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Preparation of High Strength Concrete using Meta-kaolin and Investigating its Freeze - Thaw Resistance

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Preparation of High Strength Concrete using Meta-kaolin and Investigating its Freeze-Thaw Resistance

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Abstract

The Worldwide consumption of concrete aggregates is approximately 11.5 billion tons per year for the construction of any infrastructures (Mehta and Monteiro, 2013). It has been predicted that more than 2.5 billion tons per year of coarse aggregates are expected to be consumed by the year 2020 for construction purposes (USGS, 2009). The raw material (i.e., coarse aggregate) used for concrete is becoming costly, depleting day by day, and its production uses a substantial amount of energy. Hence, the recycled aggregate (RA) provides the perfect solution for this growing problem. RA implementation would not only help in reducing landfill costs but also it stands as a eco-friendly solution to conserve natural virgin aggregates. Therefore, using these recycled aggregates presents a sustainable solution to the environmental impact at hand. Also, literature said that meta-kaolin is substance that can improve the strength of the concrete and more room than a natural aggregate consists is required for improved freeze-thaw resistance. For this, recycled aggregate has more voids and room inside for the water to expand when it melts inside.Hence, the current research foccuses on finding an optimum high strength concrete mix with an improved freeze-thaw resistance.

Methodology

- The standard test method for sieve analysis of fine and coarse aggregates determines the particle size distribution of fine and coarse aggregates by sieving.
- The standard test method for relative density and absorption of fine and coarse aggregate determine the specific gravity and absorption of the aggregates.
- The standard test method for resistance of coarse aggregate to degradation by abrasion determines the resistance to abrasion using the Micro-deval apparatus.
- Tests on freeze-thaw resistance of concrete include the relative dynamic modulus, weight loss and the length change tests.
- Slump test and air content tests are considered default when concrete was mixed initially. The air entrainment used was AEA PolychemVCR and super plasticizer was Melchem-M , both from GRT, Inc.
- The standard test method for compressive strength determine the compressibe strength of the specimens such as molded cylinders and drilled chores. All the test methods were and will be performed based on various ASTM specifications as shown in the references section.

Problem Statement

To find the optimum concrete mix which includes meta-kaolin and air entrainment to check for increase in the freeze-thaw resistance and durability of the recycled aggregate concrete. Concrete is mixed with different percentages of meta-kaolin and air entrainment as a trail and error substitution.

Results and Discussions

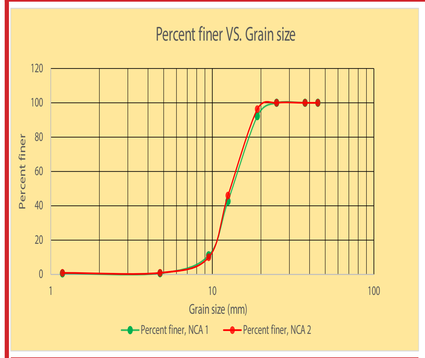

Figure 1: Gradation curve of natural concrete aggregate

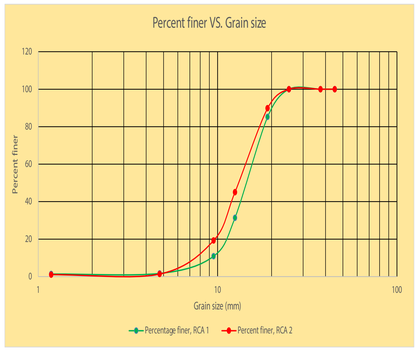

Figure 2: Gradation curve of recycled concrete aggregate

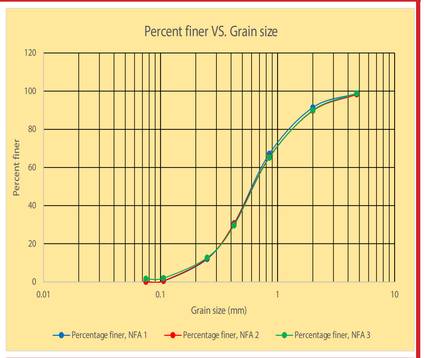

Figure 3: Gradation curve of natural fine aggregate

Material	NCA	RCA	NFA
Relative Density (Specific gravity) (OD)	2.66	2.39	2.59
Relative Density (Specific Gravity) (SSD)	2.67	2.46	2.58
Apparent Relative Density (Specific gravity)	2.68	2.58	2.57
Absorption	0.33	2.93	0.68

Table 1: Absorption and specific gravity test results of natural coarse, recycled coarse and natural fine aggregates

Figure 4: Apparent Relative Density Test

Figure 5: Before and After of the Micro-deval test

Passing Sieve	Retained	Mass required (g)	NCA (g)	RCA (g)
19 mm	16 mm	375	375.743	375.437
16 mm	12.5 mm	375	375.423	375.654
12.5 mm	9.5 mm	750	749.064	752.149
Initial weight (g)		1500	1502.23	1503.24
Final weight (g)			1313.93	1233.83
Percentage loss			12.5	17.9

Table 2: Results of micro-deval test including percentage abrasion loss.

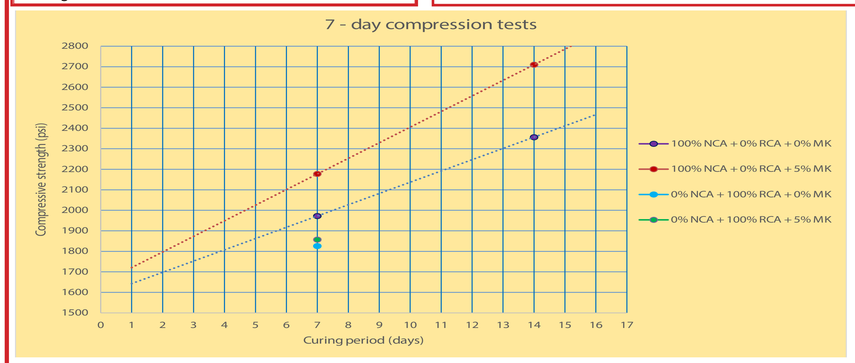

Table 3: Seven days compression test results - shows clear increase in strength of concrete due to meta-kaolin

Fig 6: Compression test of a cylindrical sample

Figure 7: Freeze - Thaw Chamber in the labararatory

Concrete Mix	Slump (in)	Slump with superplasticizer (in)	Air content (%)	Compressive strength (psi)	
				7 - days	14 - days
100% NCA + 0% RCA + 0% MK	2.9	4.5	7.5	1972.2	2709.41
100% NCA + 0% RCA + 5% MK	2.9	4.9	7.2	2177.19	2941.46
0% NCA + 100% RCA + 0% MK	3	4.6	7.2	1825.95	4/4/2017
0% NCA + 100% RCA + 5% MK	2.4	4.5	7.6	1857.1	4/5/2017

Table 4: Slump and Air - content of different concrete mixes

Conclusions

- The Particle size gradation of the fine aggregate has the least size of 0.075 mm and the maximum size of almost 4.75 mm; whereas, the natural and recycled coarse aggregate both have the least size of 1.18 mm and the maximum of 19 mm diameter.
- The three different relative densities and absorption values of the fine, natural coarse and recycled coarse aggregates were found out and presented in the results and discussion section as shown. It can be seen that the recycled aggregate has a very high absorption value and a lower specific gravity than the natural aggregate.
- According to the microdeval results, it is found that abrasion resistance of recycled aggregates is much weaker than that of the natural or virgin aggregates. The recycled coarse aggregate definitely has less density and more air content as compared to the natural aggregate which is required for the improved freeze-thaw resistance.
- The compressive strength of the natural aggregates has increased by 9.5 % and that of the recycled aggregate has increased around 1.8% at seven days on the addition of 5% meta-kaolin. It's my hypothesis that this strength will increase with time and with a different percentage addition of meta-kaolin.

Limitations: Due to several external factors includ-ing the shortage of time and recycled aggregate, this research couldn't be completed to its fullest and hence, the freeze-thaw tests and compression tests are still going on and will be completed by late summer this year.

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