Improving CBR Value of Subbase Layer by Using Waste Recycled Glass

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Abstract

The aim of this study is to improving of CBR value of subbase layers by using waste recycled glass as secondary aggregate. The study work covers four percentages of glass content those are (25, 50, 75 and 100 %) by weight of total mix, and four sizes of glass those are (3/8, No.4, No.8 and (50+200)). The bearing properties of the control and glass mixtures are CBR test.

The study results show that the CBR value is increasing when glass size is decrease and using (17, 23 and 34%) glass size lower than 0.3 mm had increased in CBR value from 40% to (85, 105 and 140%) respectively.

الخلاصــة

أن هدف هذه الدراسة هو تحسين قيمة نسبة تحمل كاليفورنيا لطبقة الحصى الخابط باستخدام مخلفات الزجاج كركام ثانوي. تضمنت هذه الدراسة أربع نسب لمحتوى الزجاج (25، 50، 75و 100%) من الوزن الكلي للخلطة، وأربع أحجام للزجاج (19، 4.75، 2.36 و(0.3 و0.075) ملم)، وتم تقييم خواص التحمل للخلطة المرجعية والمحسنة بالاعتماد على فحص نسبة تحمل كاليفورنيا.

أظهرت نتائج الدراسة أن قيمة نسبة تحمل كاليفورنيا تزداد كلما كان حجم الزجاج المستخدم صغير، وباستخدام زجاج ذو حجم يقل عن 0.3 ملم وبنسبة (17، 23، و 34%) فأن قيمة نسبة تحمل كاليفورنيا تزداد من 40% إلى (85، 105، و 140%) على التوالي.

1. Introduction

The vast quantities of waste (such as scrap tires, glass, blast furnace slag, steel slag, plastics, construction and demolition wastes) accumulating in stockpiles and landfills throughout the world are causing disposal problems that are both financially and environmentally expensive. The environmental consciousness of governments and the public is causing more difficulty in disposing of these materials, particularly where restrictive provisions discourage or even prohibit them from being placed in sanitary landfills **(Greg Arnold, et al. 2008)**.

Dealing with the growing problem of disposal of these materials is an issue that requires coordination and commitment by all parties involved. One solution to a portion of the waste disposal problem is to recycle and use these materials in the construction of highways. However, such a use should not compromise the quality and performance of the highway infrastructure nor create an environmental problem **(Greg Arnold, et al. 2008)**.

2. Subbase Layer

Pavement performance is strongly influenced by the underlying layers, particularly with respect to stability, bearing strength, consolidation over time, and moisture susceptibility. Frequently one or more layers are placed between the soil sub-grade and the pavement. In flexible pavements, the layer directly above the sub-grade is termed the subbase.

The AASHTO Guide for Design of Pavement Structures **(AASHTO 1993)** defines a subbase as “one or more compacted layers of granular or stabilized material” between the sub-grade and pavements.

Careful attention to the design and construction of sub-grades and subbases is essential to ensure the structural capacity and ride quality of all types of pavements. For concrete pavements, the requirements may vary considerably depending on sub-grade soil type, environmental conditions, and amount of heavy truck traffic. In any case, the objective is to obtain a condition of uniform support for the pavement that will prevail throughout its service life **(PCA/ACPA 1991)**.

As an example, a parking lot carrying only light vehicle traffic would usually be built directly on the compacted subgrade. A subbase would be used only to deal with unsuitable soil **(ACI Committee 330 2001)**. For streets and local roads, subbases are generally not used for residential pavements, but would be used to prevent pumping for collector and arterial streets and local roads **(ACI Committee 325 2002)**. For highways, AASHTO recommends the use of a subbase unless the sub-grade soils are equal in quality to subbase materials, or if the projected traffic is less than one million ESALs **(AASHTO 1993)**.

3. Function of Subbase Layer

The subbase layer has three main functions, as follows **(David Croney and Pual Croney, 1998)**:

1. It is a structural layer which will accept greater compressive stress than the sub-grade, and it thus reduces the deformation of the pavement under traffic loading.
2. To provides a working platform over which the construction plant can operate when the layer above is being placed.
3. It prevents frost from penetrating into frost-susceptible sub-grades.

AASHTO soil classes A-1, A-2-4, A-2-5, and A-3 granular materials may need to be treated with portland cement to make cement-treated subbases. Use of a subbase will increase the k-value over that provided by the subgrade soil. The PCA developed a chart to calculate the increase in k-value due to aggregate (Table 1) **(PCA 1984)**.

Table (1) Effect of untreated subbase on k-values (PCA 1984).

Subgrade k-value, MPa/m (psi/in)	*Subbase k-value, MPa/m (psi/in)*			
	100 mm (4 in)	*150 mm (6 in)*	*225 mm (9 in)*	*300 mm (12 in)*
13.5 (50)	17.5 (65)	20 (75)	23 (85)	30 (110)
27 (100)	35 (130)	38 (140)	43 (160)	51 (190)
54 (200)	60 (220)	62 (230)	73 (270)	87 (320)
81 (300)	87 (320)	89 (330)	100 (370)	117 (430)

4. Recycled Glass

Ordinary glass is rigid and brittle and easy to crush to form satisfactory particles for asphalt concrete applications. Glass is a non-metallic inorganic made by sintering selected raw materials comprising silicate and other minor oxides. The ratio of main oxides SiO2, Na2O, CaO are: 77%, 9.4% and 6.7% respectively **(Shaopeng Wu, et al. 2008)**.

Recycled glass processed from containers comes mainly from empty soft drink, beer, food, wine, and liquor containers collected at residential curbside, drop boxes, trash barrels, deposit stations, or recycling stations, and is either source-separated or co-mingled with plastics, aluminum cans, ceramics, or colored glass containers **(Landris T. Lee, 2007)**.

Man-made glass was first made by heating a sand, soda, and lime mixture, which formed a clear liquid that turned into a hard solid when cooled. Glass has been made into containers since about 1500 BC, and glass-making evolved from the Roman times about 50 AD when transparent glass with various colors was formed into mouth-blown shapes **(Glass Packaging Institute 2005)**.

5. Specification of Materials Used

The source of the subbase materials used in this study is Al-Najaf quarry. This materials is widely used in middle areas for pavement works. The specifications of materials are shown in Table (2). The properties are compared with the State Organization of Road and Bridge specification requirements **(SCRB, 2003)**.

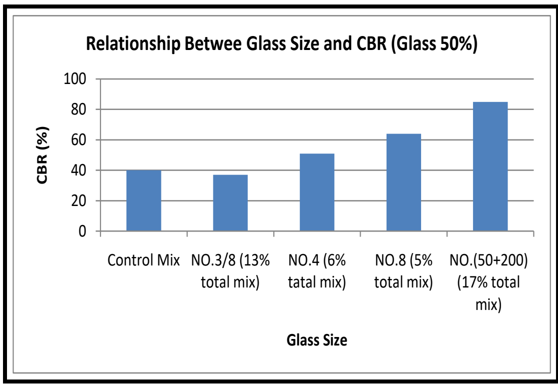
Table (2) Specification of Materials Used.

US Sieve Size (in) (ASHTOO T27 2005)							
3	2	1	3/8	No.4	No.8	No.50	No.200
-	100	85	58	45	34	21	10
CBR (%) (ASHTOO T193 2003)	**SO3**	**Gypsum (%)**	**Max. Dry Density (kgm/cm3) (ASHTOO T180 2004)**		**W.C (%) (ASHTOO T265 2004)**	**L.L (%) (ASHTOO T89 2002)**	**P.I (%) (ASHTOO T90 2004)**
40	1.86	4.0	2.23		6	20	4

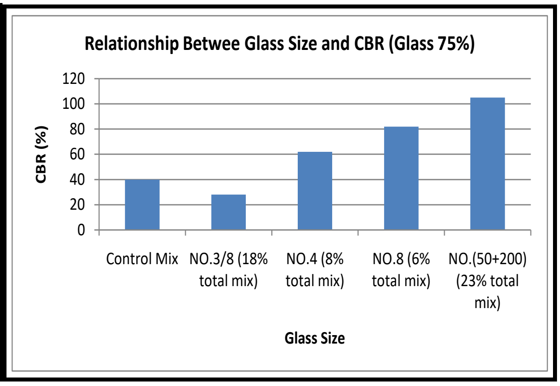
6. Results and Discussion

6.1 Effect of Glass Size

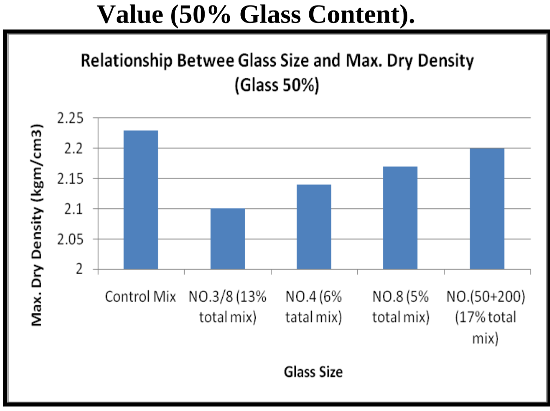
It is well known that the glass size is the major contributor to CBR value of subbase mix. The results of CBR values are presented in Figures (1,2 &3) respectively, it is clear from these Figures that the CBR value increasing with glass size decreasing and the use glass size (ret. No.3/8) and higher than decreasing the CBR value because it was broken when compacted and tested. Figures (4, 5 &6) show the relationship between glass size and max. dry density.

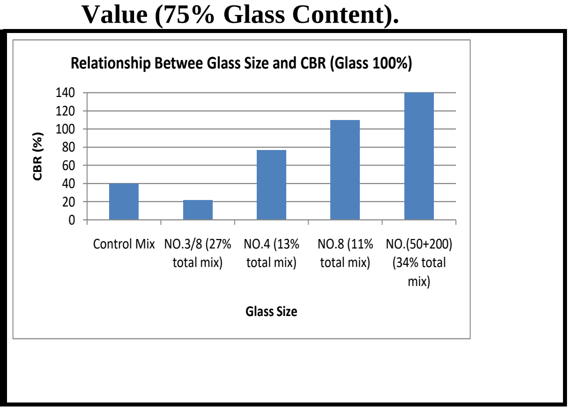


Figure(1): Influence of Glass Size on CBR Value (50% Glass Content).



Figure(2): Influence of Glass Size on CBR Value (75% Glass Content).

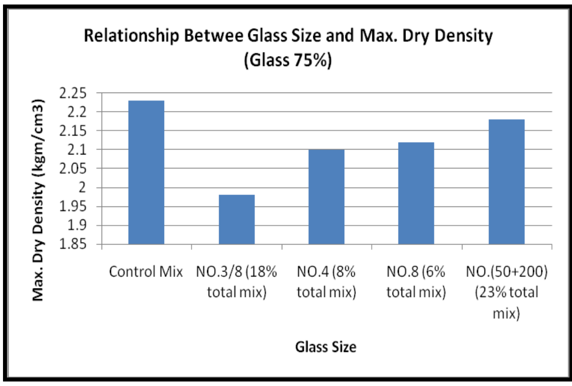




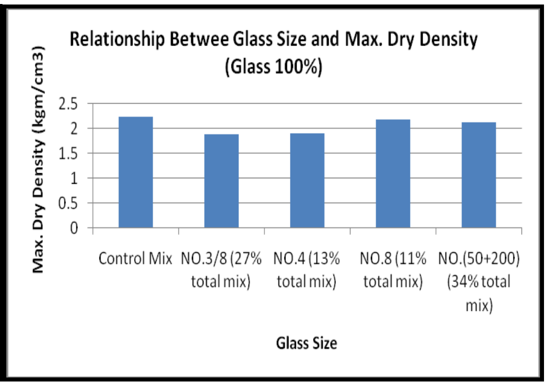
Figure(3): Influence of Glass Size on CBR

Figure(4): Influence of Glass Size on Max. Dry

Value (100% Glass Content). **Density (50% Glass Content).**



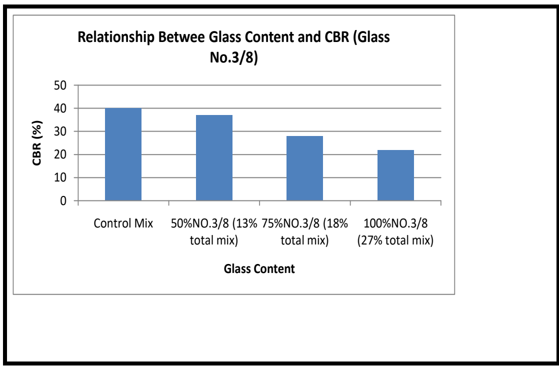
Figure(5): Influence of Glass Size on Max. Dry Density (75% Glass Content).



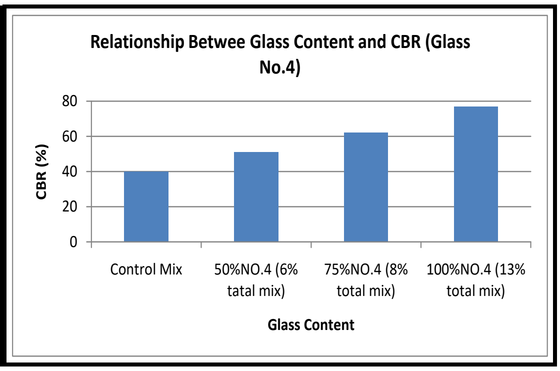
Figure(6): Influence of Glass Size on Max. Dry Density (100% Glass Content).

6.2 Effect of Glass Content

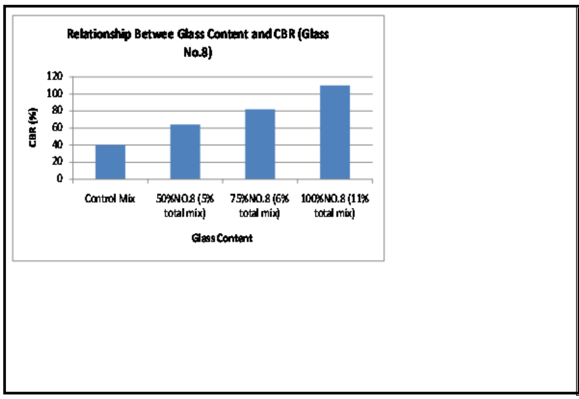
The glass content is another major factor affecting the CBR value. The results of CBR value are presented in Figures (7,8,9 &10). It can be seen from these Figures that with the increasing of glass content (expect glass size 3/8), the CBR value of subbase mix significantly increases. Figures (11, 12, 13 &14) show the relationship between glass size and max. dry density.

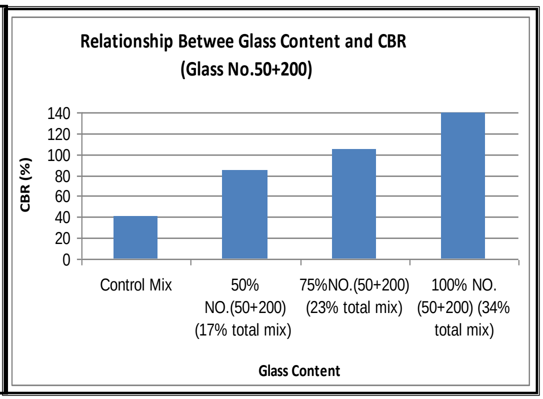


Figure(7): Influence of Glass Content on CBR Value (Glass Size 3/8).



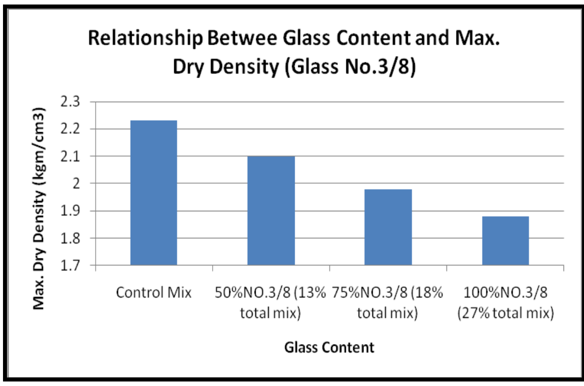
Figure(8): Influence of Glass Content on CBR Value (Glass Size No.4).



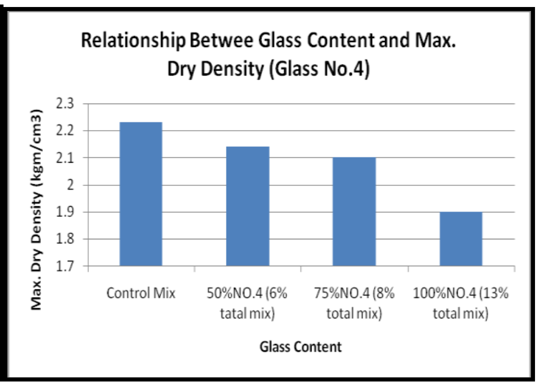


Figure(9): Influence of Glass Content on CBR Value (Glass Size No.8).

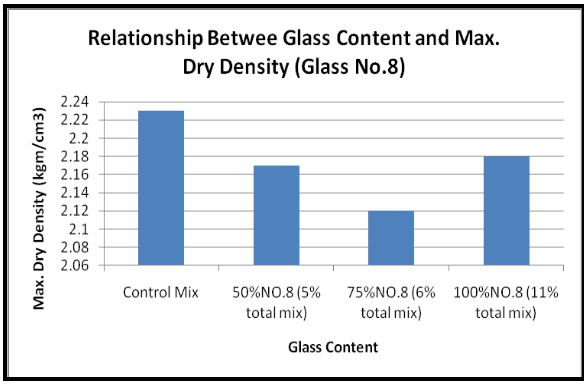
Figure(10): Influence of Glass Content on CBR Value (Glass Size No.(50+200)).



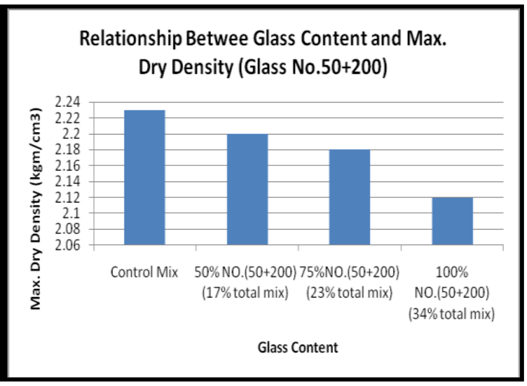
Figure(11): Influence of Glass Content on Max. Dry Density (Glass Size 3/8).



Figure(12): Influence of Glass Content on Max. Dry Density (Glass Size No.4).



Figure(13): Influence of Glass Content on Max. Dry Density (Glass Size No.8).



Figure(14): Influence of Glass Content on Max. Dry Density (Glass Size No.(50+200)).

7. Conclusion

Within the limitations of materials and testing program adopted in this work, the following are concluded:

1. CBR value is increasing when glass size decreasing.
2. Using glass size higher than 5mm decreases CBR value.
3. Using (17, 23 and 34%) glass size lower than 0.3 mm had increased in CBR value from 40% to (85, 105 and 140%) respectively.

8. Recommended

1. Using waste glass in subbase layer and stabilized with lime.
2. Conduct further studies to determine the resilient modulus of waste glass in subbase materials.

9. References

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