280 Ann St., Grand Rapids, MI 49504
ph: 616-365-9220 fx.: 616-365-2668
www.williamsform.com

FINAL TEST DATA

PROJECT: ANCHOR WALL SYSTEM USING #5 GR60 ALL-THREAD REBAR

PROJECT NO: TS1239

CLIENT: CERCORP INITIATIVES INC.

Kevin Heinert – Marketing Engineer – Anchor Systems
Rich Timmer – Project Engineer – Engineering Dept.
Williams Form Engineering Corp.
September 24, 2002 - Released

SUPPORT INFORMATION INDEX

Abstract

The purpose of this test program was to determine the tensile capacity of a series of cement grout bonded concrete anchors. The anchors were installed in foundation wall test specimens with various wall thickness dimensions, ranging from eight inches to twelve inches. The test anchors were Williams Form Engineering #5 Grade 60 All-Thread Rebars with an ultimate tensile capacity of 28.8 kips. A grouted anchor was defined as a headed Williams All-Thread Bar embedded twelve inches, installed into a hole in hardened concrete utilizing a high strength grout as the bonding agent. The anchors were spaced sixteen inches apart and each test consisted of a series of three anchors.

The test results revealed that when the concrete test wall was twelve inches thick the average anchor failure load was 29.6 kips, for the ten inch thick walls the average tensile failure load was 26.7 kips and for the eight inch walls the average tensile failure load was 23.3 kips. The failure modes all consisted of a concrete splitting/cone failure, noting that the twelve-inch wall failure still exceeded the bars tensile capacity.

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Introduction

Concrete Masonry wall units can be post-tensioned to provide structural support. Williams All-Thread bars can serve as the post-tensioning tendons…anchored into the foundation and connected at the top of the wall with a plate and nut connection. The tendons will be pre-stressed to place the masonry units into compression and thus providing structural support. Williams All-Thread Bars are anchored into a twelve-inch hole at the surface of the foundation, with a hex nut embedded at the bottom of the anchor to serve as a headed stud. The anchor is then filled with a high strength grout as a bonding agent and then extended through the masonry units and attached at the top of the wall with a plate nut assembly. Testing is essential to determine what the pull out capacity of the anchors are for a specific embedment depth, reinforcing pattern, concrete strength and wall geometry. These tests will help provide guidelines for the concrete anchor design portion of the Flex-Wall system. These tests are be performed strictly for reporting anchor behavior under specific parameters (Fc', embedment, wall geometry and reinforcing patterns). Anchor design recommendations will not be reported.

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Test Procedures

1. concrete wall specimens were formed to reflect “real life application” conditions of the concrete anchors. All concrete test blocks included a specified steel reinforcement pattern consisting of # 4 bar. Concrete cylinders were taken.

2. After the concrete hardened (2-3 days), concrete anchor holes were drilled and anchors were placed and grouted. Grout was mixed with the manufactured recommended water cement ratios and was poured into the drill holes. (inserting grout into drill holes with the use of a grout pump is recommended)

3. concrete strength was monitored, so that when concrete strengths of 3000psi was achieved the anchors would be tested. Also the cement grout used as the bonding agent was compressive strength tested at that time to ensure that the grout was a minimum of 4000 psi to reduce the chances of pull out or bond failures.

4. Two steel channels were placed side by side approximately three inches apart and supported on each end by steel plates. This beam assembly was used to support the test jacks and functioned as a means to ensure that the anchors were loaded in an unconfined condition.

5. The test jack assembly consisted of three hydraulic jacks that worked off a single pump. The jacks distributed an equal amount of force to all anchors in the test series.

6. Each test consisted of a group of three anchors.

7. A dial indicator gauge was used on the center of the three anchors in the test series to measure anchor movement.

8. Anchor load was applied in varying intervals.

9. Load was applied until a failure occurred and the load at failure and anchor movement was recorded.

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Testing Apparatus

1. Wms. R51-05 #5 GR60 All Thread Rebar and Wms. R53-05 GR60 hex nut.
2. Five Star Fluid 100 Cement Grout
3. 2 ea. C12 x 25 steel channels x 60" long
4. One dial indicator gauge and mounting equipment
5. 3 ea. 30 ton hydraulic test rams (RRH307) with gauge and electric pump
6. Manifold that allows three jacks to be used in a series
7. Buckets and water for mixing grout
8. Hydraulic jack hoses

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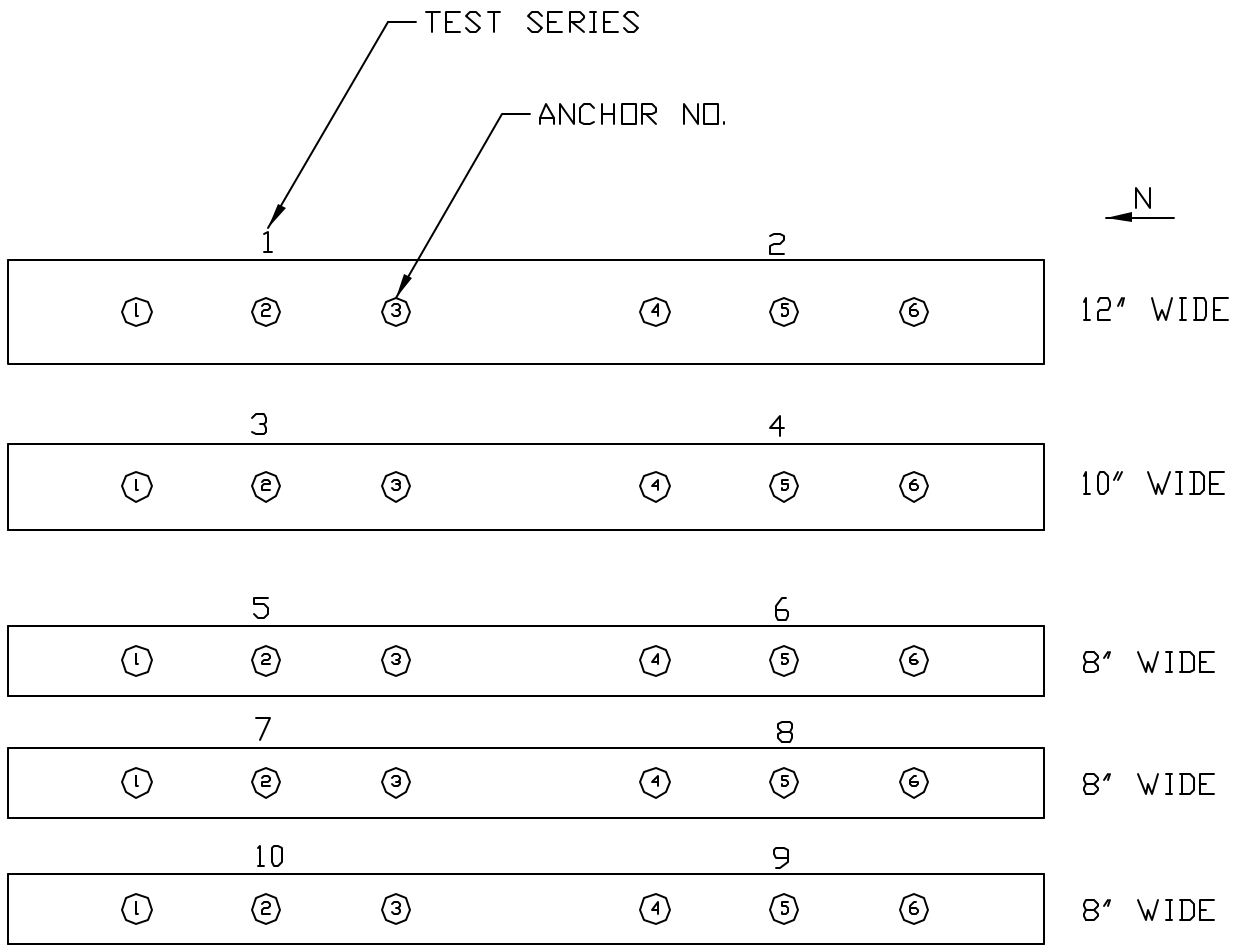
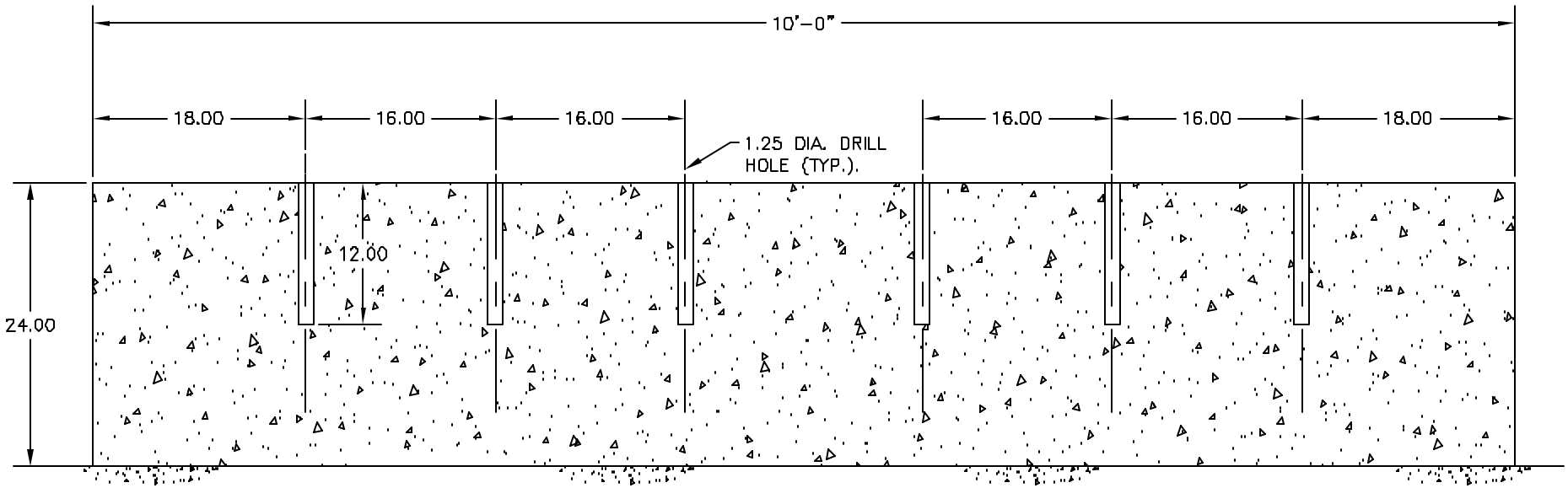


THURSDAY 8-1-01
fu' = 7 DAY (3,880 LBS.)
= 4 DAY (3350 LBS.)
GROUT fu' = 6000 P.S.I. (3 DAY)
TEMP 90°
WEATHER - SUNNY

WILLIAMS® FORM ENGINEERING CORP.
280 ANN ST., GRAND RAPIDS, MICHIGAN 49504
PHONE (616) 365-9220 FAX (616) 365-0919

# 5 All-Thread Grade 60 Ultimate Strength = 28,800 lbs fc'= 7 days= 3,870 psi, tests 1-8						
		Failure Load(lbs.)			Failure Type	Movement
Test series	**Wall no.**	**Wall 8" Thick**	**Wall 10" Thick**	**Wall 12" Thick**	**Description**	**on dial indicator at failure load**
1	1			28800 lbs.	Concrete Failure	0.053
2	1			30324 lbs.	Stopped Test	n/a
3	2		26714 lbs.		Concrete Failure	n/a
4	2		26714 lbs.		Concrete Failure	0.056
5	3	23104 lbs.			Concrete Failure	0.173
6	3	23104 lbs.			Concrete Failure	n/a
7	4	24548 lbs.			Concrete Failure	0.156
8	4	22382 lbs.			Concrete Failure	0.010
9	5	27436 lbs. (28 day)			Concrete Failure	0.260
10	5	28158 lbs. (28 day)			Concrete Failure	0.300
		AVERAGE	AVERAGE	AVERAGE		
		23284 lbs	26714 lbs	29562 lbs		



WALL LAYOUT

SCALE 1/8

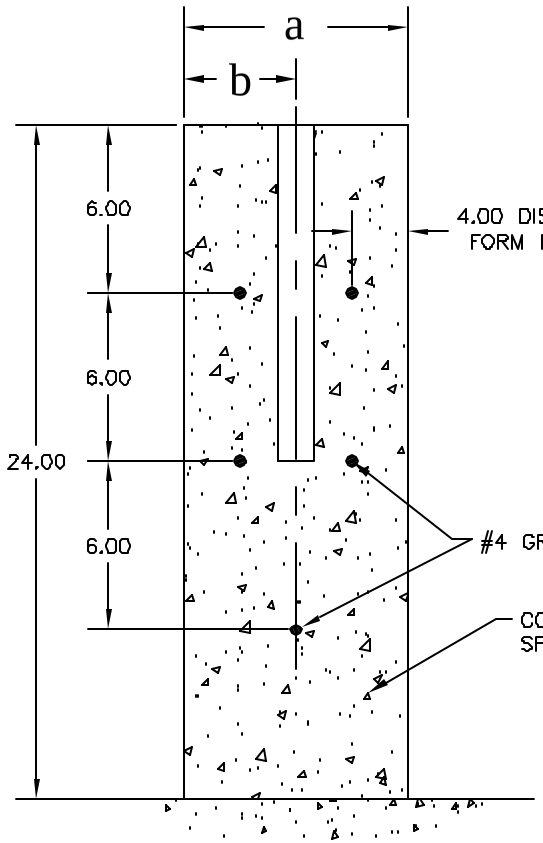
WILLIAMS FORM ENGINEERING CORP.
280 ANN ST., GRAND RAPIDS, MICHIGAN 49504
PHONE (616) 365-9220 FAX (616) 365-0919

Customer:

Project: WALL LAYOUT, ANCHOR POSITION DETAIL

DRAWN BY: RHT		ECO NO.: TS1239-1
SCALE: AS SHOWN		C/O NO.:
DATE: 08-15-02		CHECK BY:
SHEET NO.	TOTAL SHEETS	DESIGNED BY: ---
1	1	TECH REP: ---

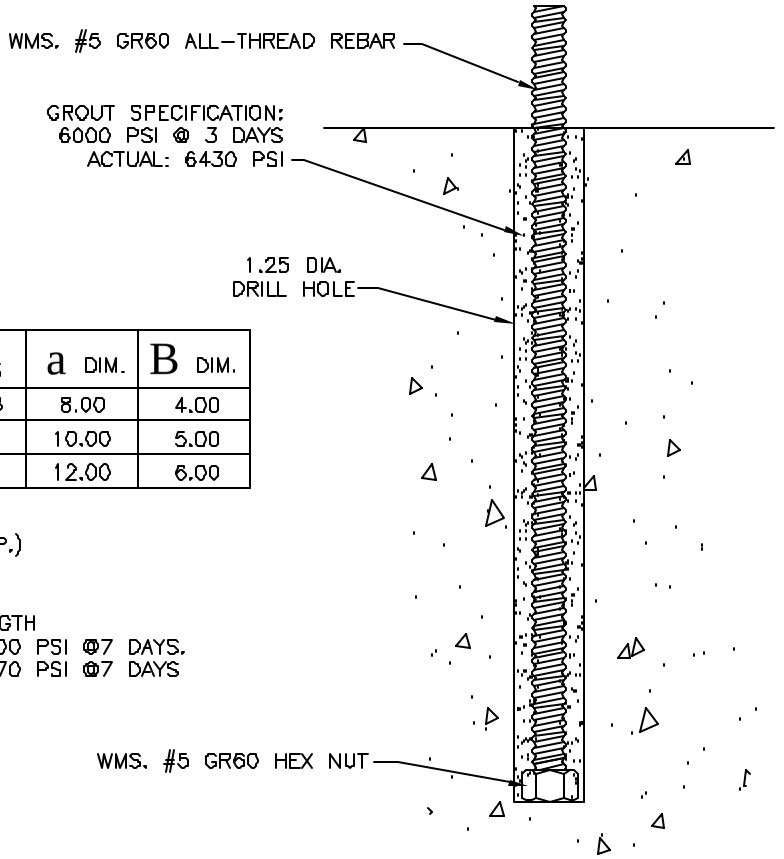
PRINT NO.: Wall layout drawing



TEST SERIES	a DIM.	B DIM.
5,6,7,8	8.00	4.00
3,4	10.00	5.00
1,2	12.00	6.00

WALL SECTION

SCALE 1/4



ANCHOR DETAIL

SCALE 1/2

WILLIAMS FORM ENGINEERING CORP.
280 ANN ST., GRAND RAPIDS, MICHIGAN 49504
PHONE (616) 365-9220 FAX (616) 365-0919

Customer:

Project: WALL SECTION LAYOUT AND ANCHOR DETAIL

DRAWN BY: RHT		ECO NO.: TS1239-2	
SCALE: AS SHOWN		C/O NO.:	
DATE: 08-15-02		CHECK BY:	
SHEET NO. 1	TOTAL SHEETS 1	DESIGNED BY: ---	
		TECH REP: ---	

PRINT NO.: Wall section and detail

Materials Testing Consultants, INC.
CORPORATE OFFICE: 693 PLYMOUTH, N.E. GRAND RAPIDS, MI 49505
(616) 456-5469 / FAX (616) 456-5784
NORTHERN MICHIGAN OFFICE: P.O. BOX 3425 TRAVERSE CITY, MI 49685-3425
(231) 922-7111

Job No. 021153

Pour Date: 07/25/02

OJECT:
CONCRETE ANCHOR TESTS

CLIENT:
WILLIAMS FORM ENGINEERING
280 ANN STREET NW
GRAND RAPIDS, MI 49504

CONTRACTOR:

ARCHITECT OR ENGINEER:

REPORT OF CONCRETE COMPRESSION TEST - ASTM C-39

Source of Concrete: GRAND RAPIDS GRAVEL Ticket No. -
Location of Placement: TEST WALLS

Specifications For Mix NONE

Slump in inches - Min.- Max.-
Entrained Air in % - Min.- Max.-
Cement in sks./cu.yd. - Min.-
Water Cement Ratio - Max.-

Unit Wt. - lbs./cu.ft.
Air Temp. - deg.F
Concrete Temp. - deg.F
Quantities in cu.yds.
Total this pour -
At time of test -
This truck -

Minimum strength specification
3000 p.s.i. at 7 days

oratory Number	Age in Days	Days Field Cured	Type of Cap	Type of Fracture	Cross section area - sq.in.	Load in pounds	Compressive strength - p.s.i.	Percent of Design
0258	4	1	E	C	28.2	94510	3350	111
80259	7	1	E	C	28.2	109390	3870	129
80260	SP							
80261	SP							

Average 7 day compressive strength = 3870 p.s.i.

Problems and Solutions:

Remarks:

Tested by: PJ
Molded by: CLIENT Reviewed by: 8-6-02
Distribution:

Legend

Test date:
SP = Spare Cyl.

Cap type:
E = Elastometric
S = Sulfur

Fracture Type:
C = Cone
S = Shear
CS = Cone & Shear
CSP = Cone & Split
CO = Columnar
N = Not Fully Fractured

Testing Consultants, INC.
CORPORATE OFFICE: 693 PLYMOUTH, N.E. GRAND RAPIDS, MI 49505
(616) 456-5469 / FAX (616) 456-5784
NORTHERN MICHIGAN OFFICE: P.O. BOX 3425 TRAVERSE CITY, MI 49685-3425
(231) 922-7111

Job No. 021153

Pour Date: 07/29/02

PROJECT:
CONCRETE ANCHOR TESTS

CLIENT:
WILLIAMS FORM ENGINEERING
280 ANN STREET NW
GRAND RAPIDS, MI 49504

CONTRACTOR:

ARCHITECT OR ENGINEER:

REPORT OF CONCRETE COMPRESSION TEST - ASTM C-39

Source of Concrete: GRAND RAPIDS GRAVEL Ticket No. -
Location of Placement: -

Specifications For Mix NONE

Slump in inches - Min.- Max.- Unit Wt. - lbs./cu.ft.
Entrained Air in % - Min.- Max.- Air Temp. - deg.F
Cement in sks./cu.yd. - Min.- Concrete Temp. - deg.F
Water Cement Ratio - Max.- Quantities in cu.yds.
Total this pour -
At time of test -
This truck -

Minimum strength specification
- p.s.i. at 28 days

Laboratory Number	Age in Days	Days Field Cured	Type of Cap	Type of Fracture	Cross section area - sq.in.	Load in pounds	Compressive strength - p.s.i.	Percent of Design
80396	3	1	E	S	7.02	45140	6430	
80397	7	1	E	S	7.02	97640	13900	
80398	28	1	E	S	7.02	97940	13950	

Average 28 day compressive strength = 13950 p.s.i.

Problems and Solutions:

Remarks:
ALL INFORMATION WAS PROVIDED BY THE CLIENT

Tested by: PJ
Molded by: CLIENT Reviewed by: P.J
Distribution:

Legend

Test date:
SP = Spare Cyl.

Cap type:
E = Elastometric
S = Sulfur

Fracture Type:
C = Cone
S = Shear
CS = Cone & Shear
CSP = Cone & Split
CO = Columnar
N = Not Fully Fractured

FIVE STAR® FLUID GROUT 100

High Performance Fluid Grout

PRODUCT DESCRIPTION

Five Star Fluid Grout 100 is the industry's leading cement-based, nonmetallic, nonshrink fluid grout for supporting machinery requiring precision alignment. When tested in accordance with ASTM C 827, Five Star Fluid Grout 100 shows positive expansion. Five Star Fluid Grout 100 meets the performance requirements of ASTM C 1107 and CRD-C 621 specifications for nonshrink grout for Grades A, B and C over a wide temperature range and a long working time.

ADVANTAGES

- Placement within tight clearances
- Early cut back (3 hours)
- High 24 hour strength
- Permanent support for machinery requiring precision alignment
- Does not contain gas generating additives, such as aluminum powder
- Nonshrink from the time of placement
- 95% Effective Bearing Area (EBA) is typically achieved following proper grouting procedures
- Formulated with Devoider® for optimum load transfer
- Locally manufactured under strict quality control standards

USES

- 24 hour start-up time
- Grouting clearances to one-half inch
- Installation of anchors and dowels
- Support of tanks and vessels
- Preplaced aggregate grouting
- Grouting of machinery baseplates to maintain precision alignment
- Nonshrink grouting of structural steel and precast concrete

TECHNICAL SUPPORT

Five Star Products maintains the industry's foremost Engineering and Technical Support Group:

- Over 30 years of experience in precision grouting
- Technical Center staffed with experienced engineers available for consultation
- Design-A-Spec™ for engineering specification assistance
- Experienced representatives for field service
- Corporate research laboratory available to customize products for unique applications

PACKAGING AND YIELD

Five Star Fluid Grout 100 is packaged in heavy-duty, polyethylene lined bags containing 55 lb (24.9 kg), yielding one-half cubic foot (14.2 liters).

SHELF LIFE

One year in original unopened packaging when stored in dry conditions. Higher humidity will reduce the shelf life.

TYPICAL PROPERTIES AT 73°F (23°C)

Early Height Change, ASTM C 827		0.0 - 4.0%	
Hardened Height Change, ASTM C 1090		0.0 - 0.3%	
Effective Bearing Area		95%	
Bond Strength, ASTM C 882		2000 psi (13.8 MPa)/28 Days	
Pull-Out Strength, Shear Bond		2000 psi (13.8 MPa)/7 Days	
135 ksi threaded bar			
Compressive Strength, ASTM C 109		Min. Water psi (MPa)[1]	Max. Water psi (MPa)[2]
	1 Day	5800 (40.0)	3500 (24.2)
	3 Days	7500 (51.8)	6000 (41.4)
	7 Days	8000 (55.2)	6500 (44.9)
	28 Days	10000 (69.0)	8000 (55.2)

[1] 100 - 125% flow on flow table, CRD-C 621 (ASTM C 230, 5 drops in 3 seconds).
[2] 20 to 30 second flow by Corps of Engineers Flow Cone Method, CRD-C 611.

QUALITY CERTIFIED ISO 9001 FIVE STAR PRODUCTS

The data shown above reflect typical results based on laboratory testing under controlled conditions.

PLACEMENT GUIDELINES

1. SURFACE PREPARATION: All surfaces in contact with Five Star Fluid Grout 100 shall be free of oil, grease, laitance and other contaminants. Concrete must be clean, sound and roughened to ensure a good bond. Soak concrete surface for 8 to 24 hours prior to application, with liberal quantities of potable water, leaving the concrete saturated and free of standing water.
2. MIXING: Mix Five Star Fluid Grout 100 thoroughly for approximately 5 minutes to a uniform consistency with a mortar mixer. For optimum performance, maintain grout at ambient temperatures between 40°F and 90°F (4°C and 32°C). Use heated or chilled water to help adjust working time. Do not mix to a flow of less than 20-30 seconds through a flow cone per ASTM C 939 and CRD C-611, or a consistency that will cause segregation. Working time is approximately 30 minutes at 73°F (23°C). Follow printed instructions on the package.
3. METHODS OF PLACEMENT: Five Star Fluid Grout 100 may be poured or pumped into place. For pumping applications and for placement thicknesses of less than one-half inch (13 mm), or greater than three inches (75 mm), call the Five Star Products Engineering and Technical Center at 203-336-7900.
4. POST-PLACEMENT PROCEDURES: Grout shoulders may be cut back in approximately three hours after placement. Five Star Fluid Grout 100 shall be wet cured for a minimum of three days, or coated with an approved curing compound after a minimum 24 hour wet cure. In-service operation may begin immediately after the required grout strength has been reached.
   NOTE: PRIOR TO APPLICATION, READ ALL PRODUCT PACKAGING THOROUGHLY. For more detailed placement procedures, refer to Design-A-Spec™ installation guidelines or call the Five Star Products Engineering and Technical Center at 203-336-7900.

LIMITATIONS

- At time of placement, if temperatures of equipment and surfaces are not between 40°F and 90°F (4°C and 32°C), refer to Design-A-Spec™ for cold and hot weather grouting procedures.
- Never exceed the maximum water content as stated on the bag or add an amount that will cause segregation.
- For placements thinner than one-half inch (13 mm) or greater than three inches (75 mm), call the Five Star Products Engineering and Technical Center
- Construction practices dictate concrete foundation should achieve its design strength before grouting.

CAUTION

Contains cementitious material and crystalline free silica. International Agency for Research on Cancer has evaluated that there is sufficient evidence for the carcinogenicity of inhaled crystalline silica to humans. Take appropriate measures to avoid breathing dust. Avoid contact with eyes and contact with skin. In case of contact with eyes, immediately flush with plenty of water for at least 15 minutes. Immediately call a physician. Wash skin thoroughly after handling. Keep product out of reach of children. PRIOR TO USE, REFER TO MATERIAL SAFETY DATA SHEET.

For worldwide availability, additional product information and technical support, contact your local Five Star distributor, local sales representative, or you may call Five Star's Engineering and Technical Center at 203-336-7900.

Corporate Offices
Five Star Products, Inc.
425 Stillson Road
Fairfield, CT 06430
Tel: 203-336-7900
Fax: 203-336-7930
www.fivestarproducts.com

MATERIAL SAFETY DATA SHEET

FIVE STAR PRODUCTS, INC
425 Stillson Road
Fairfield, CT 06430
203-336-7900

EMERGENCY TELEPHONE NO. 1-(800) 255-3924

FOR CHEMICAL EMERGENCY
Call Chem Tel
1-800-255-3924
24 hrs./7days per week

Issue Date: 1/15/01 Preparer: R.M. Camara, Environmental & Safety Mgr. Signature: R.M. Camara

SECTION I - Product Identification: FIVE STAR® GROUT 100, FIVE STAR® FLUID GROUT 100, FIVE STAR® SPECIAL GROUT 110, FIVE STAR® SPECIAL GROUT 120, FIVE STAR® SPECIAL GROUT 130, FIVE STAR® SPECIAL GROUT 150, FIVE STAR® SPECIAL GROUT 200, FIVE STAR® SPECIAL GROUT 120 PG, FIVE STAR® SPECIAL GROUT 120 UW PG

SECTION II - Hazardous Ingredients/Identity Information

Components:	C.A.S. No.:	OSHA PEL:	ACGIH TLV:	Other Limits:
Hydraulic Cement	65997-15-1	5 mg/m³* 15 mg/m³**	10 mg/m³**	50 MPPCF

Silicon Dioxide, Crystalline Silica, Silica Sand SiO_2 C.A.S. No. 14808-60-7

OSHA PEL (Permissible Exposure Limit): Exposure to airborne crystalline silica shall not exceed an 8-hour time-weighted limit as stated in MSHA Standards, Subpart D, Section 56.5001 on air quality specifically "Silica: Crystalline: Quartz (respirable) PEL - TWA = 0.1 mg/m and 29 CFR 1910.1000 Table Z-1-A, Air Contaminants, specifically: Crystalline Quartz (Respirable) 10 mg/m³ / %SiO_2+2

ACGIH TLV (Threshold Limit Value): Crystalline Quartz TLV-TWA = 0.05 mg/m³ (Respirable Dust). See Threshold Limit Value and Biological Exposure Indices for 1991-1992. American Conference of Governmental Industrial Hygienists.

Other Limits Recommended: National Institute for Occupational Safety and Health (NIOSH). Recommended standard maximum permissible concentration = 0.05 mg/m³ (respirable free silica) as determined by a full-shift sample up to 10-hour working day, 40-hour week.

*Raspirable Dust **Total Dust

HMIS: Health = 1 Fire = 0 Reactivity = 1 Personal Protection = E

SECTION III: - Physical/Chemical Characteristics

Boiling Point (°F):	N/A	Specific Gravity (H_2O = 1).	2.7
Vapor Pressure (mm Hg.):	N/A	Melting Point (°F):	N/A
Vapor Density: (AIR = 1):	N/A	Evaporation Rate: (Butyl Acetate = 1)	None
Solubility in Water: Negligible		Appearance and Odor:	Gray, white or brown, finely ground solid--no odor.

SECTION IV - Fire and Explosion Hazard Data

Flash Point: Noncombustible. Flammable Limits: LEL: N/A, UEL: N/A.
Extinguishing Media: N/A. Special Fire-Fighting Procedures: Not applicable. Unusual Fire and Explosion Hazards: None.

SECTION V - Reactivity Data

Stability: Unstable: ( ) Stable: (X)
Conditions to Avoid: N/A. Incompatibility (Materials to Avoid): Strong acids. Hazardous Decomposition or Byproducts: None known. Hazardou
Polymerization: May occur. ( ) Will not occur. (X)

SECTION VI - Health Hazard Data

Routes of Entry: Inhalation: Yes Skin: Yes Ingestion: Yes
Health Hazards (Acute and Chronic): Prolonged overexposure to Crystalline Free Silica Dust above the threshold limit may cause scarring of the lungs with cough and shortness of breath. A delayed lung injury silicosis may result from breathing free silica. Acute: Wet cement, especially as an ingredient in plastic (unhardened) concrete, mortar or slumes, can dry the skin and cause alkali burns. Cement dust can irritate the eyes and upper respiratory system. Chronic: Cement dust can cause inflammation of the lining tissue in the interior of the nose and inflammation of the cornea. Carcinogenicity: NTP? Yes. "Known to be a human carcinogen." IARC Monographs? Yes. OSHA Regulated? No. IARC Group 1. *"IARC states there is 'sufficient evidence' for the carcinogenicity of inhaled crystalline silica to humans."* Signs and Symptoms of Exposure: May cause coughing, sneezing and nasal irritation. May cause skin irritation, dryness, burns. Medical Conditions Aggravated by Exposure: Respiratory ailments. Emergency and First Aid Procedures: Remove to fresh air. Immediately flush eyes with plenty of water for at least 15 minutes. Wash exposed areas with water thoroughly after handling. Product may harden on contact with water. ***See physician.***

SECTION VII - Precautions for Safe Handling and Use

Steps To Be Taken in Case Material is Released or Spilled: Avoid breathing dust. Avoid creating additional dust. Vacuum or sweep, using methods that do not disperse dust. Emergency procedures are not required. Waste Disposal Method: May be disposed of in an unrestricted sanitary landfill. Precautions To Be Taken In Handling and Storing: Keep dry until used to preserve product utility. Avoid contact with eyes and skin. Wash thoroughly after handling. Other Precautions: None.

SECTION VIII - Control Measures

Respiratory Protection: Dust mask. OSHA, MSHA or NIOSH-approved respirator. Ventilation: Local Exhaust: Mechanical required if necessary. Mechanical (General): May be used if necessary. Special: None. Other: None. Protective Gloves: Barrier creams or impervious gloves to protect skin. Eye Protection: OSHA, MSHA or NIOSH-approved tight-fitting goggles or masks. Other Protective Clothing or Equipment: Impervious clothing to protect skin from burns. Work/Hygienic Practices: Wash exposed skin thoroughly.

GRAND RAPIDS GRAVEL COMPANY

May 28, 2002

Williams Form Engineering
280 Ann Street, NW
Grand Rapids, MI 49504

Re: Concrete Mix Design

Attn: Kevin Heinert

Gentlemen;

We submit for your information the proportions of the concrete mix supplied to you on Friday, May 24, 2002. All weights are saturated surface dry for one cubic yard and are subject to minor adjustment.

Mix 1 - 5.5 sack 1 Inch	211
Cement - Holcim Type I	517 lbs.
Fine aggregate	1480 lbs.
Coarse aggregate - 1 inch max.	1860 lbs.
Water	267 lbs.

If you have any questions please feel free to contact us.

Very truly yours;
GRAND RAPIDS GRAVEL COMPANY

James E. English
Quality Control

2700 - 28TH STREET SW • P.O. BOX 9160 • GRAND RAPIDS, MI 49509-0160 • PHONE (616) 538-9000 • FAX (616) 538-8877

Conversion Chart for 30 Ton Hydraulic Jack

ENERPAC - Double acting

Jack no. RCH307 Ram Area = 7.22 Sq.In.

Jack Gauge psi to Bolt Tension in Lbs. (7.22 sq.in. x psi)

GAUGE P.S.I	RAM PRESSURE IN LBS.	GAUGE P.S.I	RAM PRESSURE IN LBS.	
100 psi	722 lbs.	4,100 psi	29,602 lbs.	
200 psi	1,444 lbs.	4,200 psi	30,324 lbs.	
300 psi	2,166 lbs.	4,300 psi	31,046 lbs.	
400 psi	2,888 lbs.	4,400 psi	31,768 lbs.	
500 psi	3,610 lbs.	4,500 psi	32,490 lbs.	
600 psi	4,332 lbs.	4,600 psi	33,212 lbs.	
700 psi	5,054 lbs.	4,700 psi	33,934 lbs.	
800 psi	5,776 lbs.	4,800 psi	34,656 lbs.	
900 psi	6,498 lbs.	4,900 psi	35,378 lbs.	
1,000 psi	7,220 lbs.	5,000 psi	36,100 lbs.	
1,100 psi	7,942 lbs.	5,100 psi	36,822 lbs.	
1,200 psi	8,664 lbs.	5,200 psi	37,544 lbs.	
1,300 psi	9,386 lbs.	5,300 psi	38,266 lbs.	
1,400 psi	10,108 lbs.	5,400 psi	38,988 lbs.	
1,500 psi	10,830 lbs.	5,500 psi	39,710 lbs.	
1,600 psi	11,552 lbs.	5,600 psi	40,432 lbs.	
1,700 psi	12,274 lbs.	5,700 psi	41,154 lbs.	
1,800 psi	12,996 lbs.	5,800 psi	41,876 lbs.	
1,900 psi	13,718 lbs.	5,900 psi	42,598 lbs.	
2,000 psi	14,440 lbs.	6,000 psi	43,320 lbs.	
2,100 psi	15,162 lbs.	6,100 psi	44,042 lbs.	
2,200 psi	15,884 lbs.	6,200 psi	44,764 lbs.	
2,300 psi	16,606 lbs.	6,300 psi	45,486 lbs.	
2,400 psi	17,328 lbs.	6,400 psi	46,208 lbs.	
2,500 psi	18,050 lbs.	6,500 psi	46,930 lbs.	
2,600 psi	18,772 lbs.	6,600 psi	47,652 lbs.	
2,700 psi	19,494 lbs.	6,700 psi	48,374 lbs.	80%
2,800 psi	20,216 lbs.	6,800 psi	49,096 lbs.	Max
2,900 psi	20,938 lbs.	6,900 psi	49,818 lbs.	Allow
3,000 psi	21,660 lbs.	7,000 psi	50,540 lbs.	Limit
3,100 psi	22,382 lbs.	7,100 psi	51,262 lbs.	
3,200 psi	23,104 lbs.	7,200 psi	51,984 lbs.	
3,300 psi	23,826 lbs.	7,300 psi	52,706 lbs.	
3,400 psi	24,548 lbs.	7,400 psi	53,428 lbs.	
3,500 psi	25,270 lbs.	7,500 psi	54,150 lbs.	
3,600 psi	25,992 lbs.	7,600 psi	54,872 lbs.	
3,700 psi	26,714 lbs.	7,700 psi	55,594 lbs.	
3,800 psi	27,436 lbs.	7,800 psi	56,316 lbs.	
3,900 psi	28,158 lbs.	7,900 psi	57,038 lbs.	
4,000 psi	28,880 lbs.	8,000 psi	57,760 lbs.	

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Conclusion

In these testes, the full ultimate tensile capacity of the headed #5 Grade 60 All-Thread Bar could be developed in concrete that is approximately 3500- 4000psi with steel reinforcing equivalent to these specifications, twelve inches anchor embedded and a wall thickness of a minimum of twelve inches and two feet high. Anchor spacing closer than sixteen inches is out of the scope of these tests, however anchor spacings larger than sixteen inches may demonstrate larger anchor capacities. (especially in narrower walls). For walls that are ten or eight inches in width, anchor capacity reduction factors should be considered because test results revealed that the full steel capacity of the anchor rod could not be developed. If additional anchor testing is found to be necessary…higher concrete strength and a more aggressive steel reinforcing pattern should be the adjusted parameters. All test failure modes consisted of concrete failure except for test number two. Grout bond failures or pull out failures were not observed in this test program demonstrating that embedment depth, grout selection and anchor deformations are adequate.
It is our opinion that with additional vertical reinforcement and a 5000 psi concrete mix, the full ultimate tensile capacity of the #5 grade 60 All-Thread Bar could possibly be reached in an eight inch wide concrete wall that is a minimum of two feet tall.

280 Ann St., Grand Rapids, MI 49504 - ph: 616-365-9220 fx.: 616-365-2668 - www.williamsform.com