

Development of Chemical Deficiencies in Post-Tension Grout Materials

Rutambara Sonawane, Samanbar Permeh, and Kingsley Lau
Civil and Environmental Engineering Department, Florida International University
10555 W. Flagler St., Miami, FL 33174

PT construction provides efficient bridge with advantages in construction, economy, and serviceability. In bonded post-tensioned systems, the introduction of stresses to the reinforced concrete element is made through tensioned high-strength steel strand that are encapsulated in a cementitious grout. The hardened grout provides corrosion protection by the presence of the alkaline pore water to passivate the steel strand and by creating a barrier from external contaminants. However, there have been documented cases of strand corrosion relating to deficiencies of the grout materials. Segregation of thixotropic grouts allowed for the development of chemically deficient grouts (characterized as having high sulfate concentrations) in vertically-deviated tendons in part attributed to an upward moisture and ion mobility. The Schupak pressure bleed test and vertically-cast grout specimens was utilized to assess the performance of grout materials subjected to adverse construction practices including prehydration and addition of excess mix water. Results indicated that there is limited availability of sulfate ions upon initial grout casting but would still be able to accumulate via transport of the free water. Greater pressures and vertical deviations allowed for greater moisture transport and sulfate accumulation.

Keywords, PT tendons, grout, segregation, sulfate, bleed

INTRODUCTION

Bridge construction utilizing post-tensioned (PT) tendon systems have become increasingly popular. ¹⁻² PT construction allows engineers greater options for the design of highway bridges and provides efficient structures with advantages in construction, economy, and serviceability. In bonded post-tensioned systems, the introduction of stresses to the reinforced concrete element is made through tensioned high-strength steel

strand that are anchored and encapsulated in a cementitious grout within a tendon.³⁻⁴ The hardened grout allows development of the stress along the length of the tendon and also provides corrosion protection by the presence of the alkaline pore water to passivate the steel strand and by creating a barrier from external contaminants. However, there have been documented cases of strand corrosion relating to deficiencies of the grout materials.⁵⁻¹² In the 1990's, the corrosion was attributed to the development and accumulation of bleed water that allowed for volume changes grout void formation. In the early 2010's segregation of zero-bleed thixotropic grouts allowed for the development of chemically deficient grouts characterized as having high sulfate and alkali ion accumulation.¹³⁻²⁰ The formation of the deficient grout was in part attributed to the susceptibility of the material to segregate in presence of excess water. Material subjected to aging and inadequate storage are less robust in the presence of the excess mix water.²¹⁻²⁴ In a case study bridge in Florida, the steel corrosion typically occurred at higher elevations;²⁵⁻³⁰ although, there were instances of segregated grout at low points as well. The presence of elevated sulfate concentrations (that can allow for corrosion initiation)³¹⁻³⁴ and alkali ions in the segregated grouts in presence of the large vertical deviation was in part attributed to an upward moisture and ion mobility.³⁵⁻³⁶

The Schupack pressure bleed test described in ASTM C1741-18³⁷⁻⁴¹ and outlined in PTI M55⁴² was developed in part to address bleed water formation that can be associated with hydrostatic pressures from vertical deviations. The test specimen consisted of a Gelman filter with stainless steel screen and a type A fiberglass filter. An air pressure supply is attached to the top of the filter, and a graduated cylinder that is placed under the filter to collect the bleed water. The Gelman filter is filled with grout mixed with water and compressed air is supplied into the filter apparatus. Pressure levels vary from 30 psi to 100 psi depending on the grout class and vertical rise intended in construction.

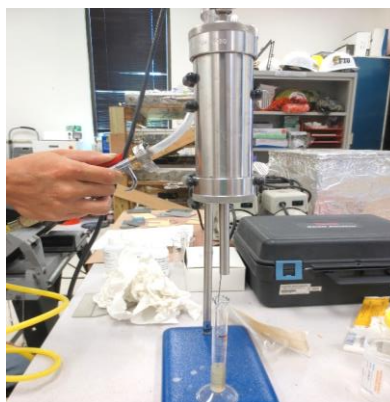


Figure 1: Example of Schupack bleed test

In the work described here, the effect of pressure relating to the vertical deviation of the tendon on the accumulation of water and sulfate ions was considered.

METHODOLOGY

Two commercially available thixotropic PT grouts that were subjected to adverse conditioning prior to mixing (materials past manufacturers' expiration date and bags stored without external containment in the lab) and a neat grout made from ordinary Portland cement. The testing included the Schupak pressure bleed test for freshly mixed grouts and casting of grout specimens in molds with extended vertical deviation. Test conditions are shown in Table 1. The effect of hydrostatic pressure was considered by the level of applied pressure in the Schupak bleed test and the height of vertical deviation in the cast grout.

Table 1
Test Conditions

Test Parameter	Test	
	Schupak Pressure Bleed Test	Vertical Deviation
Grout Material	Grout A and B, Neat Grout	Grout A and B, Neat Grout
Water Content	Thixotropic Grout I. (10-50% excess); II. (30,50% excess) Neat Grout I. (0.4-0.7 w/c); II. 0.45 w/c	Thixotropic Grout (30% excess) Neat Grout (0.45 w/c)
Pressure	I. (50 psi); II. (10, 20, 50, 100 psi)	2 and 4 ft vertical deviation

The Schupack test was performed generally conforming to ASTM C1741.³⁷ Testing was initially made (Test I) with thixotropic grout cast with 10-50% excess water and neat grout cast from 0.4-0.7 w/c. The pressure was held at 50 psi for 10 minutes. Subsequent testing (Test II) used thixotropic grout with 30 or 50% excess mix water and a 0.45 w/c neat grout held at 10-100 psi for 10 minutes.

The grout specimens cast with vertical deviation was made with PVC pipe and caps. The commercially available grout material using 30% extra water were cast in 2 ft or 4 ft PVC pipe sections. After 24 hours, the samples were cut into small 2" to 4" sections. These sections were then used to measure the moisture content (following gravimetric methods (ASTM C642)⁴³ at the top, middle, and bottom elevation of the test specimen. Select