Effect of Temperature on the Gelling Time of Acrylamide Grout

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Abstract: In this study, acrylamide-based chemical grouts were investigated with different amounts of accelerator and initiator. Gelling time of the chemical grouts was studied at different initial temperatures. The internal temperature changes in the gelling grout were monitored during and after the gelling process. A multivariable relationship was developed to predict the gelling time based on the amount of catalysts and initial temperature.

1. Introduction

Acrylamide (the chemical formula C_3H_5NO) grout is a mixture of organic monomers, which can be polymerized at ambient temperatures, with a controllable gelling time from a few seconds to several hours based on the amount of catalysts added. The change from liquid to solid phase is almost instantaneous for the shorter gel times. Basic characteristics of acrylamide grouts are described in ASTM F 2304-03 (Standard practice for rehabilitation of sewers using chemical grouting) [1, 2].

Acrylamide grouts at ambient temperatures are catalyzed with a two-component redox system, and one part (the initiator or catalyst) can be a peroxide or a persalt. Ammonium persulfate (AP), a powder, is most commonly used. The second part (the accelerator or activator) is an organic such as triethanolamine (TEA), nitrilotrispropionamide (NTP), or dimethylaminiopropionitrile (DMAPN). Gel time is independent of monomer concentration but directly dependent on the temperature and concentration of the catalyst, activator and inhibitor [1].

2. Objectives

The overall objective of this study was to establish a relationship between the gelling time of acrylamide grouts with initial mix temperature and catalyst content.

3. Materials and methods

Commercially available AV-100 Powder Blend and AV-118 Duriflex were used as acrylamide based grouts. The acrylamine resins were polymerized by adding ammonium persulfate($(NH_4)_2S_2O_8$) or sodium persulfate ($Na_2S_2O_8$) as a catalyst and triethanolamine ($C_6H_{15}NO_3$) as an activator.

TANK A	TANK B
10% AV-100 Powder Blend Grout or 25% AV-118 Duriflex Grout + 0.5-3% AV-101 Activator + Water to complete 50% solution	0.5-3% AV-102 Catalyst AP or 0.5-3% AV-103 Catalyst SP + Water to complete 50% solution

Fig 1: Compositions of the grout mixes

For both acrylamide-based grouts, effects of catalyst and activator proportions between 0.5%-3% were studied at different temperatures; 40°F, 60°F and 80°F. As shown in Fig. 1, two different solutions were prepared to catalize the acrylamide-based grouts. In the first tank (Tank A), 10% by weight of the total mixture AV-100 or 25% by weight AV-118 was added and AV-101 was used as activator with varied proportions (0.5%-3%) for both acrylamide based grouts. Then, the tank was completed to 50% of the total mixture by adding water. In the second tank (Tank B); AV-102 Catalyst AP for AV-100 grout or AV-103 Catalyst SP for AV-118 grout was mixed with water as per its proportion (0.5%-3%) to prepare an equal amount of solution as Tank A. Then, the two tanks were mixed at a predetermined temperature to observe gelling time, and a thermocouple was used to monitor the internal temperature of the mixture during gelling.

4. Analysis and Discussions

Gelling times (GT) for both grouts at three different initial temperatures (40°F, 60°F, 80°F) with varied proportions (0.5%-3%) of catalyst (Cat) and activator (Act) were studied. The temperature (Temp) change with time for AV-100 acrylamide grout at three different initial temperatures are shown in Fig. 2. Maximum temperature changes for the three initial temperatures were all very close 53°F.

$$GT = k * [Act]^{-a} * [Cat]^{-b} * [Temp]^{-c};\ a, b, c, k \text{ are constants} \qquad (1)$$

In order to analyze the data, the above formula was derived to correlate gelling time to catalyst and activator proportions, and temperature. The predicted values by using the formula (Eqn. 1) were compared with the experimental data in Fig. 3.

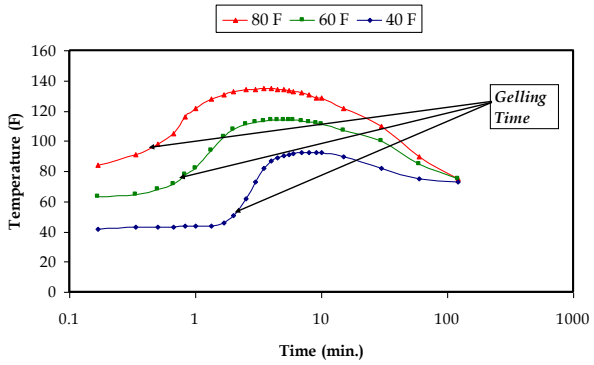

Fig 2: Temperature change during the gelling process (AV-100, 1% AV-101 activator and 1%AP catalyst)

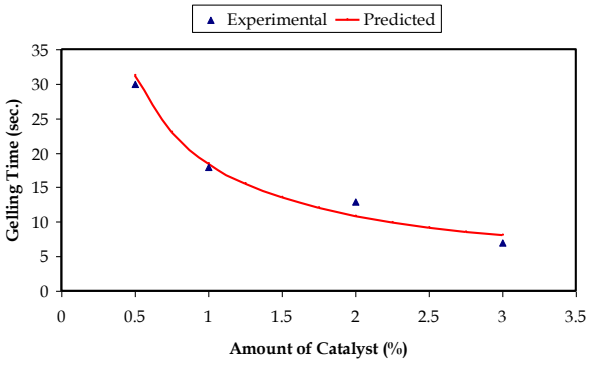

Fig 3: Comparison of the formula with experimental data (AV-118, 3% AV-101 @ 60°F)

5. Conclusions

Gelling times for AV-100 and AV- 118 acrylamide-based chemical grouts were studied at three different temperatures (40°F, 60°F, 80°F) with varied catalyst and activator proportions (0.5%-3%). AV-118 exhibited lesser temperature increase than AV-100 during gelling process. The derived relationship predicted the gelling time very close to experimental data.

6 Acknowledgements

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7 References

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2-ASTM F 2304-03. "Standard Practice for Rehabilitation of Sewers Using Chemical Grouting." Annual Book of ASTM Standards. Vol. 04.12. 2007, pp. 1569-1576, West Conshohocken, Philadelphia.