Concrete Whiteness for Barrier Rails

Final Report
For
MLR-97-4

September 1997

Project Development Division

Iowa Department Of Transportation

Final Report
For
MLR-97-4

Concrete Whiteness for Barrier Rails

By
Todd D. Hanson, P.E.
Pavement Materials Engineer
515-239-1649
Fax 515-239-1092
Office of Materials
Project Development Division
Iowa Department of Transportation
Ames, Iowa 50010

September 1997

TECHNICAL REPORT TITLE PAGE

1. REPORT NO.

MLR-97-4

2. REPORT DATE

September 1997

3. TITLE AND SUBTITLE

Concrete Whiteness for
Barrier Rails

4. TYPE OF REPORT & PERIOD COVERED

Final Report, 8-97 to 9-97

5. AUTHOR(S)

Todd Hanson
Pavement Materials Engineer

6. PERFORMING ORGANIZATION ADDRESS

Iowa Department of Transportation
Materials Department
800 Lincoln Way
Ames, Iowa 50010

7. ACKNOWLEDGMENT OF COOPERATING ORGANIZATIONS/INDIVIDUALS

8. ABSTRACT

Research has shown that maximum reflectivity, using white cement concrete contributes to increased safety of barrier rails. This research evaluated the whiteness of concrete mixes using white cement, ground granulated blast furnace slag, and natural sand versus manufactured sand. Results indicated mixes containing white cement achieve the highest reflectivity.

9. KEY WORDS

White cement
Barrier rail
Ground granulated blast
Furnace slag

10. NO. OF PAGES

10

TABLE OF CONTENTS

DISCLAIMER

INTRODUCTION

This research is to evaluate the whiteness of various concrete mixes using white cement and ground, granulated blast furnace slag. Research has shown that maximum light reflectivity is important in traffic safety. White cement has been used in concrete median barriers to provide maximum reflectivity and increased safety. Six concrete mixes were evaluated for light reflectivity.

OBJECTIVE

The objective of this research is to determine which combination of materials exhibit the maximum light reflectivity. White cement and ground, granulated blast furnace slag, which tens to lighten Portland cement, were used in various mix combinations with a light gray to which limestone. Also, natural sand versus manufactured sand from a light colored limestone source were used in various combinations to determine the effect on lightness of the concrete mix.

MATERIALS

Cements – Type I white cement from Lehigh and Type I/II gray Portland cement from Holnam were used in this research. The white cement is manufactured using low iron raw materials to achieve its white color. ASTM requires less than 0.50% Fe_20_3 to be considered white cement. The chemical analysis is included in Table 1. Also, ground granulated blast furnace slag was examined as a mineral admixture since it tends to lighten the color of concrete.

Six mix combinations were examined. All of the mixes used Fort Dodge limestone, a light gray to white colored limestone, as the coarse aggregate. The various combinations are as follows:

Mix 1 - Lehigh White Cement
Natural Sand.

Mix 2 - Lehigh White Cement
Manufactured Sand – Ames Mine

Mix 3 - Holnam Portland Cement – 65%
Holnam ground granulated blast furnace slag – 35%
Natural Sand – Cordova, IL

Mix 4 - Holnam Portland Cement – 65%
Holnam ground granulated blast furnace slag – 35%
Manufactured Sand – Ames Mine

Mix 5 - Lehigh White Cement – 65%
Holnam ground granulated blast furnace slag – 35%
Natural Sand – Cordova, IL

Mix 6 - Lehigh White Cement – 65%
Holnam ground granulated blast furnace slag – 35%
Manufactured Sand – Ames Mine

All mixes used C-4 mix proportions. See Table 2 for each mix proportion. Carter Waters Ad-Aire air entraining agent was used in each mix. No other admixtures were used.

TEST PROCEDURE

All six combinations were mixed and cast into 1" × 6" × 20" molds. The specimens were cured in the moist room for seven days and then removed and allowed to air dry. The specimens were visually examined later for color lightness. The color photos are included in Figures 1 – 6.

Also, a Macbeth Colorchecker 545 portable spectrophotometer was used on each specimen to apply a value to the reflectivity of each of the concrete mixes. The values obtained from a spectrophotometer are related to the percent reflectivity, ranging in value from 0, or no reflectivity (black), to 100, or 100% reflectivity. The spectrophotometer was used to check reflectivity at three locations on each specimen and the results were averaged. The average values obtained for each mix and for gray Portland cement concrete are included in Table 3.

DISCUSSION OF RESULTS

Based on visual observation, the specimens using white cement or white cement in combination with ground granulated blast furnace slag appear to be the lighter or whiter concrete. There does not appear to be any visual difference between the concrete mixes with natural sand versus manufactured sand.

The spectrophotometer results indicate that the concrete mix with white cement and manufactured sand have the highest reflectivity with a value of 77.46. The results also show a

slight increase in reflectivity using manufactured sand over natural sand. Concrete mixes with either white cement or a combination of white cement and ground granulated blast furnace slag exhibit the higher values of reflectivity, ranging in value from 74.52 to 77.46. Those concrete mixes using gray Portland cement and ground granulated blast furnace slag were lower ranging from 55.92 to 61.46. All reflectivity values were higher than gray Portland cement concrete where the average value was 45.15.

SUMMARY

Results, both visually and those values obtained from the spectrophotometer, indicate that concrete mixes using white cement or a combination of white cement and ground, granulated blast furnace slag exhibit the brightest reflectivity. The effect of manufactured sand over natural sand results in a slightly higher value of reflectivity as indicated by the spectrophotometer. Using natural sand may result in color changes later due to the effect of iron in the sand, but using manufactured sand will produce a harsher, less workable mix. These results were based on the laboratory mixes and no effects due to environment, which may affect long term reflectivity, were taken into account.

CONCLUSIONS

Based on the results of this research, the following is concluded:

1. White cement or a combination of white cement and ground granulated blast furnace slag result in highly reflective concrete mixes.
2. There is a minimal difference between the reflectivity of concrete mixes using natural sand and manufactured sand.

ACKNOWLEDGEMENTS

The author would like to thank the Cement and Concrete Section of the Central Materials Laboratory for their efforts in this research.

TABLE TITLES

1. Chemical Analysis of Lehigh White Cement
2. Mix proportions, lbs/cu. yd.
3. Macbeth Colorchecker 545 Portable Spectrophotometer

Table 1
Chemical Analysis of Lehigh White Cement

MGO	SO3	LOI	INSOL	SiO2	Fe2O3	Al2O3	CaO	C3A	Na2O	K2O	Na2O Equiv.
1.92	2.50	1.00	0.15	22.17	0.39	4.44	65.02	11.78	0.12	0.4	0.38

Table 2
Mix Proportions, lbs/cu. yd.

	Cement	GGBFS	Fine Aggregate	Coarse Aggregate	Water
Mix 1	624.0		1515.7	1521.4	249.6
Mix 2	624.0		1470.3	1521.4	249.6
Mix 3	405.6	218.4	1506.6	1512.3	249.6
Mix 4	405.6	218.4	1461.5	1512.3	249.6
Mix 5	405.6	218.4	1506.6	1512.3	249.6
Mix 6	405.6	218.4	1461.5	1512.3	249.6

Table 3
Macbeth Colorchecker 545 Portable Spectrophotometer

Readings, Cap Y Values

	1	**2**	**3**	**Average**
Mix 1	75.39	74.57	75.28	78.05
Mix 2	78.93	78.44	75.01	77.46
Mix 3	55.16	58.73	53.88	55.92
Mix 4	61.73	63.51	59.13	61.46
Mix 5	72.21	75.48	75.88	74.52
Mix 6	76.93	74.53	76.41	75.95
Gray Concrete	41.06	45.06	49.35	45.15

FIGURE CAPTIONS

1. Mix 1 – Lehigh White Cement, Natural Sand Cordovia
2. Mix 2 – Lehigh White Cement, Manufactured Sand Ames Mine
3. Mix 3 – Holnam Cement 65%, GGBFS 35%, Natural Sand Cordovia
4. Mix 4 – Holnam Cement 65%, GGBFS 35%, Manufactured Sand Ames Mine
5. Mix 5 – Lehigh White Cement 65%, GGBFS 35%, Natural Sand Cordovia
6. Mix 6 – Lehigh White Cement 65%, GGBFS 35%,Manufactured Sand Ames Mine

Mix 1 – Lehigh White Cement, Natural Sand, Cordova

Mix 2 – Lehigh White Cement, Manufactured Sand, Ames Mine

Mix 3 – Holnam Cement 65%, GGBFS 35%, Natural Sand, Cordova

Mix 4 – Holnam Cement 65%, GGBFS 35%, Manufactured Sand, Ames Mine

Mix 5 – Lehigh White Cement 65%, GGBFS 35%, Natural Sand, Cordova

Mix 6 – Lehigh White Cement 65%, GGBFS 35%, Manufactured Sand, Ames Mine