.	260	410	390	7 hrs.	9 hrs.
	270	420	395		
	270	405	46		
	<u>300</u>	<u>475</u>	<u>500</u>		
	230	405	455		
2 hrs.	290	430	575	8 hrs. 5 m.	10 hrs.
	260	425	460		
	310	505	480		
	<u>---</u>	<u>---</u>	<u>505</u>		
	297	457	505		
3 hrs.	280	440	440	10 hrs.	10 hrs. 50 m.
	310	375	410		
	280	400	465		
	<u>290</u>	<u>400</u>	<u>460</u>		
	284	410	461		
4 hrs.	245	310	315	9 hrs. 40 m.	10 hrs. 25 m.
	260	300	415		
	230	345	415		
	<u>205</u>	<u>210</u>	<u>380</u>		
	233	305	369		
5 hrs.	210	300	295	10 hr. 5 m.	10 hrs. 10 m.
	210	305	255		
	225	310	290		
	<u>215</u>	<u>345</u>	<u>310</u>		
	215	335	275		

1:3 Mortar.

Hours before removing	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	150	255	370		
	180	280	325		
	175	260	315	6 hrs. 25 m.	8 hrs. 50 m.
	190	275	290		
	<u>178</u>	<u>255</u>	<u>325</u>		
1 hr.	190	285	300		
	215	270	305		
	180	260	320	6 hrs. 35 m.	9 hrs. 5 m.
	170	275	360		
	<u>189</u>	<u>260</u>	<u>351</u>		
2 hrs.	200	255	300		
	195	255	255		
	210	205	270	7 hrs. 15 m.	9 hrs. 5 m.
	---	255	300		
	<u>202</u>	<u>235</u>	<u>279</u>		
3 hrs.	160	245	250		
	200	275	250		
	150	240	290	7 hrs. 50 m.	9 hrs. 50 m.
	190	250	300		
	<u>175</u>	<u>250</u>	<u>275</u>		
4 hrs.	155	205	240		
	195	240	315		
	135	250	300	7 hrs. 35 m.	9 hrs. 50 m.
	180	265	290		
	<u>179</u>	<u>240</u>	<u>286</u>		
5 hrs.	185	250	205		
	190	190	300		
	160	215	255	8 hrs. 25 m.	10 hrs. 25 m.
	---	200	225		
	<u>173</u>	<u>214</u>	<u>235</u>		

1:4 Vert r.

Hours before retesting	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	150	210	240	6 hrs. 30 m.	9 hrs. 50 m.
	140	200	235		
	140	215	240		
	150	200	235		
	<u>155</u>	<u>205</u>	<u>235</u>		
1 hr.	130	210	210	8 hrs. 35 m.	10 hrs. 25 m.
	155	215	245		
	140	235	250		
	110	215	235		
	<u>134</u>	<u>215</u>	<u>235</u>		
2 hrs.	130	190	210	8 hrs. 35 m.	11 hrs. 30 m.
	135	250	275		
	120	190	270		
	150	185	280		
	<u>134</u>	<u>175</u>	<u>251</u>		
3 hrs.	95	195	225	9 hrs. 30 m.	11 hrs. 50 m.
	130	190	250		
	90	155	220		
	105	200	255		
	<u>105</u>	<u>155</u>	<u>250</u>		
4 hrs.	145	200	200	9 hrs. 30 m.	12 hrs. 10 m.
	100	195	230		
	120	200	190		
	100	225	205		
	<u>116</u>	<u>205</u>	<u>206</u>		
5 hrs.	120	190	250	9 hrs. 30 m.	12 hrs. 10 m.
	110	200	230		
	120	190	215		
	80	190	250		
	<u>105</u>	<u>190</u>	<u>251</u>		

TEST OF PORTLAND CEMENT.

Plasticity - - - - - 22.5% water

Time of setting

Initial - - - - - 3 hrs. 30 m.

Final - - - - - 5 hrs. 10 m.

Specific Gravity.

Dry Cement (Le Chatelier flask) - - - - - 3.20

Fineness

Residue on No. 200 sieve - - - - - 27.6%

Residue on No. 100 sieve - - - - - 9.7%

Percent of Water for Mortars.

1:2 Mortar - - - - - 11.5%

1:3 Mortar - - - - - 9.1%

1:4 - - - - - 9.0%

Soundness Tests

Accelerated, air and water tests -

No cracks or disintegration.

Tensile Strength (net).

7 ds.	28 ds.	60 ds.
585	680	680
545	845	690
550	850	690
555	690	680
<u>554</u>	<u>811</u>	<u>685</u>

NEW A-100A 00-200

1:2 Torbar.

Hours before rearing	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	280	430	465	3 hrs. 35 m.	5 hrs.
	270	440	430		
	235	420	470		
	285	465	435		
	<u>208</u>	<u>459</u>	<u>490</u>		
1 hr.	310	475	505	4 hrs. 25 m.	4 hrs. 50 m.
	345	490	410		
	325	450	450		
	330	450	440		
	<u>345</u>	<u>466</u>	<u>451</u>		
2 hrs.	310	450	435	5 hrs.	6 hrs. 30 m.
	370	470	400		
	300	410	400		
	310	390	370		
	<u>310</u>	<u>393</u>	<u>451</u>		
3 hrs.	275	385	490	6 hrs. 30 m.	7 hrs. 15 m.
	265	420	410		
	290	415	430		
	340	---	410		
	<u>290</u>	<u>407</u>	<u>455</u>		
4 hrs.	255	420	370	4 hrs. 50 m.	7 hrs. 40 m.
	250	410	390		
	320	405	365		
	290	385	420		
	<u>279</u>	<u>405</u>	<u>386</u>		
5 hrs.	320	270	340	6 hrs. 35 m.	7 hrs. 15 m.
	225	375	330		
	195	365	350		
	200	---	390		
	<u>235</u>	<u>370</u>	<u>352</u>		

NEW ASTM METHOD

1:3 Mortar.

Hours before removing	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	200	270	295	3 hrs. 50 m.	6 hrs. 20 m.
	195	275	310		
	200	245	295		
	185	280	260		
	<u>195</u>	<u>270</u>	<u>290</u>		
1 hr.	200	295	290	4 hrs. 20 m.	7 hrs.
	210	305	310		
	235	280	310		
	210	280	330		
	<u>214</u>	<u>278</u>	<u>310</u>		
2 hrs.	190	290	240	5 hrs. 20 m.	7 hrs. 20 m.
	190	260	270		
	165	275	280		
	170	285	290		
	<u>171</u>	<u>270</u>	<u>263</u>		
3 hrs.	195	310	330	6 hrs.	8 hrs.
	205	310	285		
	185	285	320		
	185	300	300		
	<u>185</u>	<u>286</u>	<u>309</u>		
4 hrs.	200	285	295	6 hrs. 20 m.	8 hrs. 20 m.
	160	290	295		
	185	195	315		
	145	255	300		
	<u>175</u>	<u>251</u>	<u>251</u>		
5 hrs.	180	200	290	6 hrs. 50 m.	8 hrs. 10 m.
	180	235	235		
	155	195	180		
	125	210	190		
	<u>154</u>	<u>210</u>	<u>214</u>		

NEO-ASTMA CEMENT

1:4 Mortar.

Hours before removing	Tensile Strength			Time of setting	
	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	110	220	235	2 hrs. 35 m.	5 hrs. 50 m.
	145	240	225		
	150	215	240		
	125	235	220		
	<u>135</u>	<u>228</u>	<u>230</u>		
1 hr.	140	250	250	5 hrs. 30 m.	7 hrs.
	185	210	240		
	140	195	230		
	130	280	215		
	<u>149</u>	<u>234</u>	<u>234</u>		
2 hrs.	125	190	150	4 hrs. 50 m.	7 hrs.
	120	170	220		
	120	170	190		
	135	---	225		
	<u>123</u>	<u>177</u>	<u>206</u>		
3 hrs.	130	195	235	6 hrs. 50 m.	7 hrs. 25 m.
	150	175	275		
	120	190	240		
	135	190	225		
	<u>134</u>	<u>186</u>	<u>249</u>		
4 hrs.	85	155	150	7 hrs. 10 m.	8 hrs. 50 m.
	105	160	190		
	95	150	200		
	70	170	140		
	<u>89</u>	<u>159</u>	<u>180</u>		
5 hrs.	100	135	190	7 hrs. 40 m.	8 hrs. 50 m.
	85	125	190		
	105	145	185		
	70	165	185		
	<u>90</u>	<u>145</u>	<u>185</u>		

TEST of PORTLAND CEMENT.

Plasticity - - - - - 2 1/2 water

Time of setting

Initial - - - - - 4 hrs. 30 m.

Final - - - - - 6 hrs. 45 m.

Specific Gravity

Dry cement (Le Chatelier flask) - - - - - 3.15

Fineness

Residue on No. 200 sieve - - - - - 17.8%

Residue on No. 100 sieve - - - - - 2.4%

Percent of Water for Mortars

1:2 Mortar - - - - - 11.0%

1:3 Mortar - - - - - 9.7%

1:4 Mortar - - - - - 9.3%

Soundness Tests

Accelerated, air and water tests -

No cracks or disintegrations.

Tensile Strength (net).

7 da.	28 da.	60 da.
650	570	650
665	560	435
555	600	560
555	600	510
<u>606</u>	<u>585</u>	<u>541</u>

1:2 Fortar.

Tentacle Strength				Time of setting	
Hours before removing	7 da.	28 da.	60 da.	Initial	Final
0 hrs.	360	440	420	1 hr.	35 m. 3 hrs.
	360	495	520		
	440	425	500		
	315	470	485		
	<u>305</u>	<u>475</u>	<u>431</u>		
1 hr.	360	430	400	2 hrs.	30 m. 3 hrs. 25 m.
	370	465	470		
	310	480	460		
	360	420	500		
	<u>315</u>	<u>445</u>	<u>437</u>		
2 hrs.	280	355	400	3 hrs.	3 hrs. 10 m.
	275	420	460		
	315	360	455		
	310	395	365		
	<u>295</u>	<u>375</u>	<u>403</u>		
3 hrs.	310	455	420	4 hrs.	20 m. 4 hrs. 55 m.
	375	430	515		
	300	460	535		
	350	410	455		
	<u>325</u>	<u>455</u>	<u>495</u>		
4 hrs.	285	290	400	4 hrs. 40 m.	5 hrs. 20 m.
	280	320	370		
	260	365	325		
	275	385	345		
	<u>275</u>	<u>385</u>	<u>350</u>		
5 hrs.	205	310	350	5 hrs. 30 m.	5 hrs. 55 m.
	240	285	340		
	230	300	290		
	255	320	355		
	<u>235</u>	<u>305</u>	<u>311</u>		

PORTLAND CEMENT

1:3 Mortar.

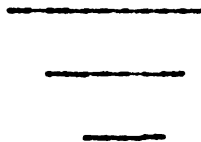
Hours before testing	Tensile Strength			Time of setting	
	7 ds.	28 ds.	60 ds.	Initial	Final
0 hrs.	230	320	368	2 hrs. 45 m.	4 hrs. 15 m.
	235	390	315		
	240	340	320		
	255	310	350		
	<u>243</u>	<u>340</u>	<u>345</u>		
1 hr.	270	380	340	3 hrs. 20 m.	4 hrs. 40 m.
	230	315	310		
	250	400	355		
	250	350	310		
	<u>250</u>	<u>355</u>	<u>324</u>		
2 hrs.	225	310	300	4 hrs. 10 m.	5 hrs. 25 m.
	225	350	340		
	225	375	300		
	220	315	310		
	<u>224</u>	<u>345</u>	<u>315</u>		
3 hrs.	245	320	355	4 hrs. 30 m.	5 hrs. 50 m.
	270	320	315		
	225	310	360		
	220	340	305		
	<u>240</u>	<u>330</u>	<u>331</u>		
4 hrs.	190	250	305	5 hrs. 20 m.	6 hrs. 40 m.
	200	290	290		
	215	290	210		
	225	290	315		
	<u>208</u>	<u>280</u>	<u>300</u>		
5 hrs.	140	255	240	6 hrs. 15 m.	7 hrs. 35 m.
	175	250	255		
	200	260	260		
	140	230	240		
	<u>164</u>	<u>245</u>	<u>255</u>		

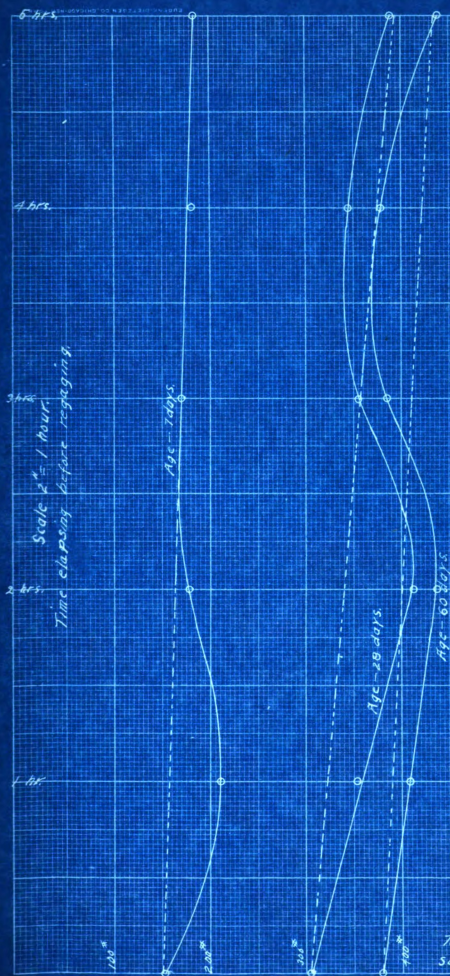
PRELIMINARY REPORT

1:4 Mortar.

Hours before regaining	Tensile Strength			Time of setting	
	7 da.	38 "	60 "	Initial	Final
0 hrs.	310	265	310	4 hrs. 45 m.	6 hrs. 30 m.
	190	205	280		
	200	230	270		
	170	220	260		
	<u>195</u>	<u>235</u>	<u>285</u>		
1 hr.	190	255	275	5 hrs. 15 "	6 hrs. 45 m.
	185	300	300		
	215	270	270		
	185	240	295		
	<u>194</u>	<u>270</u>	<u>285</u>		
2 hrs.	180	270	270	6 hrs. 40 m.	7 hrs. 5 m.
	170	270	270		
	195	270	270		
	215	270	300		
	<u>205</u>	<u>280</u>	<u>27</u>		
3 hrs.	180	270	270	7 hrs.	8 hrs. 30 m.
	160	255	270		
	140	230	250		
	180	240	260		
	<u>160</u>	<u>240</u>	<u>260</u>		
4 hrs.	180	270	270	8 hrs. 5 m.	9 hrs.
	205	260	270		
	175	230	260		
	180	27	265		
	<u>175</u>	<u>235</u>	<u>271</u>		
5 hrs.	240	240	240	8 hrs. 15 "	9 hrs. 10 m.
	195	240	240		
	215	200	230		
	180	210	245		
	<u>203</u>	<u>235</u>	<u>238</u>		

Curves showing relationship of
Tensile strength and time elapsing before
Regaging.



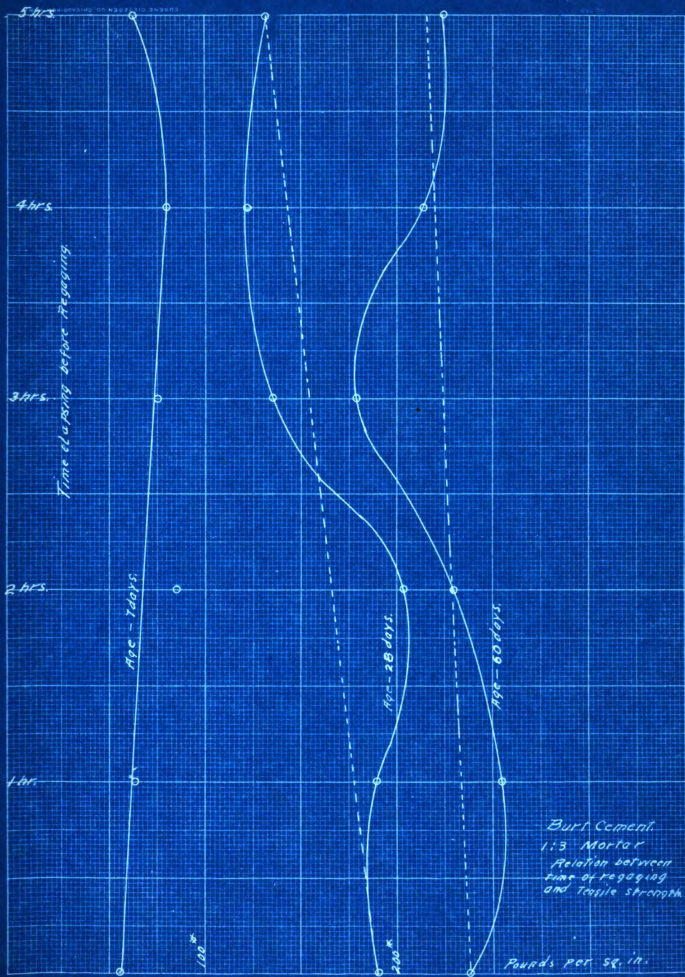


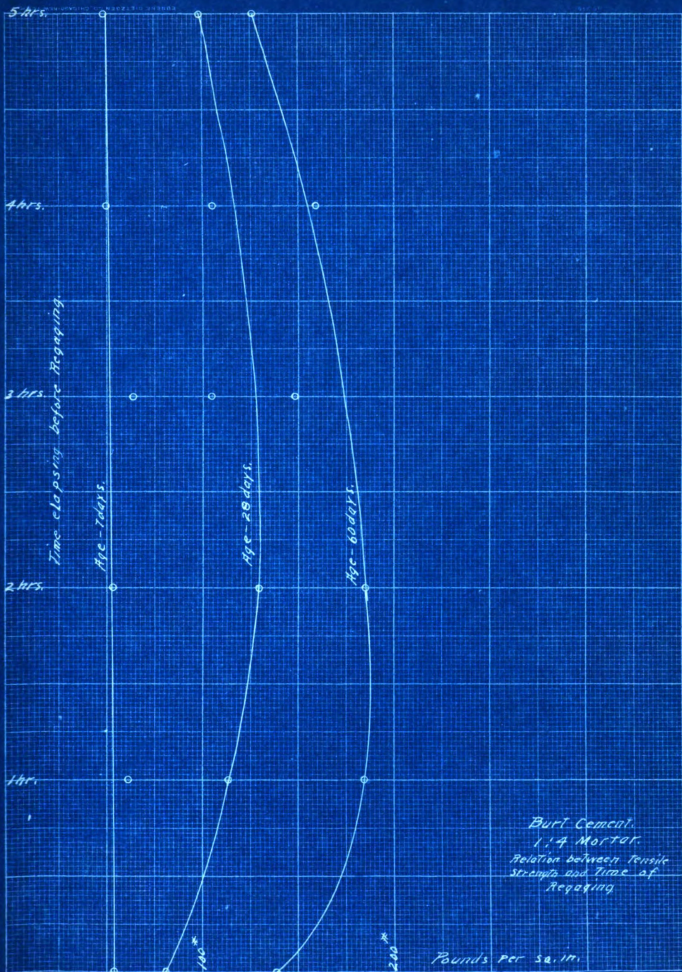
Burt Cement

1:2 Mortar.

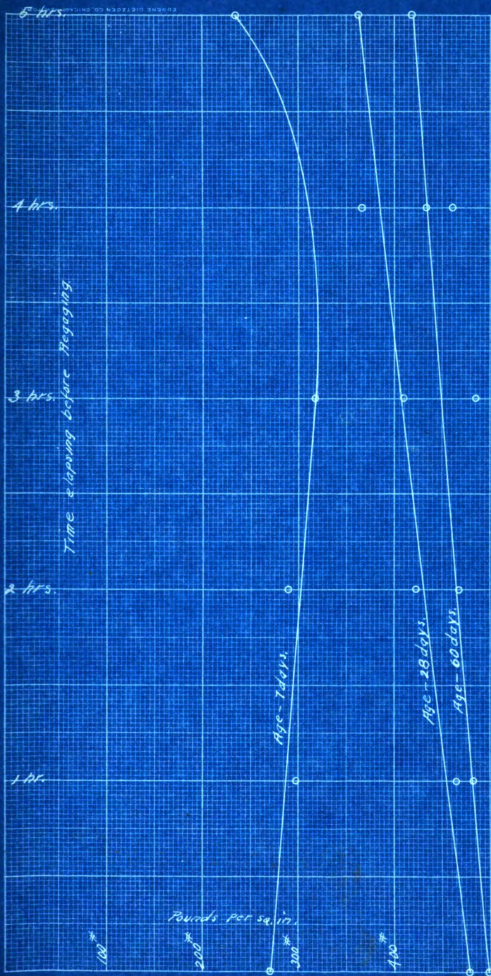
Relation between
tensile strength and
time of regaging.

Tensile strength.
Scale $\frac{1}{4}'' = 100$ lbs/sq. in.





Burt Cement.
1:4 Mortar.
Relation between Tensile
Strength and Time of
Regaging.



Peerless Cement.
7 1/2" Mortar.
Relation between
tensile strength
and time of
Regaging.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before Regaging.

Age = 7 days

Age = 28 days

Age = 60 days

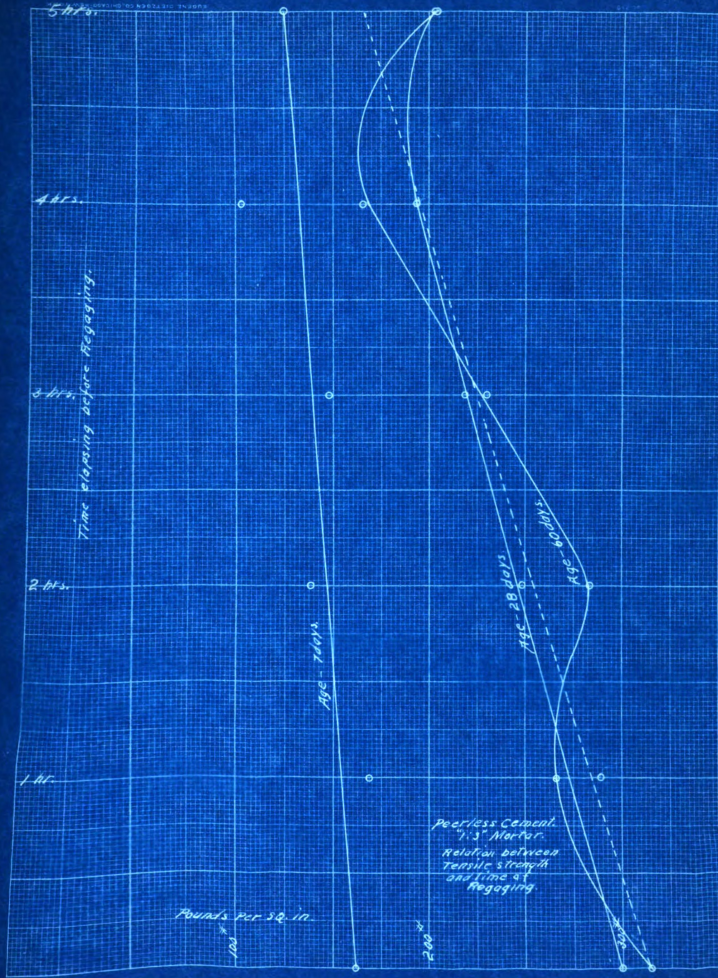
Pearless Cement.
"1:3" Mortar.
Relation between
Tensile strength
and time of
Regaging.

Pounds per sq. in.

100

200

300



5 hrs.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before Regaging

Age - 7 days

Age - 28 days

Age - 60 days

100 %

200 %

Peerless Cement
 1/4" Mortar.
 Relation between
 tensile strength
 and time of
 Regaging.

Pounds Per Sq. in.

5 hrs.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before Regaging

Age - 7 days

Age - 28 days

Age - 60 days

Universal Cement,
1:2 Mortar.
Relation between
Tensile strength
and time of
Regaging

Pounds Per Sq. In.

100

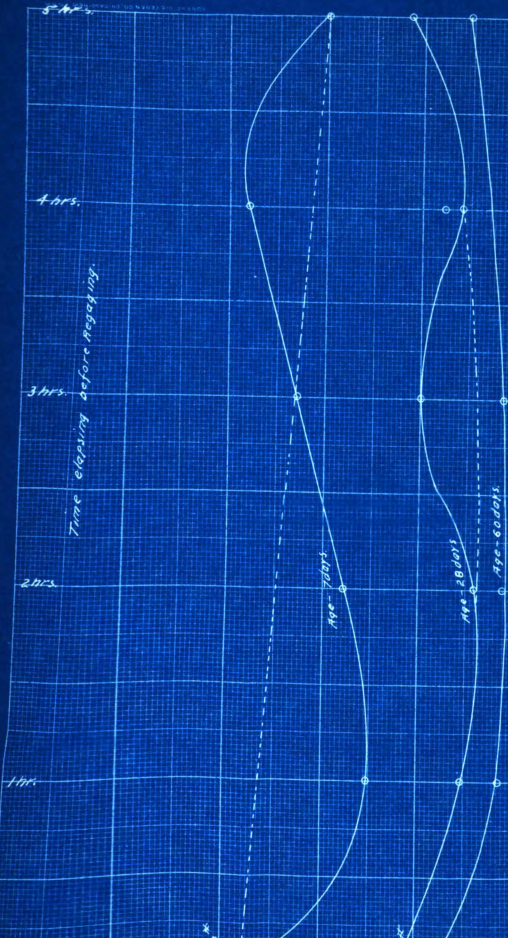
200

300

400



Universal Cement.
1:3 Mortar.
Relation between
Tensile strength and
Time of Regaging.



University of Cement.
7.4" Mortar.
Relation between
Tensile Strength
and Time of
Regaging.

5 hrs.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before Regaging

Age - 7 days

Age - 28 days

Age - 60 days

Omega Cement
 1/2" Mortar,
 Relation between
 Tensile strength
 and time of
 Regaging

Pounds per sq. in.

100

200

300

400

500

600

5 hrs.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before testing.

Age - 1 days

Age - 28 days

Age - 60 days

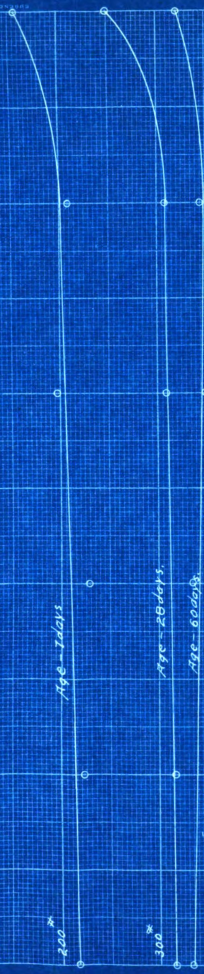
100

200

300

Pounds per sq. in.

Omega Cement
1:3 Mortar.
Relation between
Tensile strength
and time of
aging.



5 hrs.

4 hrs.

3 hrs.

2 hrs.

1 hr.

Time elapsing before Regaging

Age - 7 days

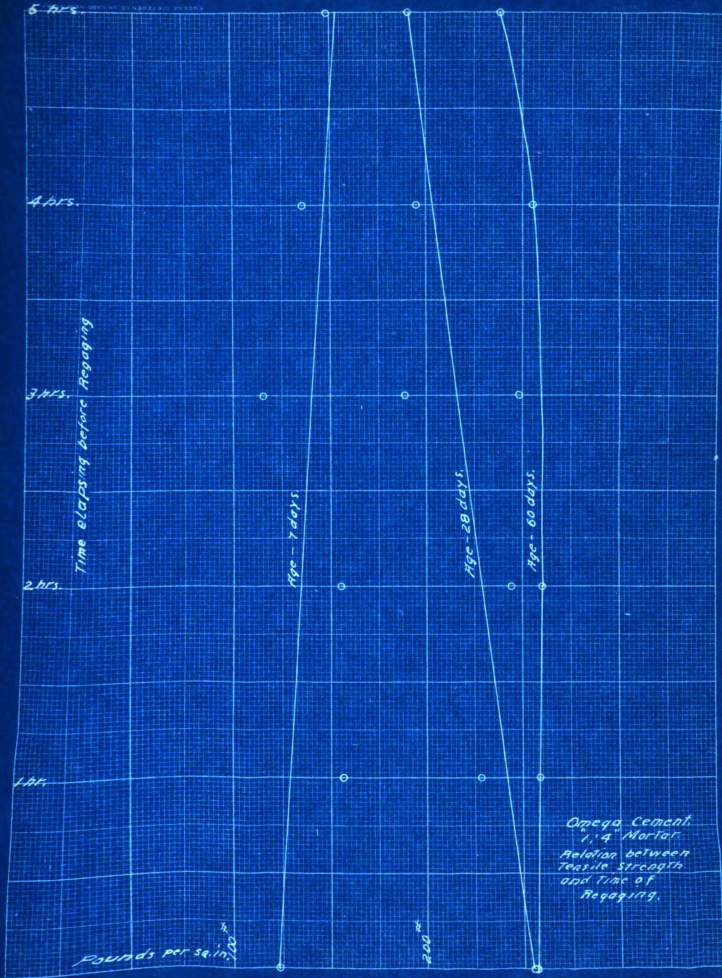
Age - 28 days

Age - 60 days

Pounds per sq. in. $\frac{1}{100}$

200

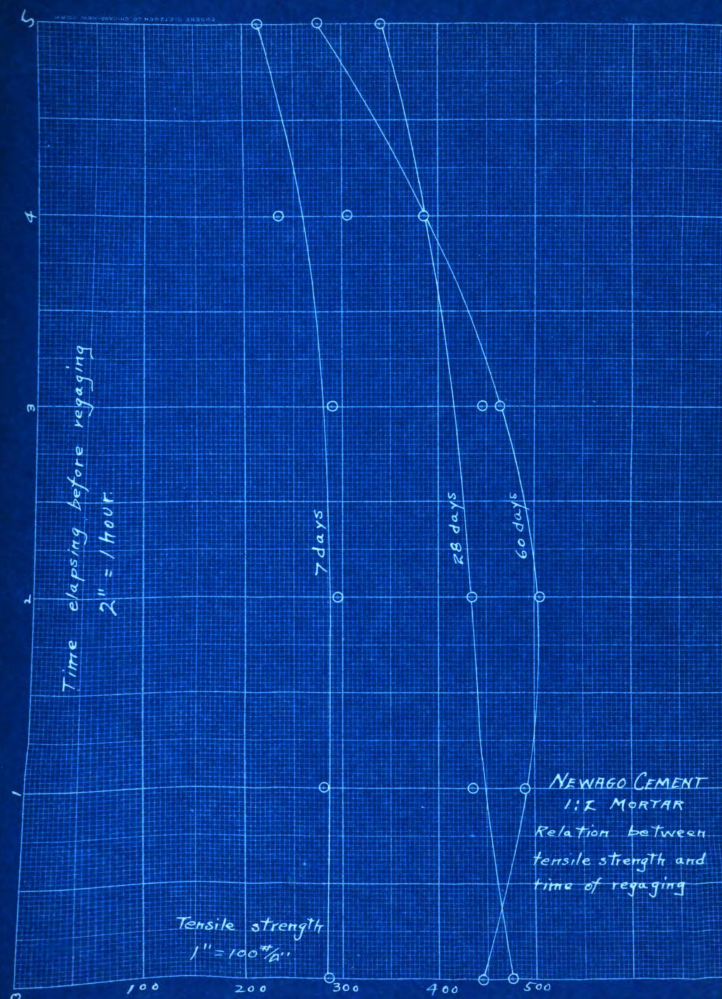
Omega Cement.
1:4 Mortar.
Relation between
Tensile Strength
and Time of
Regaging.



Time elapsing before regaging
 2" = 1 hour.

Tensile strength
 1" = 100 $\frac{lb}{in^2}$

NEWAGO CEMENT
 1:2 MORTAR
 Relation between
 tensile strength and
 time of regaging



Time elapsing before regaging
 $2'' = 1 \text{ hour}$

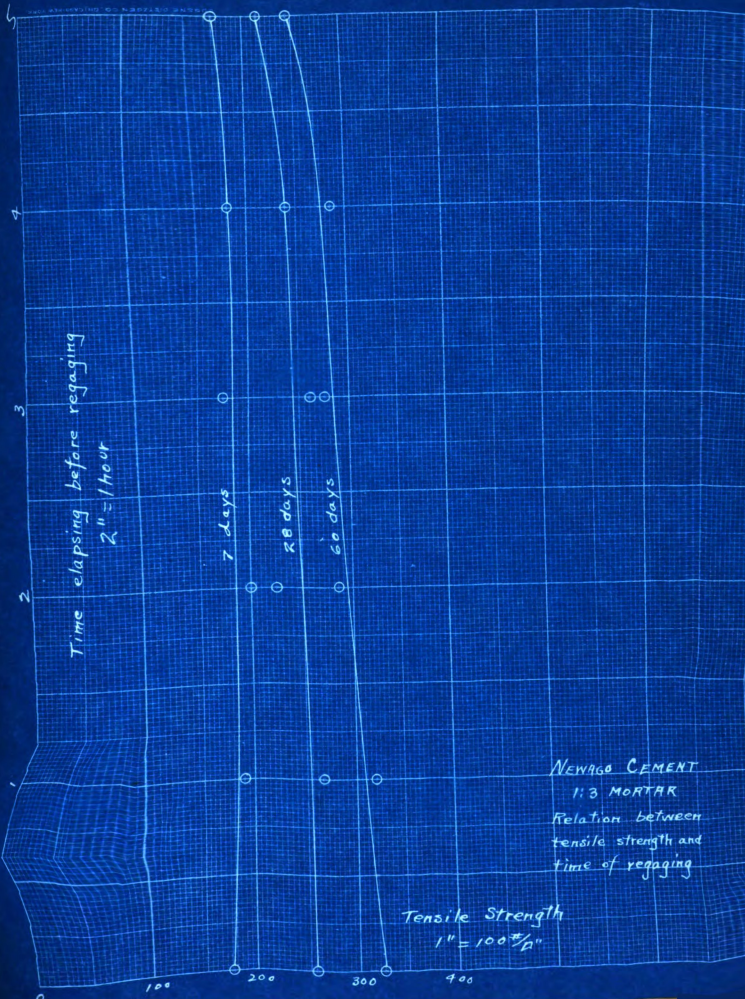
7 days

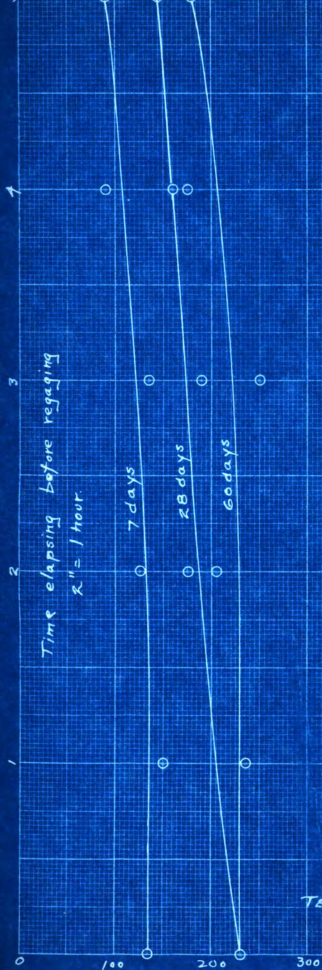
28 days

60 days

NEWAGO CEMENT
1:3 MORTAR
Relation between
tensile strength and
time of regaging

Tensile Strength
 $1'' = 100 \frac{\text{kg}}{\text{cm}^2}$





NEW AETNA CEMENT

1:4 MORTAR

Relation between
tensile strength and
time of regaging

Time elapsing before regaging

$2'' = 1 \text{ hour}$

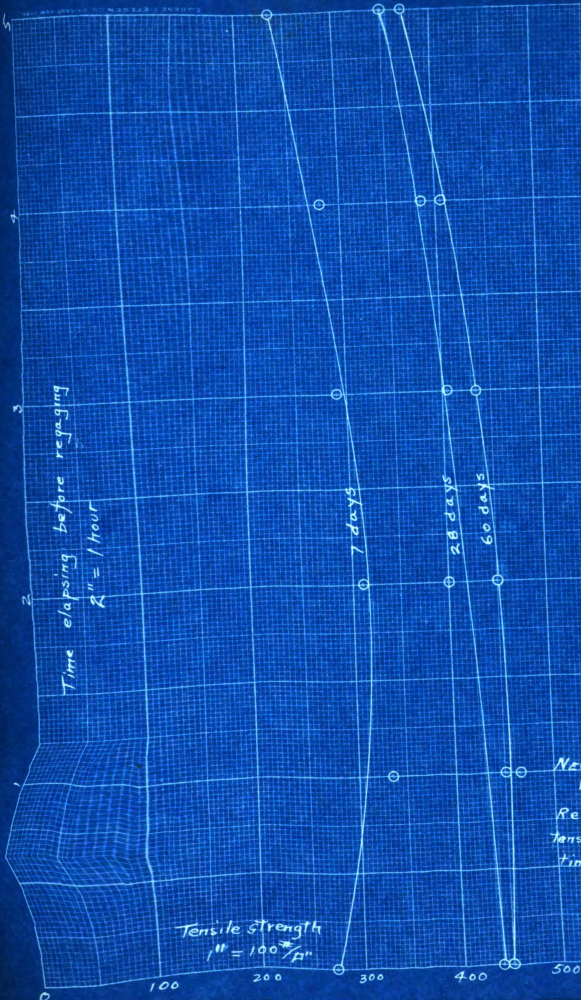
1 days

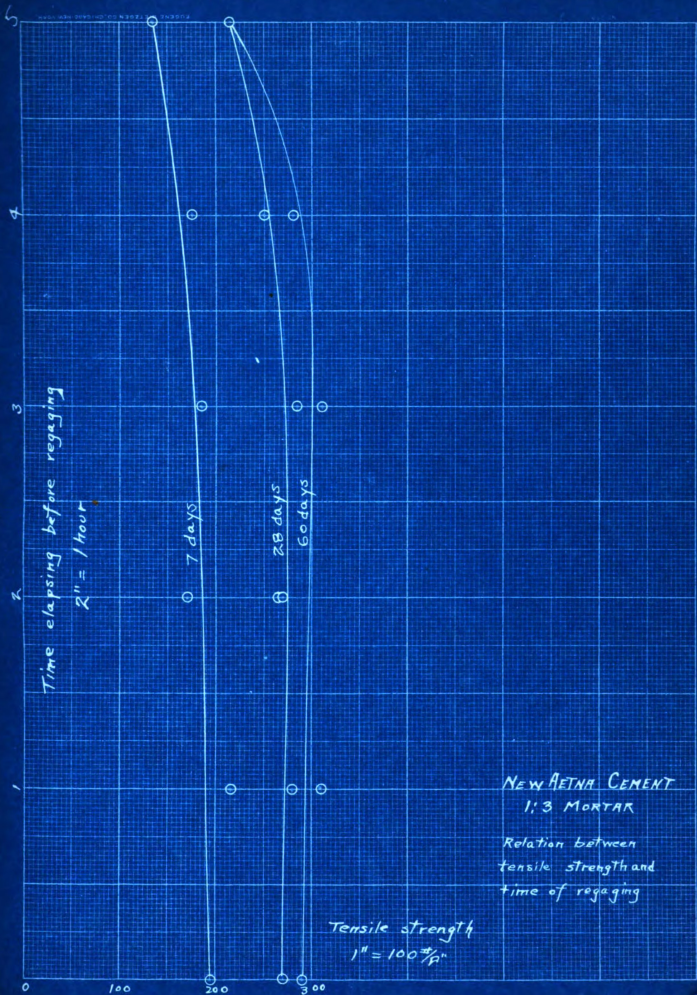
28 days

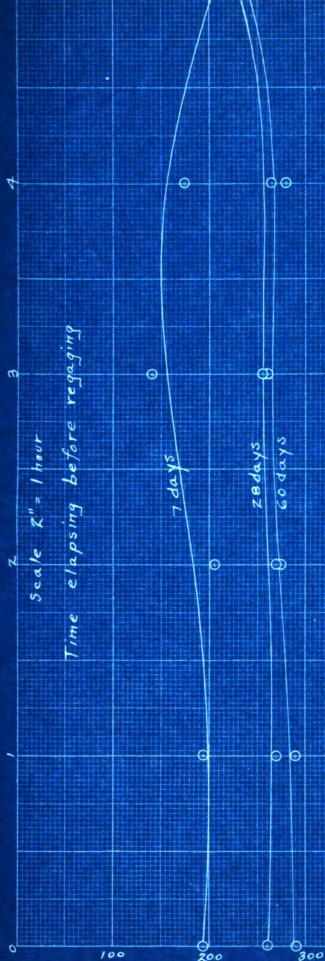
60 days

Tensile strength
 $1'' = 100 \frac{\text{lb}}{\text{in}^2}$

NEW AETNA CEMENT
1:2 MORTAR
Relation between
tensile strength and
time of regaging







PENINSULAR CEMENT

1:4 Mortar

Relation between
tensile strength and
time of regaging

At first thought it may seem that each one of the above cement mortars deserves a separate discussion and conclusion, and this would be true were we making relative tests of the different cements. However, that is what we are not doing, but instead striving to investigate Portland cement mortars in general. Consequently we must make certain assumptions which ~~must~~ are only approximate, for example, we assume that all Portland cements show the same general characteristics. The tests of the above seven brands, so far bear us out in this assumption.

The result of the tensile tests when plotted with the hours elapsing before reaching, give as a rule either straight lines or slightly decreasing curves. It might logically be expected that at least when the reworking was done before the initial set had begun, an increase in strength would result due to the more thorough mixing. Such was generally the case, however, as a rule the reworked mortars show a slight decrease in strength. This is contrary to many authorities, but the procedure used by them was in all probability different than the one here used.

As stated in the discussion, we used no water in reworking, and this would naturally tend to have some effect on the briquettes. After being allowed to set for some time a portion of the water has been taken up chemically and the mortar becomes dryer. It is at least less plastic when reworked after five hours than the fresh mixture. Hence with the same amount of pressure applied while making the briquettes, the mortar is less compact. The briquettes would then naturally break at a lower value than the fresh mixture, other things being constant. In this way at least some of

the decrease in strength is accounted for.

Considering that the decrease in strength was only slight, and that this could probably be eliminated by the addition of water upon reworking, it seems safe to state that for practical work reworking is in no way detrimental.

Upon examining the values of the times of setting, it will be noticed that fifteen of the twenty-one mixtures show a marked increase in the time required, ten vary only by small amounts and the remaining mixtures show a decrease. Even in the cases where the four and five hour readings show a decrease in the time of setting, the one, two and three hour readings show a very marked increase in the time required.

Examining the values as a whole there is no doubt but that reworking somewhat greatly increases the time required for both the initial and final set.

It also seems evident from the curves and results, that the general effect of reworking seems independent of both the time of initial setting of the cement, and the ratio of cement to sand.

BIBLIOGRAPHY.

Concrete, Plain and Reinforced - Taylor and Thompson . p 157.

Cements, Mortars and Concretes - Fink p 16, table III.

Cement and Concrete - Sabin p 210.

Owing to the fact that there never has been done much work along this line the material gathered is somewhat limited.

While all of the above agrees as to the increase of time of setting, they are a little varied as to the effect on the strength. The first reference says the strength is not lowered after two hours standing after mixing and that continuous grinding increases strength. Fink's table shows a decrease in strength for successive readings. Sabin says that some mortars develop a higher tensile strength by moderate re-mixing. But these references where the strength increases and many others like them refer only to continuous grinding and so it is quite a different problem from re-mixing for only one or a half minutes after the interval of 1, 2, 3, 4 or 5 hours.

A P P E N D I X.

It would probably be best to give here, some idea of the hardness and condition of the mortars before they were removed.

In some of the mixtures even after the mortar had been allowed to set for five hours it could be crumbled easily with the fingers. In other cases the mortar was quite hard, the most notable case being in the "1:2" mortar of Universal cement. Extract from Laboratory note-book referring to above mortar.

"After standing for three hours the mortar became quite hard, but not particularly difficult to break up with the hands. However, after standing five hours the mortar was so hard that a trowel could be forced through it only by considerable pressure."

It is interesting to note that even under these extreme conditions the tensile strength was practically the same as that of the fresh mortar, and the time of setting only slightly increased.

Although the results aimed at were only relative and the different mortars used solely to make the investigation more general, it is certainly not out of place to remark on the relative times of setting of the different mixtures. Without exception the time of setting of the "1:3" mortar was longer than that of the "1:2", and also the "1:4" mixture required a longer time to set than did the "1:3". Considering the fact that in the weaker mortar strength depends more on adhesion and less on cohesion, this appears perfectly reasonable.

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03178 6019