AN EXPERIMENTAL AND FINITE ELEMENT STUDY ON REINFORCED CONCRETE BEAMS UTILIZING ALUMINIUM WASTE IN IMPROVING SHEAR PERFORMANCE

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Keywords:

Aluminum, Finite Element, Shear, Concrete, Waste, Optimum, recycling, cement

Introduction:

Now a days, in the field of construction we are predominantly re-using the various Non-renewable resource like aggregates, wood, various metals, glass etc. thereby reducing the waste generated in the field of construction. Today, many favourable circumstances exist for the useful and beneficial reduction of waste generated that might have been disposed in our environment but thanks to those recycling, reuses and construction base recovery of waste and the systems that allows such to be feasible. Waste materials are a major environmental problem, which is a threat to the environment. It is important to reuse these materials and dispose of them. Waste can be used in the construction industry in two ways: by reusing (reuse components) and recycling (processing waste into raw materials used in the production of building materials).

Aluminium is one of the extensively used construction resources in the globe, and throughout the aluminium manufacture, a huge amount of waste is generated. During the smelting process of aluminium, Aluminium dross/waste, a by-product is obtained. Certain industrial waste materials like aluminium dross/waste, when appropriately processed and integrated into construction materials, can enhance properties like strength, durability, thermal conductivity, and insulation.

There are noticeable effects on workability, compressive strength, flexural strength, and density. The decrease in these properties is often attributed to the release of hydrogen gas due to the chemical reaction between aluminium and cement's alkaline content. Varying percentages of aluminium waste replacements (ranging from 0% to 30% by weight of cement) have been tested in different studies. The optimal replacement levels differ across studies, with some reporting better strength at lower replacement percentages (e.g., 20% replacement of aluminium dross) while others identify 10% as optimal.

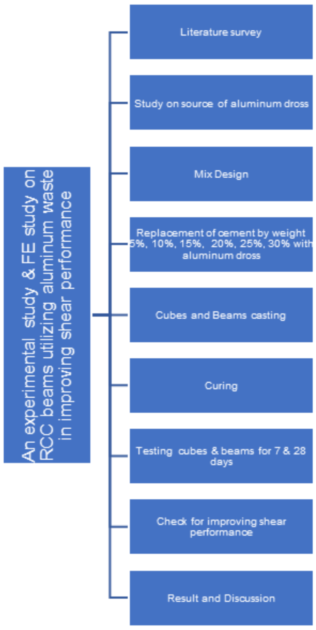
Objectives:

The primary aim of this experimental study is to investigate the impact of incorporating Aluminium waste into Reinforced Concrete Beams that exhibit insufficient shear capacity.

1. Study the influence of different proportions of Aluminium waste on the shear capacity, strength, and deformation characteristics of the RC Beams under vertical loads.
2. Evaluate the mechanical properties, including shear strength, ductility, and crack propagation behaviour, of reinforced concrete beams containing varying proportions of aluminum waste.
3. Conduct numerical simulations using finite element models to validate and correlate experimental findings. Evaluate the accuracy and reliability of these models in predicting the behaviour of Reinforced Concrete Beams with Aluminium waste.
4. Optimize the mix design parameters, such as aluminum waste content, water-cement ratio, and aggregate gradation, to maximize the shear strength and efficiency of reinforced concrete beams.

Methodology:

The various materials used in the projects are aggregates consisting of coarse aggregate 20mm and fine aggregate M sand, cement, water, aluminum waste, plasticizers and steel reinforcement. The Experiment such as Specific Gravity is conducted on these materials in order to ensure Quality control, to obtain required density, to enhance durability & performance and for mix designing. Marsh flow test is conducted on cement by keeping water cement ratio constant and by varying the percentage of plasticizers in order to determine the optimum percentage of plasticizers to be used.



- ***Concrete Mixing:*** As per the Design Mix of M20, suitable quantity of materials are added and mixed well in concrete mixing machine
- ***Transport and placement:*** Concrete mix is carried to the place of casting without spillage and placed over the suitable moulds
- ***Beam Casting:*** Formwork of beam of specified size should be made ready and is applied with form release agent or mould oil to the interior surfaces of the formwork to facilitate easy removal of the concrete beams after casting. Reinforcement to be placed at suitable position over the cover blocks and concrete is poured over the formwork
- ***Finishing and Consolidation:*** Concrete poured over formwork need to be compacted well with the help of vibrator and top surface is finished smooth
- ***Demoulding and Curing:*** Formwork/mould is removed and beam is placed inside a tank for curing period of 7 days and 28 days.
- ***Testing and Quality Control:*** Once the concrete beams have completed the curing period, conduct quality control tests, such as compressive strength tests, flexural strength

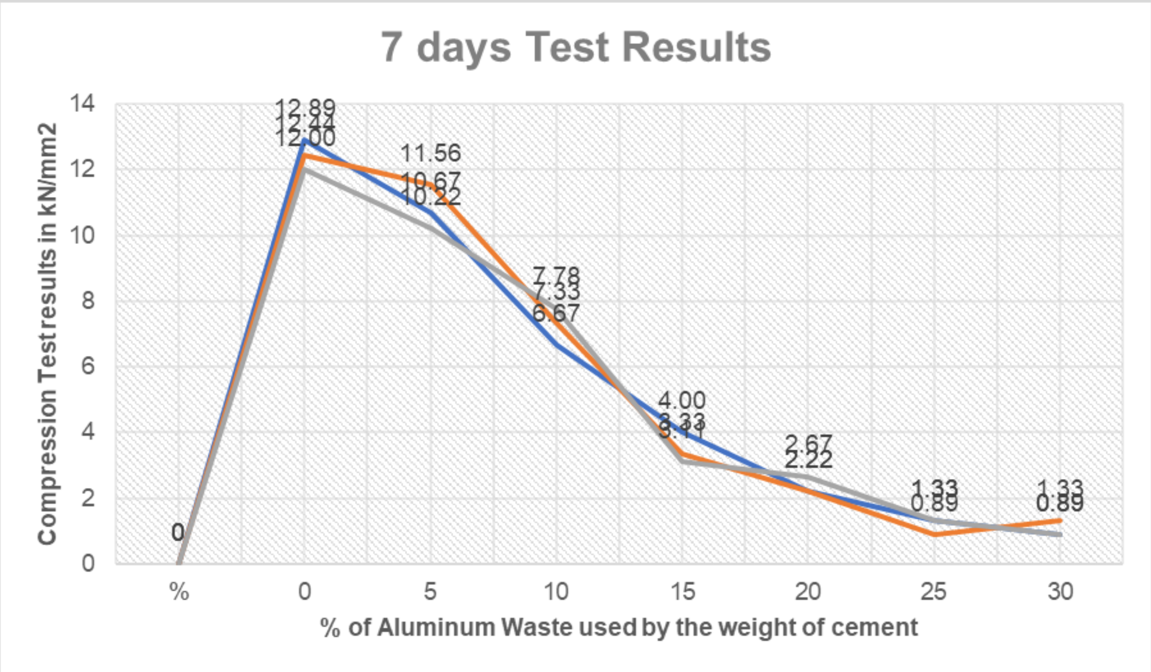
Conclusion:

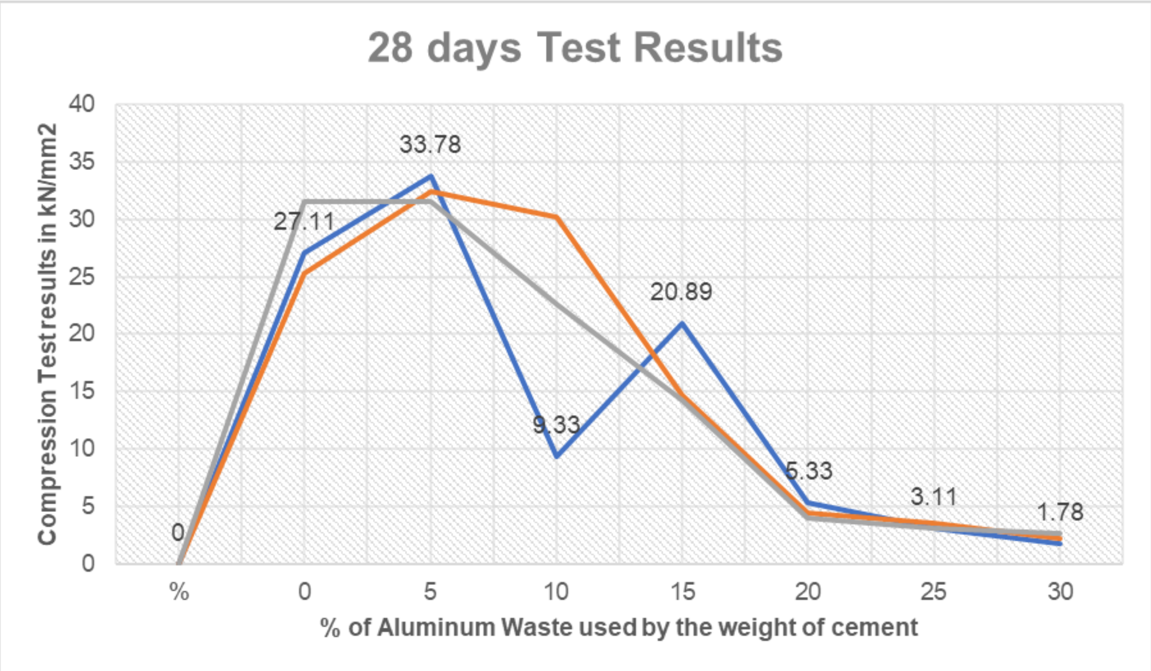
The Cubes are casted with 0%, 5%, 10%, 15%, 20%, 25%, and 30% replacement of cement by aluminum waste by the weight of cement. Specific gravity of cement, coarse & fine aggregate and aluminum waste is determined by test conducted in lab and the value is used for the design mix calculation. The quantity of cement, water, plasticizers, coarse aggregate and fine aggregate is determined by the Design mix calculation for M20 and using OPC 43 grade cement, with moderate exposure environment, target slump of 75mm, fine aggregate confined to zone III, maximum size of aggregate is 20mm and water absorption of 0.86% for coarse aggregate & 1.25% for fine aggregate.

For each % of aluminum waste 6 cubes are casted, 3 are tested for 7 days and the other 3 are tested for 28days. Results. The test conducted is compression test and the results for 7 days and 28days are as tabulated below and the graph is plotted for the same.

	7 days Test Results (kilo Newton/mm^2)			
		Cube 01	**Cube 02**	**Cube 03**
% of Aluminum Waste (by weight of cement)	**0%**	**12.89**	**12.44**	**12.00**
	5%	**10.67**	**11.56**	**10.22**
	10%	**6.67**	**7.33**	**7.78**
	15%	**4.00**	**3.33**	**3.11**
	20%	**2.22**	**2.22**	**1.33**
	25%	**1.33**	**0.89**	**1.33**
	30%	**0.89**	**1.33**	**0.89**

	28 days Test Results (kilo Newton)			
		Cube 01	Cube 02	Cube 03
% of Aluminum Waste (by weight of cement)	0%	27.11	25.33	31.56
	5%	33.78	32.44	31.56
	10%	9.33	30.22	22.67
	15%	20.89	14.67	14.22
	20%	5.33	4.44	4.00
	25%	3.11	3.56	3.11
	30%	1.78	2.22	2.67





From the results and graphs of 28 days we can notice that the compression test results will increase till 5% replacement of cement by aluminum waste by the weight of cement.

Now the Beams are casted with 0%, 1%, 2%, 3%, 4%, and 5% replacement of cement by aluminum waste by the weight of cement and tested for flexural strength at 28days. From the results, shear performance of concrete is validated by finite element modelling using Ansys software.

Scope for future work:

1. Optimum percentage of Aluminium Waste for high strength concrete. Here we need to investigate the optimum percentage of aluminium waste in concrete mixes to achieve the maximum enhancement in shear performance while maintaining other mechanical properties such as compressive strength, flexural strength, and durability.
2. Effect of Aggregate Size and Gradation on the shear performance of concrete beams containing aluminum waste. We need to investigate how variations in aggregate sizes and its characteristics can affect the interlocking and shear performance of concrete mix.
3. Durability and Long-Term Performance tests on the concrete with optimum percentage of aluminium waste. We can Conduct long-term durability studies to study the resistance of concrete beams with aluminium waste to environmental factors such as freeze-thaw cycles, chemical attack, and corrosion of reinforcement and to evaluate the durability performance over exposure periods to corelate with the real-world conditions.
4. The environmental impacts and sustainability benefits of using aluminum waste in concrete construction compared to conventional materials like the energy consumption, greenhouse gas emissions, and resource depletion etc.
5. Cost-benefit analysis to evaluate the economic feasibility and financial abstraction of implementing concrete mixes with aluminum waste in construction projects. Assess the overall cost savings, material efficiencies, and market opportunities for utilizing recycled materials in concrete production.