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Enhancing Concrete Barrier Reflectivity with a Focus on Recycled Glass Aggregate Replacement

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ABSTRACT

On the roadways of the United States, increased accident rates during the evening and rainy weather conditions entail the need of improving the visibility of highway concrete barriers. The reflectance of these delineators is directly correlated to their degree of visibility. The use of white cement as opposed to grey cement and the installation of raised pavement markings to the side of the barriers are two of the suggested approaches that might potentially boost the reflectivity of these concrete barriers. There are several other potential methods. One of the suggested approaches that was put through more laboratory testing was the use of recycled glass in the production of concrete. The purpose of the laboratory experiment was to determine the appropriate mixing proportions that would reduce the likelihood of the alkali-silica reaction (ASR) occuring in recycled glass aggregate concretes without having any detrimental impacts on the compressive strength of the concrete. This paper includes the results of an evaluation done on the retro reflectivity of different concrete mixes.

Keywords: Recycled Glass, Aggregate Replacement, Barrier Reflectivity

INTRODUCTION

This research was motivated by an interest in determining the key techniques that may be taken to increase the visibility of concrete safety barriers, which served as the driving force for the study. When the weather is severe and when individuals are driving late at night, the improvements that are being recommended need to make these barriers more effective. It is crucial that these barrier systems have a low overall cost, a long lifetime, and a rate of deterioration that is lower than that of the systems that are currently in place. These requirements should all be met simultaneously. The proposed methods shouldn't alter the geometry of the concrete barriers in any way, nor should they have any adverse effects on their durability and strength; rather, they should only enhance the reflectivity of the concrete barriers. In order to confirm the safety and efficacy of the barrier, more crash testing would need to be conducted in the event that the geometry of the barrier was significantly altered. Longevity and strength of the concrete barrier have to be kept at the same levels in order for the barrier to continue to fulfil its primary function without any interruptions. It was decided to do more investigation into the potential use of shattered glass in the concrete mixture so that we may make a better informed conclusion. The use of recycled glass, which was noted later in the report as one of the accessible alternatives, required more investigation to see whether or not it was practicable as a material that was both effective and long-lasting. This was stated since it was one of the possibilities that were available. Choosing this path would be favourable since it would have a positive effect on the natural environment that is all around you. An outlet for the reuse of recycled glass might be formed as a consequence of the usage of recycled glass as opposed to the utilisation of glass beads that have been expressly made.

In the combination of concrete, there is a potential for hazardous chemical reactions between the glass and the cement, most notably the alkali-silica reaction (ASR). These reactions might be disastrous. There is a possibility that these responses will take place. The following provides a more in-depth discussion of their responses: The goal of the laboratory research was to establish the proper mixing proportions that would lower the risk of ASR developing in recycled glass aggregate concretes. This was accomplished by comparing several recycled glass aggregate concretes with each other.

When it comes to reducing the risk of head-on collisions, one of the most important things that can be done is to have concrete barriers installed along highways. These barriers are also necessary for the maintenance of safety in the areas around highway building projects in order to prevent accidents. It is critical to the successful operation of these barriers that they be brought into public view. They are obligated to provide a motorist with two distinct types of assistance: the first type is to assist the driver in anticipating the road route directly in front of them in order to decrease the likelihood of lane weaving, and the second type is to highlight the road pattern farther ahead in order to give the driver sufficient time to make a choice. Visibility is affected by the reflection of the barrier; this impact is reduced when the time of day is evening and when there is precipitation in the air. The driver's ability to preview the oncoming road pattern is hindered when the surface's reflectivity is reduced, which increases the likelihood that the driver may engage in unsafe driving behavior.

The addition of white pigment to concrete mixtures, which is intended to provide a visible demarcation between the barrier and the road surface, is currently a standard way to improving the visibility of barriers. The goal of this demarcation is to reduce the risk of vehicles colliding with the barrier. This delineation's primary objective is to forestall any potential collisions between moving vehicles and the barrier. Sadly, when conditions are wet and it is dusk, this differentiation loses practically all of its significance. An additional obstacle that has to be conquered is the fact that the reflectivity of many of the existing methods that are employed in improving visibility, such as the addition of white pigment to concrete mixes and the use of reflective tape, decreases at a quick speed as a result of the buildup of dirt. This is something that needs to be remedied.

According to the information provided in the preceding sentence, one method that is effective in boosting the reflectivity of a concrete barrier is the application of glass beads to the surface of the barrier. It is likely that you might have a larger variety of positive results by switching to glass beads manufactured from recycled glass rather than those made from glass that was generated particularly for the purpose of the beads. The incorporation of recycled glass into the composition of the concrete not only offers the possibility of enhancing the reflectivity of the barrier, but it also affords the possibility of recycling glass. Both of these outcomes are desirable. The most major obstacles that are currently faced in the process of recovering glass are impurities that are detected in recovered glass as well as the high costs associated with colour sorting mixed colour waste stream.

The quantity of glass that has been separated by colour (Shi and Yin) is much lower than the amount of mixed waste glass. It is possible that the procedure of colour sorting recycled glass in order to produce glass cullet that is suitable for utilisation in the manufacturing of glass bottles is a costly one. This is due to the fact that the stream of waste glass is sometimes rather enormous, and the glass itself may include huge particles as well as being polluted. Because of this, many facilities that recover recyclable materials are forced to dispose of recovered glass in landfills. This is an unfortunate reality that must be accepted. Because there is a substantial need for the development of a technique that may enable the recycling of mixed-color waste glass, one of the possibilities that was investigated as part of this project was the incorporation of waste glass of mixed colours into construction products. This was done because there was a need for the creation of a system that may allow for the recycling of mixed-color waste glass.

Object

- The Study Enhancing Concrete Barrier Reflectivity
- The Study A Focus on Recycled Glass Aggregate Replacement

RESEARCH METHODOLOGY

This study's objective is to determine realistic approaches to improving the reflectivity of highway barriers. The use of recycled glass (RG) in the formulation of the concrete is one approach that may be considered. Previous studies on this topic were extensively analysed and reported in. Following the completion of this literature study, a strategy for conducting research on the physical testing of concrete that contains RG aggregate was developed. The qualities of the fresh concrete and the hardened concrete will both be tested physically.

Investigating fresh concrete qualities such as workability, slump, and air content are some examples of what may be done. Compressive strength, alkali-silica reactivity (ASR), and reflectivity of the various concrete mixture designs will be investigated as hardened concrete qualities to be evaluated. Evaluating the adverse consequences of ASR and coming up with potential solutions to such problems is one particular objective of this project. Since ASR is a chronic issue that could not become apparent for many years, we will be using a sped-up strategy in order to investigate the consequences of the condition.

Cement

In the course of this investigation, both ordinary Portland cement and white cement were used as sources of cement. A local materials and hardware business was used as the source for the acquisition of the ordinary Portland cement. The Lehigh Cement Company was responsible for supplying the white cement. cement is ground finer than cement, resulting in more reactive surfaces for hydration; this, in turn, creates high-early strength cement.

Cement and cement are chemically identical to one another, but cement is physically distinct from cement. This particular kind of cement may be used in the production of concrete blocks, as well as precast and prestressed buildings and structures. During the winter months, when high early strength is required for processes like as pre-casting, it is widely employed (Lehigh Cement Company, 2009)

Admixtures

There are three different types of liquid admixtures used: an air entraining admixture, a superplasticizer, and an ASR regulating admixture. All of these goods were given by the producer, which is known as Sika Corporation. Satisfies the criteria for an air entraining admixture that are specified by the ASTM C260 standard. The use of this additive results in an improvement in the workability and place-ability of the concrete due to the lubricating effect of the small bubbles that are present in the mixture.

Because less water is needed to achieve the necessary degree of workability, this results in an improvement in the flow of the concrete as well as a reduction in bleeding and shrinkage. In order to entrain between 4 and 6 percent air, the recommended dose rate is between 16 and 65 millilitres per 100 kilogrammes (0.25-0.1 ounces per 100 pounds) of cement.

In order to properly incorporate this additive into the concrete mixture, it must first be thoroughly combined with either the water or the sand, but never with the dry cement. Because this admixture is added along with another admixture, careful attention must be paid to ensure that each of these admixtures is dispensed in its own unique manner. The Product Data Sheet for the admixture was consulted in order to collect all of the information that was necessary to understand Sika® AEA-15. The ASTM C494 Types A and F standards may be satisfied by using Sika Visco Crete® 6100 since it is a high-range water-reducing and super plasticizing admixture.

With the addition of Sika Visco Crete® 6100, this combination has been transformed into one that can solidify on its own. This admixture produces a decrease in water of 10 to 15 percent when used in small quantities, but when used in greater dosages, a reduction in water of up to 45 percent may be attained. Because of its super plasticizing activity, the concrete produced by it has a high slump and flows well while retaining an outstanding workability. This admixture has been designed to provide the highest possible water reduction, the highest possible early strength, and the best possible finishing qualities.

The dose that is suggested ranges from 195 to 520 millilitres per one hundred kilogrammes (three to eight fluid ounces per one hundred pounds) of cementitious material. It is possible to utilise a dose of up to 780 ml per 100 kg (12 oz per 100 lbs) of cementitious material to achieve the highest possible decrease in water use. In order to get the best possible results when super plasticizing concrete, this additive should be poured into the newly mixed concrete in the concrete mixer at the very end of the batching cycle.

The Sika ViscoCrete® 6100 information that was acquired was taken directly from the Product Data Sheet that was provided by the supplier. The sole mixed design in which Sika® Control ASR was used was for the purpose of conducting research on the impact of this admixture.

This admixture contributes lithium nitrate to the mixture, which then becomes a part of the alkali-silica gel on its own. Because of the presence of these lithium ions, the ASR gel does not swell when it comes into contact with water. This gel is not harmful since it does not possess the potential to swell.

Approximately 4.6 litres (0.55 gallons for every pound) of Sika® Control ASR should be applied for every kilogramme (0.55 gallons for every pound) of sodium equivalent that is given by the cement in the concrete mixture. The dose is determined by the alkali level of the concrete mixture. This admixture changes the ratio of water to cementitious material (also known as w/cm), and in order to correct it, 0.85 litres (0.23 gallons) of water must be deducted for every litre (0.26 gallons) of the admixture that is added to the mixture.

This admixture should be introduced at the very end of the batching cycle, either to the water or to the mixture; however, it should be added separately from any other admixtures that are being given at the same time. The Product Data Sheet for the admixture served as the source for all of the information that was obtained pertaining to Sika® Control ASR. The term "pulverised fly ash" (PFA) refers to a powder additive that may be used in lieu of cement. This item was generously given by Headwaters Incorporated of Havana, Illinois. It was a Class C PFA that was utilised.

Mixing Process

The Gunness Laboratory at the University of Massachusetts Amherst served as the location for all of the concrete mixing that was done. ASTM C192 was followed in its execution throughout the mixing process. We utilised a STOW concrete mixer Model CM6 that had a capacity of 165 litres, which is equal to 6 cubic feet. The concrete mixer was first loaded with roughly one quarter of the total mixing water before the coarse aggregate (rock and/or glass pieces of a coarser size) was added.

When the coarse aggregate had absorbed an adequate amount of moisture, the fine aggregate (sand and/or fine-size glass) was added. This was followed by the coarse aggregate being thoroughly combined with the fine aggregate until a homogenous mixture was achieved. After that, the cement, PFA, and the majority of the water that was left over were added, and the mixture was stirred for two minutes (Figure 3.8).

Figure 1 Depiction of Addition of Aggregate to the Mixer

DATA ANALYSIS

Fresh Concrete

Results It was discovered that because of the flowable nature of self-consolidating concrete mixes, there was a propensity for the cement paste to flow into the petcocks of the Air Pressure Metre. This may possibly result in inaccurate air readings if the topping off water addition did not completely fill the chamber. Because partial topping off might result in extremely high apparent air content measurements, extreme care is required when interpreting air readings for certain combination designs. For each and every Air Pressure Metre measurement, it was seen that the water pouring out of the petcocks had a significant amount of paste, which often caused the petcock to get blocked. This was due to the flowable nature of the paste.

Because of this, a fresh test was carried out, or an assumption was made in the event that obstacles could not be circumvented. However, the water that was coming from the petcock in each instance was of a smaller volume than what would be considered normal, and it needed a substantial amount of pressure from the bulb that was delivering the input water. When attempting to determine air contents using the Chase Indicator Kit, we ran across a number of challenges as well. The test required the acquisition of a sample of mortar that was indicative of the whole. In order to carry out this test accurately, it was necessary to remove from the mortar sample any sand particles that were larger than the No. 10 sieve's 2 millimetre (0.079 inch) tolerance. This turned out to be a challenging process, which led to part of the aggregate being stuck in the constricting neck of the tube. As a result, the tests had to be redone. When the extra mortar sample was struck from the top of the cup, the flowable nature of the paste may have allowed more air to escape than in a typical mixed design, leading to an air content measurement that was lower than what was really there. Figure 4.1 depicts the tube and cup/stopper that come with the Chase Air Indicator Kit (Forney model LA-0340).

Figure 2 Glass Indicator and Cup/Stopper (Forney Model LA-0340)

It was consequently a difficult job to verify the permissible air content range of percent for the control, self-consolidating trial mixes. When multiple degrees of air entraining admixture were used in the testing mixes, the outcome was air contents that were higher than the goal values. A high air content would be advantageous in that it would serve to reduce cracking in the concrete as a result of ASR gel expansion; but, it would also serve to weaken the concrete as a result of the large number of air spaces. This research had a major emphasis on ASR, and a decreased air content would significantly increase the likelihood that ASR issues would arise. It was concluded that the combinations with the least amount of air would be the most important to the project because of the possible inaccuracies that were found while analysing the air content. As a result of this, it was decided that the final test specimens would not include any admixtures that might entrain air.

Effects of Using Fine-Size Rg

It was found that the fresh concrete characteristics of combination MG-3030 were less fluid than those of MW-0000A and MW-0000B. This resulted in a spread diameter of 55.25 centimetres (21.75 inches), which is slightly below the permitted limit for self-consolidating concrete. While the concrete was being mixed, it was observed that there was foaming of the concrete, which was also observed as bubbling at the surface of the moulds (Figure 4.2). However, the Chase Air Indicator Kit reported only 4.25 percent of air, which was likely an incorrect reading due to the propensity for air to escape with minimal disturbance to the paste. It was hypothesised that this behaviour may be caused by fine-size glass particles, and it seems to support this hypothesis. In order to verify this, MW-3000 was combined. In this particular combination, fine-size glass was used to substitute fine aggregate at the rate of thirty percent by weight. The diameter of the spread was 66.04 centimetres (26 inches) when this combination was used. Even though the diameter of the circle that was spread was within the permissible range, this spread could not pass muster due to its unsatisfactory physical qualities. The spread circle is seen in Figure 4.3, and it depicts how the coarse aggregate should be placed around the periphery, while the fine aggregate should be placed in the middle. The dispersion of the mixture showed the great degree of segregation that existed within this combination. In any of the other spread experiments, this was not seen.

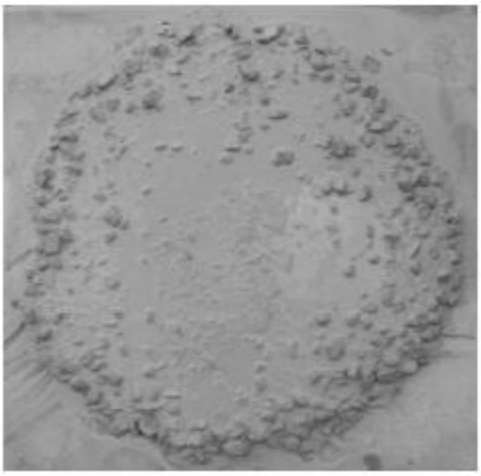

Figure 3 MW-3000 Spread Diameter

The degree of foaming and bubbling that was shown by the MW-3000 was comparable to that of the MG3030 5.2). The behaviour of the MG-3030 was mirrored by that of the Air Pressure Metre, which showed that there was only 3.25 percent air present. Although aggregate separation was not noticed in the spread of MG-3030, it was observed inside the mixer. The coarse aggregate had a tendency to concentrate at the bottom of the mixer, while the fine aggregate was found on the top. This segregation and bleeding of the concrete was noticed on the concrete prisms and the concrete cylinders for MG-3030. Both of these shapes were made of concrete. When the concrete prisms made from mixture MW-3000 were removed from their moulds after 24 hours of curing, it was discovered that despite the fact that the mixture looked to be entirely set, the surface crumbled into dust when it was scraped. This occurred despite the fact that the mixture had been cured.

CONCLUSION

Concrete median barriers on highways play an essential role in the prevention of accidents on highways, particularly in construction zones. Increasing their reflectivity may make them more effective in performing their purpose. Unfortunately, their reflectance is reduced when it is evening and when circumstances are damp. A comprehensive literature search was carried out in order to identify potential approaches that may improve the reflectivity of concrete barriers. Altering the concrete mixture by using white cement rather than grey cement in the mixture design is a workable choice that is often used in the construction industry at this time. The retroreflective difference between grey cement concrete and white cement concrete was determined to be around 9 mcd/m2 /lx during laboratory testing of concrete mixes utilising white cement as opposed to grey cement. The testing was conducted on concrete mixtures using either white or grey cement. Other potential solutions include embedding raised pavement markers, glass beads inside pavement markings, reflective paint, traffic sign sheeting, and/or pavement marking tape into the surface of the barrier. Other possible solutions include traffic sign sheeting. Altering the surface shape of the barrier is yet another option that may be available.

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