Crushed Stone Garments Wash on Denim & Knit Fabric to Ensure Sustainability Focus on Shade Variation and Visual Appearance

**Engr. Md. Eanamul Haque Nizam, Md. Reyad Sarker, Md. Shihab Uddin,
Md. Moniruzzaman, Arif**

Department of Textile Engineering,
Southeast University,
Dhaka, Bangladesh
eanamul.nizam@seu.edu.bd

Abstract-The purpose of this study is to reuse the crushed stone in a garment washing factory to conform to future sustainability by viewing the shade variation and visual appearance of the garment sample. Among 10 grades of crushed stone, the research team has taken three types (2, 3, and 5) to see the results. For testing purposes, six types of denim and knit fabric have been used in the factory lab. After washing the sample denim fabrics (woven and knit denim), a shade variation test (CMC DE, DL*, Da*, Db*, DC*, DH*, and Metamarism Index) was conducted in the factory to see the results. There are three woven denim samples that have passed the buyer standard, and other types of garments woven denim samples failed because of crushed stone size. On the other hand, most of the knit denim samples have passed the metamorphism index value, which meets the ISO standard.

Keywords- Crushed stone, Garments washing, Denim, sustainability.

I. INTRODUCTION

Construction aggregate, such as crushed stone or angular rock, is typically created by mining a suitable rock deposit and using crushers to reduce the removed rock to the required size. It differs from naturally occurring gravel, which is created by erosive weathering processes and typically has a more rounded shape. The main component of macadam road construction, angular crushed stone, depends on the interlocking of the angular faces of the individual stones for strength [1,2].

- As riprap
- As railroad track ballast
- As filter stone.
- As composite material (with a binder) in concrete, tarmac, and asphalt concrete.

1. Crushed Stone Grade 1-10[3, 4]
Generally, as the grade number goes up, the size of the stone goes down.
Crushed stone in the 1 crushed stone grade, which is the largest of the crushed stone grades, ranges in length from 2-4 inches. For bigger jobs or to fill in bigger holes, this material works great. The length of the stone in this size ranges from 1/2 to 2 inches. For projects requiring drainage and railroads, this material is a great option.

- The size of crushed stone in the number 5 is one inch or less. For use as a paver base and road surface, this material is ideal.

Fig 1. Different crushed stone size. [7]

- The size of these stones ranges from 3/8 to ½ inch. It is the stone that is used in concrete mixtures the most frequently. Crushed stone 10 is also referred to as dust or screenings. Pavers and concrete blocks are typically made with this material [5.6].

2. Objective of this study:

- To see the shade variation before and after wash.
- To see the visual appearance before and after wash.
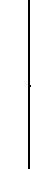
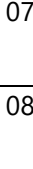## II. MATERIAL & METHOD

1. Materials:

Table 1. Fabrics (Denim). [8]
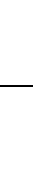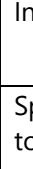
Sl No	Fabric Composition	Fabric Construction	Gsm In Oz	Fabric Picture
01	66% Cotton 25% Poly 8% Rayon 1% Spandex	91 x 48/10 x 16+40D	10.5	
02	70% Cotton 28% Poly 2% Spandex	10 x 300/70D	11.0	
03	71.5% Cotton 25% Tensile 2% Rayon 1.5% Spandex	RS 10 x T/R16/70D 94 x 53	10.5	
04	77.5% Cotton 21.2% Poly 0.3% Rayon 1% Spandex	10 x 150 / 40D	8.5	
05	70% Cotton 29% Poly 1% Spandex	16 x 200 / 40D	8.5	
06	80% Cotton 18% Polyester 2% Spandex	15 x 200 / 70D	9.0	

Table 2. Fabrics (Knit).[8]

Sl. No.	Fabric Composition	Fabric Construction	Gsm In Gm/M2	Fabrics
01	97% Cotton 3% Elastane	30 x 24G 30s Cotton+ 40D Elastane.	240	
02	100% Cotton	28 x 20G 16s/1 Cotton	230	
03	95% Cotton 5% Elastane	30 x 24G 26s Cotton + 70D Elastane	320	
04	82% Cotton 14% Polyester 4% Elastane	30 x 20G 30s/1 Cotton + 40D Elastane +75D	200	

Table 3. Machines.[8]

S.No	Name	Brand	Remarks
		Polyester	
01	Washing Machine	DANIS-DCN 028, DCN110	
02	Washing Machine	TONELLO-HW,70LW1	
03	Dryer Machine	Triveneta-GrandiImpianti	
04	Hydro Extractor		
05	Rota Color Fastness	SDL Atlas	
06	Crock Meter	SDL Atlas	
07	Incubator	Perspirometer Kit Sdl Atlas	
08	Spectophoto Meter	Spectrum	
09	Light Fastness Machine	Atlas/Amet Ek	

III. RESULTS

1. Shade Variation (Woven denim garments):

Table 4. Shade Variation (Denim)- ISO 10243600

SampleNo	Obs	Cmc Decision	Cmc De	Dl*	Da*	Db*	Dc*	Dh*	Metamarism Index
1	U3000 10 Deg	Pass	0.73	0.07	-0.26	-0.51	0.57	-0.08	
	D65 10 Deg	Pass	0.73	0.13	-0.27	-0.44	0.38	-0.35	0.08
2	U3000 10 Deg	Fail	4.40	-2.24	-0.62	-4.07	4.07	-0.65	
	D65 10 Deg	Fail	3.72	-1.88	-0.07	-3.26	3.16	-0.79	1.24
	U3000	Fail	8.38	-	-	-	8.49	-	

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		Result	DE*	DL*	Da*	DH*	Db*	Dc*	MI
3	10 Deg			1.51	2.43	8.39		2.08	
	D65 10 Deg	Fail	6.89	-0.60	-1.44	-6.49	6.21	-2.36	2.49
4	U3000 10 Deg	Fail	4.53	0.74	-1.87	-5.25	5.34	-1.58	
	D65 10 Deg	Fail	4.18	1.40	-1.33	-4.03	3.84	-1.80	1.38
5	U3000 10 Deg	Fail	2.72	1.66	-0.28	-1.51	1.42	-0.59	
	D65 10 Deg	Fail	2.45	1.77	-0.12	-1.22	1.05	-0.64	0.32
6	U3000 10 Deg	Fail	5.80	-2.24	-1.70	-5.36	5.33	-1.80	
	D65 10 Deg	Fail	4.90	-1.68	-1.23	-4.20	3.83	-2.11	1.57

IV. DISCUSSION

1. Discussion of shade variation -> 1.
CMC= Colour Management Committee.

CMC is not a colour space but a colour tolerance represented by a single numerical value E. Where D/Delta are indicating the Difference. L= Lightness; C= Chroma; H= Hue. The tolerance of DE is, 0-0.75 is pass, 0.76-1= commercially pass/Warn; above 1 is fail. And metamerism Index are indicate about the deviation of shade from different light source. And its tolerance value is, 0-0.50 pass, above 0.50 is fail.

Here,
DE*= Total colour difference value.
DL*= Difference in Lightness/Darkness
(If, += lighter; -= Darker)
Da*= Difference on Redder/Greener
(If, += Redder; -= Greener)
Db*= Difference on Yellow/Blue
(If, += yellow; -= Blue)
Dc*= Difference in chroma
(If, += Brighter; -= Duller)
DH*= Difference in Hue.

So, from uppers meaning of each segment, the different value given by CMC we can understand that out shade is.

Light source U30,
- 0.7% Lighter [DL*×10=% Of shade]
- 2.6% Greener [Da*×10=% Of shade]
- 5.1% Blue [Db*×10=% Of shade]
- 5.7% Brighter [Dc*×10=% of shade]

And shade &Metamarism Index is passed as well.
Light source D65,
- 1.3% Lighter [DL*×10=% Of shade]
- 2.7% Greener [Da*×10=% Of shade]
- 4.4% Blue [Db*×10=% Of shade]
- 3.8% Brighter [Dc*×10=% of shade]
And shade &Metamarism Index is passed as well.

Light source U30,
- 22.4% Darker [DL*×10=% Of shade
- 6.2% Greener [Da*×10=% Of shade]
- 40.7% Blue [Db*×10=% Of shade]
- 40.7% Brighter [Dc*×10=% of shade]
 And shade &Metamarism Index is passed as well.

Light source D65,
- 1.3% Lighter [DL*×10=% Of shade]
- 2.7% Greener [Da*×10=% Of shade]
- 4.4% Blue [Db*×10=% Of shade]
- 31.6% Brighter [Dc*×10=% of shade]
 And shade &Metamarism Index have been failed.

Light source U30,
- 15.1% Darker [DL*×10=% Of shade]
- 24.3% Greener [Da*×10=% Of shade]
- 83.9% Blue [Db*×10=% Of shade]
- 84.9% Brighter [Dc*×10=% of shade]
 And shade &Metamarism Index is passed as well.

Light source D65,
- 1.3% Lighter [DL*×10=% Of shade]
- 2.7% Greener [Da*×10=% Of shade]
- 4.4% Blue [Db*×10=% Of shade]
- 6.21% Brighter [Dc*×10=% of shade]

And shade &Metamarism Index have been failed.
For 1st sample we can see the result is 0.73 So this sample is pass as we discussed above with pass, warn, and fail with details. For 2nd to 6th sample of denim fabric we see the test result is more than 1 So that samples are failed in this test. Because we only had a small amount of Denim sample, we had to use chemicals and other materials in a ratio to wash the fabrics. As a result, it cannot produce a better shade, and some tests failed.

2. Shade Variation (Knit denim garments):
For the first sample, we can see the test result is below 0.75, so this sample is passed in this test. The 2nd sample fabric test rate is under 0.75–0.99, so it's got warning. For 3rd and 4th sample test result is below 0.75 that's why both samples pass in this test.

All the Knit samples are passing in this test. We know that stone wash has never been used for knit fabric, but we tried it with knit fabric to see the result of the stone effect and the test result. We see from all the tests that knit fabric passed many tests with very good results, as well as the light fastness test.

Table 5. Shade Variation (Knit)- ISO 10243 600

SampleNo	Obs	Cmc Decision	Cmc De	Dl*	Da*	Db*	Dc*	Dh*	Metamarism Index
1	U3000 10 Deg	Pass	0.68	0.46	-0.22	-0.36	0.42	-0.07	
	D65 10 Deg	Pass	0.74	0.48	-0.23	-0.37	0.40	-0.17	0.03
2	U3000 10 Deg	Warm	0.96	1.10	-0.09	0.63	-0.63	-0.10	
	D65 10 Deg	Warm	0.86	1.00	-0.27	0.44	-0.49	-0.18	0.37
3	U3000 10 Deg	Pass	0.06	-0.02	-0.03	0.06	-0.06	-0.04	
	D65 10 Deg	Pass	0.08	-0.02	-0.06	0.00	0.00	-0.06	0.07
4	U3000 10 Deg	Pass	0.17	-0.14	-0.06	0.06	-0.05	-0.07	
	D65 10 Deg	Pass	0.32	-0.15	-0.21	0.00	-0.01	-0.21	0.15

3. A Light fastness test:

Table 6. CF To Artificial Light Test (Iso 105-B-02) Woven Denim.

	Before Wash	After Wash
Sample-01	4	3-4
Sample-02	3-4	3
Sample-03	3	3-4

From table 6 and graph 1, we can see that the before-wash result is 3-4 and the after-wash result is

also 3-4. Buyer-approved results are above 3, so all denim fabric light test results are passed. This machine's price is so high. Light fastness test required 24 hours to 72 hours to complete the test and it's a very costly test.
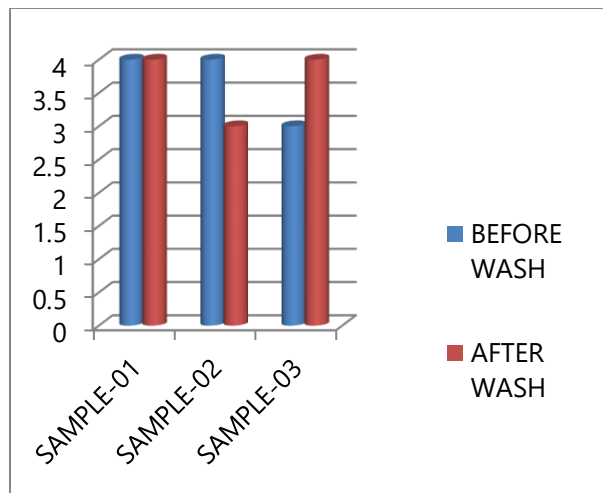
Fig 2. Graph 1: Summery of Artificial Light test (Denim).

For this reason, factories can't bear it. For those factories that have this machine, they don't use it without buyer requirements. For this causes we were not getting an opportunity to test our sample. Because of the lengthy testing process, we had only one opportunity to test for a long time. In that case, we didn't test more than this sample.

4. b Light fastness test:

Table 7. CF to Artificial Light Test (ISO 105-B-02) Knit Denim.

	Before Wash	After Wash
Sample-01	3-4	3-4
Sample-02	3	3
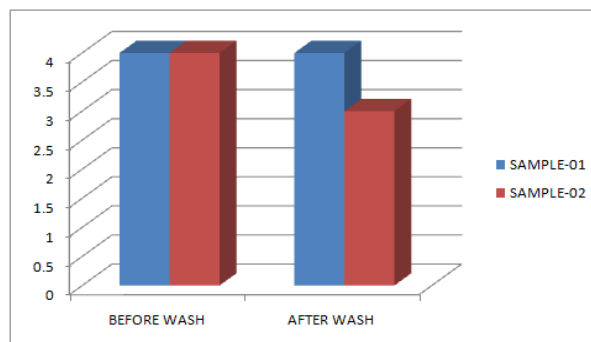
Fig 3. Graph 2: Summery of Artificial Light test (Knit).

From table 7 and graph 2, we can see that the before-wash result is 3-4 and the after-wash result is also 3-4. Buyer Approved result is above 3 so all Knit fabric light test result is passed. Light fastness test required 24 hours to 72 hours to complete the test and it's a very costly test. For this reason, factories can't bear it. For those factories who have this machine they didn't use this machine without buyer requirement. For these reasons, we were not getting an opportunity to test our sample. Because of the lengthy testing process, we had only one opportunity to test for a long time. In that case, we didn't test more than this sample.

Table 8. Woven denim appearance before and after crushed stone wash.
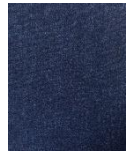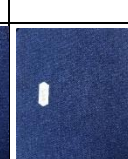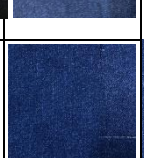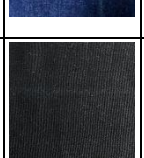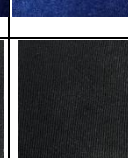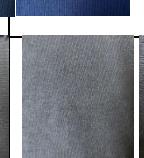
Sample No.	Before Wash	Grade - 1 Stone Wash	Grade - 3 Stone Wash	Grade - 5 Stone Wash
01				
02				
03				
04				
05				
06				

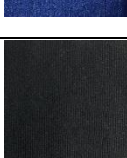Table 9. Knit denim appearance before and after crushed stone wash.

Sample No.	Before Wash	Grade - 1 Stone Wash	Grade - 3 Stone Wash	Grade - 5 Stone Wash
01				
02				
03				
04				

IV. CONCLUSIONS &RECOMMENDATIONS

The crushed stone garment washing it's a new concept for garments washing industries. Natural or pumice stone is very costly in recent years. So, it's very tough to collect the stone from different countries with a huge investment. For these reasons, the buyer recommends, most of the time, sustainable garment washing.

Because of these reasons, the research team has selected three types of stone grades to see the final appearance and shade variation. In the future, any research team can conduct tests using 13-grade crushed stone.

V. ACKNOWLEDGEMENTS

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