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Experimental Study On Geopolymer Mortar

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ABSTRACT

The thesis is mainly concerned with the investigation of geopolymer concrete with the primary aim of addressing the economic, financial and environmental issues associated with the production and use of ordinary Portland cement. Manufacture of Portland cement is known to produce a much higher volume of carbon dioxide gas into the atmosphere, therefore finding a suitable alternative can bring a desirable solution to mitigate the environmental problems caused by the cement production. The thesis gives a review of geopolymer concrete and critically analyses the economic and environmental benefits of geopolymer concrete over Portland cement concrete. Portland cement utilises waste industrial materials such as fly ash from thermal power stations to provide concrete solutions to waste management as well as environmental remediation problems. Geopolymer concrete products are known to have far better durability and strength properties than Portland cement properties. These properties are investigated in the laboratory and verified. Finally the thesis looks at the factors which may hamper the use of geopolymer concrete as an alternative to Portland cement concrete. It is believed that in some countries, the geopolymer concrete does not comply with some regulatory standards, in particular those that define minimum clinker content levels or chemical composition in contents. The issues are investigated and addressed by the thesis. Steel fibres are added with geopolymer concrete to investigate the behavior of geopolymer concrete. Experimental results show that steel fibres improves the compressive and tensile strength of geopolymer concrete.

INTRODUCTION

Geopolymer concrete has emerges a new engineering material with the potential to form an important aspect of environmentally sustainable construction and building products industry. Geopolymers are alkali-activated aluminosilicates, with a much lower carbon dioxide emission than ordinary Portland cements (Duxson et al, 2007). Industrial aluminosilicates waste materials such as coal ash and blast furnace slag are activated by alkali to form geopolymers. As reported by Duxson et al, geopolymers demonstrate improved strength and chemical properties in addition to many other characteristics which are potentially valuable. Depending on the raw material chosen and processing conditions, geopolymer concrete exhibit a diverse variety of properties, including high compressive strength, low shrinkage, fast or slow setting, acid resistance, fire resistance and low thermal conductivity (Dusxon et al, 2006). The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. The geopolymer paste binds loose aggregates and un-reacted materials together to form geopolymer concrete. The concrete can be produced with or without the use of admixtures. As in the case of

OPC, the aggregates occupy 75-80% by mass of geopolymer concrete (Hardjito & Rangan, 2005). Geopolymeric materials made from coal ash can have better chemical and mechanical properties than ordinary Portland cement products. Early researches have shown that geopolymers can be produced cheaply and can be made when naturally occurring materials are mixed with NaOH and water (Kostas et al, 2007). The manufacture of Portland cement requires the burning of large quantities of fuel, such as coal. The heating of limestone along with the impurities contained in it to produce cement results in high emissions of pollutants including greenhouse gas such as carbon dioxide, carbon monoxide, sulphur dioxide and nitrogen oxides (Riessen, 2006). Excessive carbon dioxide in the atmosphere causes the greenhouse effect which eventually leads to global warming. Geopolymer concrete is therefore expected to provide an appropriate alternative for Portland cement as a binder to mitigate these negative environmental impacts of OPC. The geopolymer concrete can be produced without the need for large quantities of fuel, making it much more energy efficient and obviates much of the environmental pollutants associated with traditional Portland cement production (Duxson et al, 2010). Unlike other technologies, there is not yet a significant bulk of research focused attention on understanding the relationships between composition, processing, microstructure and the properties of geopolymer concretes. Fly ash based geopolymer concrete would be used for studies in this thesis.

OBJECTIVE OF THE STUDY

The objectives of this study are as follows:

- Understand properties of geopolymer concrete in order to use it as alternative for Ordinary Portland cement.
- Establish the economical, technological and environmental benefits of geopolymer binders over ordinary Portland cement.
- To carry out laboratory experiments to verify some of the facts from the literature review.
- Draw conclusion on whether geopolymer technology can provide an appropriate alternative for Portland cement.

The thesis primarily focuses attention on literature review and a desk-top work on geopolymer concrete in an attempt to determine whether it can form a suitable alternative for Portland cement concrete. Limited laboratory work is carried out to verify what the literature says.

MIX PROPORTION

Mix proportion is presented in Table 1 and 2.

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Table 1: Constituents of geopolymer concrete (per 1 m^3)

Sl.No	Mix ratio	Fly ash kg (80%)	GGBS kg (20%)	FA kg	CA kg	NaOH Solution		Sodium silicate	Sodium silicate/ Sodium hydroxide	(Sodium silicate+ Sodium hydroxide)/ (Flyash + GGBS)
						Mass kg	Molarity			
1	1:1.5:3	346	86	648	1296	19.75	8 M	154.29	2.5	0.50
2	1:1.5:3	346	86	648	1296	29.62	12 M	154.29	2.5	0.50

Table 2: Constituents of geopolymer mortar

Sl.No	Mix ratio	Fly ash kg (80%)	GGBS kg (20%)	FA kg	NaOH Solution		Sodium silicate	Sodium silicate/ Sodium hydroxide	(Sodium silicate+ Sodium hydroxide)/ (Flyash + GGBS)
					Mass kg	Molarity			
1	1:3	346	86	1296	19.75	8 M	154.29	2.5	0.50
2	1:3	346	86	1296	29.62	12 M	154.29	2.5	0.50

EXPERIMENTAL RESULTS

Experimental results are shown in Table 3 to 7.

Table 3: Workability of geopolymer concrete

Sl.No	Mix ratio	Molarity of NaoH solution	Slump (mm)
1	1:1.5:3	8 M	175
2	1:1.5:3	12 M	178

Table 4: Compressive strength of geopolymer concrete

Sl.No	Mix ratio	Molarity of NaoH solution	Failure load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
1	1:1.5:3	8 M	870	38.66	38.37
			855	38.00	
			865	38.44	
2	1:1.5:3	12 M	1015	45.11	45.04
			1005	44.67	
			1020	45.33	

Table 5: Split tensile strength of geopolymer concrete

Sl.No	Mix ratio	Molarity of NaoH solution	Failure load (P) (kN)	Split tensile strength(2P/πLD) (N/mm^2)	Average split tensile strength (N/mm^2)
1	1:1.5:3	8 M	305	4.31	4.33
			310	4.38	
			303	4.28	
2	1:1.5:3	12 M	330	4.67	4.68
			340	4.81	
			322	4.55	

Table 6: Compressive strength of geopolymer mortar

Sl.No	Mix ratio	Molarity of NaoH solution	Failure load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
1	1: 3	8 M	1300	57.77	58.22
			1325	58.88	
			1305	58.00	
2	1:3	12 M	1420	63.10	63.10
			1435	63.77	
			1405	62.44	

CONCLUSION

The introduction of geopolymer technology as a feasible technology for construction purposes will form a much better alternative for Portland cement. Geopolymer technology does not only contribute to the reduction of greenhouse gas emissions but also reduces disposal costs of industrial waste. Geopolymer concrete products exhibit far better properties including durability and compressive strength than Portland cement products. Geopolymer technology encourages recycling of waste and finally it will be an important step towards sustainable concrete industry. Results show that addition of steel fibres improves the compressive and split tensile strength of geo-polymer concrete.

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