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PREPACT INTRUSION GROUT INVESTIGATION
REQUESTED BY THE ST. LAWRENCE SEAWAY AUTHORITY

by

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PREPACT INTRUSION GROUT INVESTIGATION

This work was requested by the St. Lawrence Seaway Authority as an investigation on the effect of change in the water-cement ratio on the ultimate strength properties of the Intrusion Grout mixtures.

A special portland cement INTRUSION GROUT was designed and patented by the Prepack Concrete Co. to fill the voids of prepack coarse aggregates and produce a high strength monolithic concrete.

1. Desired properties of a portland cement pressure grout.

The basic properties of grout which determine its suitability for penetration and filling the voids under pressure are:

- (1) Optimum mobility through small channels with the minimum of frictional resistance.
- (2) Ability to retain substantially the same degree of mobility when flowing slowly or at rest.
- (3) Ability to maintain its solids in suspension without appreciable settlement and water gain until the grout has set.
- (4) Ability to harden without appreciable shrinkage and having a good bond with the surrounding material.
- (5) To provide a strength of grout comparable to that of normal concrete using same w/c ratio.

2. Composition of Intrusion Grout Mixture.

In addition to portland cement, sand and water, the intrusion grout mixture contains a filler - Alfesil and Intrusion Aid.

Alfesil is finely divided siliceous material having the pozzolanic properties of combining with the free lime to contribute water tightness and a long-continued gain in strength to the grout.

Intrusion Aid is a patented surface-active agent, which acts as a grout thinner, set retarder, cement disperser and expander, thus neutralizing the effect of the setting shrinkage common in all cement grouts.

The sand, used in the Intrusion Grout mixes, is finer than that employed in ordinary concrete mixtures. Substantially all of the sand must pass No. 16 mesh sieve and the fineness modulus of the sand has to be 2.0 or less.

3. Mix Proportions.

The following proportions of materials were used in the grout mixtures under consideration.

3 bags of cement	-	262.5 lbs
1 bag Alfesil	-	70.0 lbs
1 pkg Intrusion Aid	-	2.6 lbs (1% of cement)

The amount of sand to be added to the grout, expressed in proportion by weight to cement, depends upon the desired ultimate strength of the grout, its w/c ratio, and the fineness of the sand.

The consistency of the grout must be that of a thick cream - thick enough to prevent the settlement of the sand and cement grains from the mixture and thin enough to allow the grout to be pumped through pipes. During grouting operations it is frequently necessary to change the consistency of the grout in the mixer, pump or supply line by the addition of either water or sand and cement.

Amounts of water considered by the Seaway Authority for use in the Intrusion Grout mixtures per 3 bags of cement expressed in terms of water-cement ratios by weight and by loose volume (1 c.ft. water/1 c.ft. cement) are as follows:

<u>Water</u>	<u>W/C Ratio</u>	
	<u>by weight</u>	<u>loose volume</u>
18 Imper. gals.	0.68	1.0
20 " "	0.76	1.1
22 " "	0.84	1.2
30 " "	1.14	1.6

4. Effect of W/C ratio on Strength of Grouts.

To investigate the effect of change in the water-cement ratio (W/C) on the strength properties of grouts, the following procedure was worked out.

Intrusion Grout mixes were designed, calculating from the desired proportions based on batches of 1 lb (454 gm) of cement and four different W/C ratios. One mix was made for comparison purposes without admixtures.

The compressive strength tests of these grouts were made using mortars designed with a fixed amount of standard graded Ottawa silica sand (4 lbs or 1816 gm). In this manner the effect of variable amounts of sand in the mixtures was eliminated. Identical volumes (509 cc) of each grout were mixed with the sand, producing constant volumes of mortar (1194 cc). Three 2-in. test cubes were molded from each batch and tested at 7 and 28-d. age.

The mix proportions and test results are shown in the following tabulation.

INTRUSION GROUT MIXES - TEST RESULTS

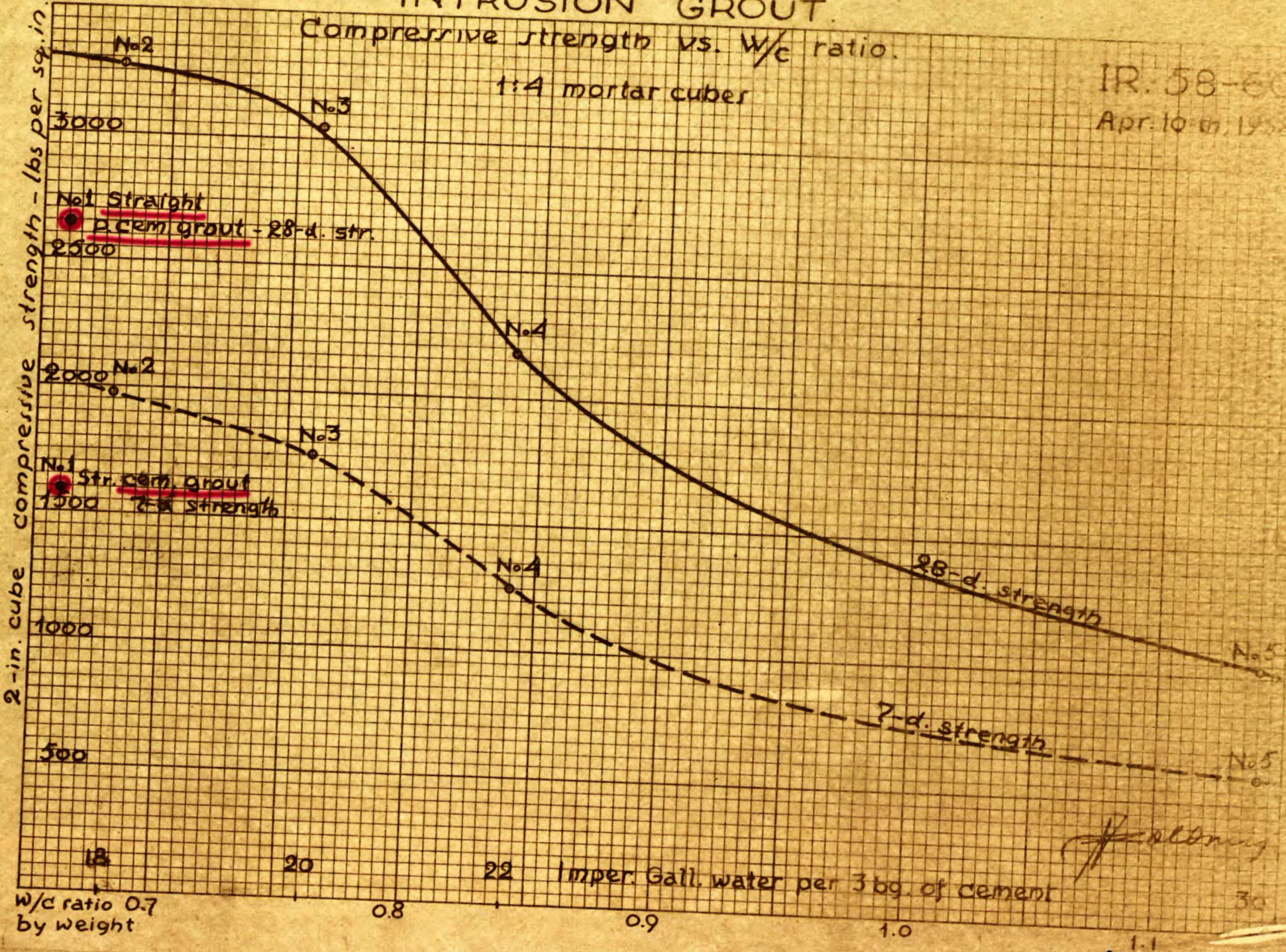
Mix No.	W/C By wt. By vol.	Cement gm	Sand gm.	Water gm.	Alfesil Intr.Aid gm.	Batch Total		Cement lb/c.ft lb/c.yd	Compr.Strength			Remarks
						By wt. gm.	By vol. cc		7-d.	%	28-d.	
GR 1	0.66	454	1816	300	N11 N11	2570	1129	25.0 675	1600	60	2650	Straight cement grout-no admixt. Flow table test -75%
2	0.68 1.00	454	1816	311½	121 4.5	2707	1194	23.7 640	1975	60	3275	Flow table test -150%
3	0.76 1.1	427	1816	325	114 4.3	2686	1194	22.3 602	1750	57	3050	Flow too great, cannot be measured.
4	0.84 1.2	400	1816	335	106 4.0	2661	1194	20.8 562	1250	57	2175	ditto
5	1.14 1.6	322	1816	368	86 3.2	2595	1194	16.8 454	600	58	1025	ditto

Note: Only the test cubes from the first six were hard enough at 24 h time to be taken out of the molds. All other mixes were too soft and were taken out only 48 hours after molding.

INTRUSION GROUT.

Compressive strength vs. W/c ratio.
1:4 mortar cubes

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The comparable compressive strength data on mortar cubes shows only one of the advantages, the strength gain, obtained by using intrusion grout rather than straight portland cement grout with the same cement factor and nearly the same w/c ratio. In addition to the 26% increase in the 28-d strength, intrusion grout has a mobility of about double that of a straight cement grout, as measured on the flow table.

Plotting compressive strength test results of intrusion grout mortar cubes against the w/c ratio, we have obtained a graph, which shows the effect of addition of water on the strength of the grout.

Higher strength results could be obtained by using higher cement factors in the mixes.

Conclusion

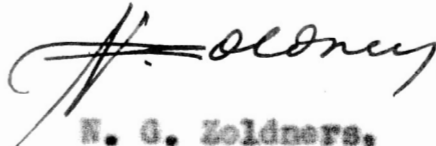
Properties desired from a grout mixture vary from job to job, and from one moment to another in grouting the same hole. Evaluation of the suitability of a grout mixture for a definite purpose, and the determination of the proper amount of water to be used, can only be made in the field.

Our investigation has covered only one of the five key properties of a grout mixture mentioned in paragraph 1 of this paper - (5) Ultimate strength of the hardened grout.

From our tests we found that the same rule pertaining to w/c ratio in concrete mixes, applies as well to the portland

cement grouts - by increasing the w/c ratio we are decreasing the strength of the hardened cement grout.

By the use of Alfesil and Intrusion Aid in prescribed amounts, the desired properties of the portland cement grouts can be improved without increasing the w/c ratio.


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