Badger Cement Products, LLC

Report on
"Badger Pozz"™

AS

Concrete Admixture

Feb 2001
By: Roland O. Roth
V.P., Marketing

Introduction

Badger Pozz is a pozzolan product that is sold and used as an admixture to cement. Pozzolans are silica-containing materials which combine with lime in the presence of water to form compounds having cementitious properties. Generally referred to as a melted quenched clay (MQC), pozzolans like Badger Pozz are found to be a pozzolanic and cementitious material, which, when used in portland cement concrete produce favorable properties. Badger Pozz meets or exceeds all physical, chemical and ASTM performance specifications, and when interground or blended with portland cement meets ASTM C595-98 for blended cements.

Badger Pozz is made from finely ground glass aggregate. Glass aggregate is considered a fully melted and quenched clay, and provides Badger Pozz's qualities as a cement pozzolan.

The following charts, graphs and tables are compilations and summaries either directly taken or extrapolated from data & tests performed over the past two years by Construction Technology Laboratories, Inc. (CTL), Skokie, IL (Peter C. Taylor, Ph.D., Project Manager).

A) Preliminary compositional and physical evaluation of Badger Pozz melted & quenched clay (MQC)

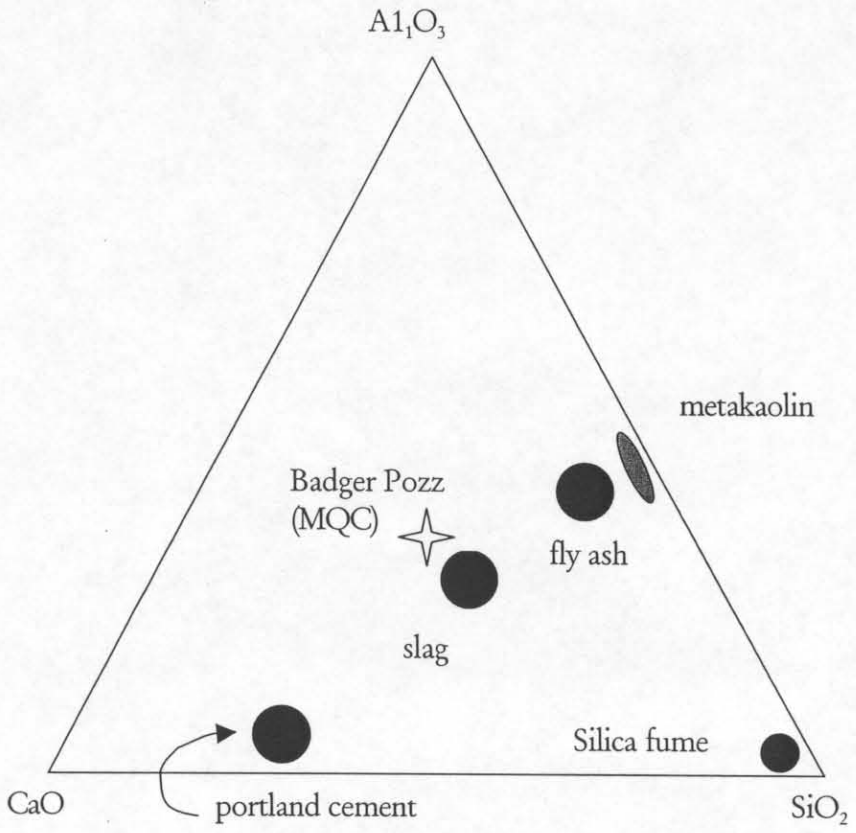


Figure 1. Ternary diagram showing typical oxide compositions of the cementitious and pozzolanic materials. The oxide composition of the Badger Pozz MQC material is closest to that of slag.

Table 1. Comparison of Badger Pozz MQC material with the compositional requirements for natural pozzolans and Class C fly ash (ASTM C 618).

Composition	Natural Pozzolan	Class C Fly Ash	Badger Pozz MQC
$SiO_2 + Al_2O_3 + Fe_2O_3$	Minimum 70.0%	Minimum 50.0%	55.17%
SO_3	Maximum 4.0%	Maximum 5.0%	0.06%
Moisture Content	Maximum 3.0%		0.09%
Loss on ignition	Maximum 10.0%	Maximum 6.0%	0.22%
Available alkalis	Maximum 1.5% Na_2O eq.		0.16%

Table 2. Comparison of Badger Pozz MQC material with the physical requirements for natural pozzolans and Class C fly ash (ASTM C 618).

Physical Requirement	Natural Pozzolan	Class C Fly Ash	Badger Pozz MQC
Fineness:			
Amount retained when wet-sieved on 45 um sieve, maximum	34%	34%	2.6%
Strength activity index with portland cemet:			
7 days, minimum % of control	75	75	90
28 days, minimum % of control	75	75	98
Water requirement, maximum % of control	115	105	95
Soundness:			
Autoclave expansion or contraction, maximum %	0.8	0.8	0.05

Table 3. Comparison of Badger Pozz MQC material with typical compositions of postcanel cement and granulated blast furnace slag.

Analyte	Weight %		
	portland cement	MQC	Slag
SiO_2	20.61	34.37	35.06
Al_2O_3	4.90	21.78	10.11
Fe_2O_3	2.18	1.23	1.09
CaO	63.74	34.79	41.39
MgO	3.79	1.46	6.92
SO_3	2.55	0.11	21.12
Na_2O	0.07	0.26	0.30
K_2O	0.67	0.11	0.24
TiO_2	0.29	5.37	0.44
P_2O_5	0.26	0.48	<.01
Mn_2O_3	0.08	0.02	0.35
SrO	0.05	0.04	0.07
L.O.I. (950°C)	0.71	0.10	-0.27
Total	99.90	100.12	97.81
Alkalies as Na_2O	0.51	0.33	0.45
Fineness, m^2/kg	360	483	471

Conclusions:

- The composition Badger Pozz is comparable to slag with higher alumina & slightly lower silica.
- No deleterious materials were found.
- Alkalai content of Badger Pozz MQC was found to be lower than both Class C fly ash and slag.
- Loss of ignition of Badger Pozz MQC was lower than both slag and Class C fly ash.
- Badger Pozz MQC reduced water demand.
- Badger Pozz SO_3 content is significantly less than both Class C fly ash and slag.

B.) Comparative performance test of Badger Pozz (MQC) as a supplemental cementing material

Table 4. Slag Activity Index Data

Slag activity index, % of control	Unblended MQC 4800 Blaine	Unblended Slag*	ASTM C 989 requirement for Grade 80	ASTM C 989 requirement for Grade 100
At 7 days	52	113	-	70
At 28 days	82	147	70	90

* from CTL data

Although the slag activity index for Badger Pozz MQC at a blaine fineness of 4800 is slightly below a grade 100, it is known that a finer grind will increase these levels.

Tests are being done at this time to determine what level can be achieved.

The expansion in sulfate solution test compares a control mix ("straight" portland cement - 639#) to a Badger Pozz MQC blend (418# portland 225# slag) and a slag blend (415# portland & 223# slag).

The Badger Pozz MQC showed the lowest expansion of the three mixes.

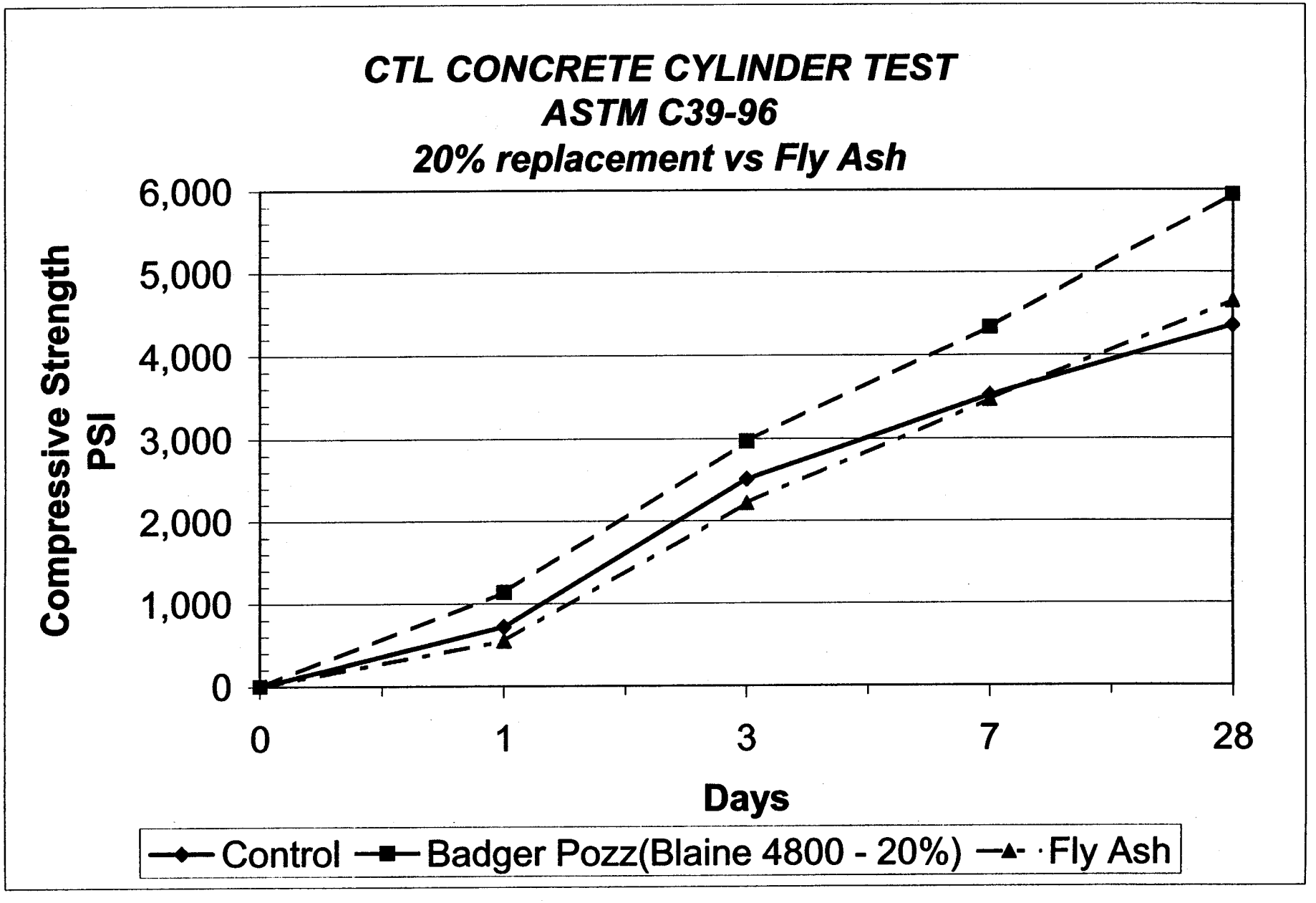
Table 5. Expansion in Sulfate Solution, ASTM C 1012

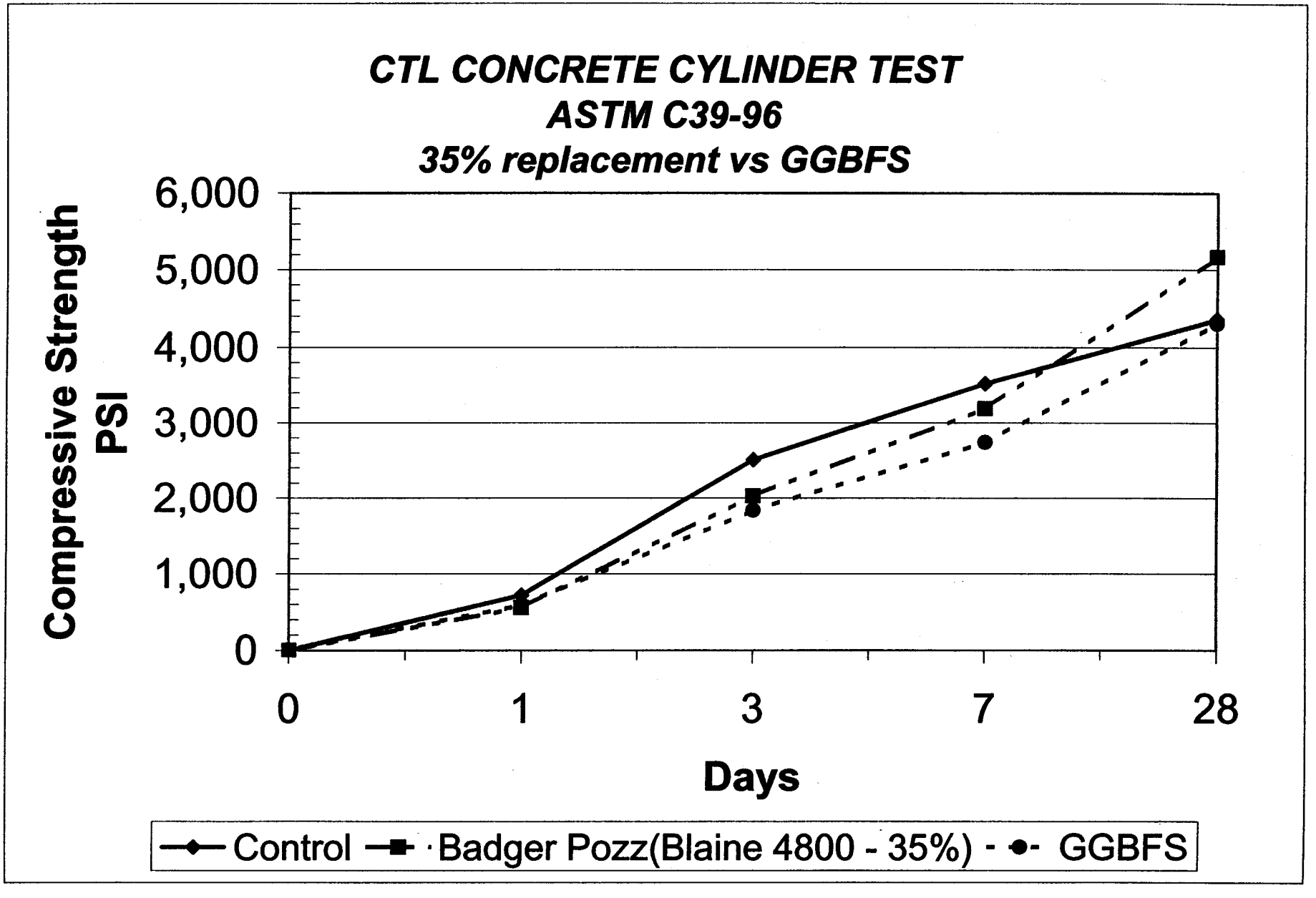
Age, days	Expansion, %		
	Control	MQC blend	Slag blend
7	0.006	0.014	0.010
14	0.012	0.015	0.015
21	0.016	0.019	0.019
28	0.018	0.019	0.020
56	0.021	0.021	0.023
91	0.030	0.024	0.027
122	0.035	0.021	0.025
183	0.142	0.030	0.044
275	0.561	0.080	0.193
365	1.514	0.262	0.515

The following graphs & charts compare results of concrete mixes. The control mix (c) contains 582# of portland cement. The fly ash (FA) mix contains 451# of cement & 113# ash (20% replacement). The slag mix contains 369# cement & 195# slag (35% replacement). Two Badger Pozz MQC mixes were used; one at a 20% (20) replacement (459# cement + 115#MQC) and one mix at a 35% (35) replacement (376# cement + 202# MQC). The MQC was at a 4800 Blaine fineness. The mixes contained 1200# of sand, 1700# No. 1 stone, water reducer & air entraining (7%). All mixes were targeted at 6" slump.

Table 6. Compressive Strength Results, psi

Age of testing, days	Control	48-20	48-35	58-20	58-35	FA	GGBFS
1	720	1,140	560	1,050	650	550	590
3	2,510	2,970	2,030	2,640	1,950	2,220	1,840
7	3,520	4,340	3,190	3,830	2,950	3,470	2,740
28	4,360	5,940	5,170	5,410	4,710	4,660	4,310
90	6,380	7,060	6,180	5,990	6,030	5,260	5,260
180	5,410	6,720	6,170	5,650	5,900	5,910	5,270
365							


CTL CONCRETE CYLINDER TEST
ASTM C39-96
20% replacement vs Fly Ash
Compressive Strength
PSI
6,000
5,000
4,000
3,000
2,000
1,000
0
0
1
3
7
28
Days
Control
Badger Pozz(Blaine 4800 - 20%)
Fly Ash


CTL CONCRETE CYLINDER TEST
ASTM C39-96
35% replacement vs GGBFS
Compressive Strength PSI
6,000
5,000
4,000
3,000
2,000
1,000
0
0
1
3
7
28
Days
Control
Badger Pozz(Blaine 4800 - 35%)
GGBFS

Drying Shrinkage of Concrete Mixes, % at Given Age (ASTM C 157)

Age, days	Control	MQC 48-20	MQC 48-35
1	0.000	0.000	0.000
7	-0.008	-0.004	0.004
11	0.008	-0.002	0.024
14	0.014	0.003	0.026
21	0.031	0.021	0.041
35	0.040	0.024	0.044
63	0.047	0.033	0.063
119	0.048	0.038	0.062
281	0.050	0.039	0.054
455			

Results of Freeze Thaw and Salt Scaling Tests (ASTM C 666 and C 672)

	Control	MQC 48-20	MQC 48035
ASTM C 666 Method A			
Number of cycles	313	309	309
Mass loss, %	-0.41	0.19	1.6
Length change, % (positive indicates expansion)	0.028	0.020	0.009
Relative dynamic modules, %	106.1	108.6	105.6
ASTM C 672			
Visual Rating after 50 cycles (ASTM C 672)	2.0	0.5	1.0

Chloride Ion Penetration, Coulombs at Given Age (ASTM C 1202)

Age, days	Control	MQC 48-20	MQC 48-36
28	4,600	2,300	3,000
56	4,000	2,000	1,200
80	3,400	1,400	1,500
180	2,800	1,300	1,100
365			

Summary & conclusions:

Badger Pozz MQC comparable to ground granulated blast furnace slag performance and in fact some characteristics indicate improved performance (sulfate test).

The Badger Pozz MQC compares favorably to a "straight" portland mix in terms of freeze thaw & chloride ion penetration.

The concrete cylinder tests indicate Badger Pozz MQC can create a superior concrete with these mix designs.

All results of these tests, performed over the past two years, indicate that Badger Pozz MQC is a reliable admixture for creating durable concrete. All results have been positive.

Minergy Products Company is committed to continued research & development of Badger Pozz to guarantee its performance as a viable product for the Wisconsin concrete industry.