"TO ENHANCE THE PROPERTY OF CONCRETE BY USING CERAMIC WASTE AS SUPPLEMENTARY CEMENTITIOUS MATERIAL"

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Abstract:- *Due to the high demand of cement in construction. It's required to reduce the production of cement by partially replacement of cement with another material. The aim of this dissertation work is that to reduce the environmental impact, reduce the cement consumption in the concrete by the replacement of ceramic material as a supplementary cementitious material. The study is done in concrete for the ceramic electrical insulator material partial replacement with cement in the concrete and checked its mechanical properties, workability and durability. In the concrete grade M25 cement has been partially replaced in 5%, 10%, 15% and 20% by weight of cement in ceramic waste. Utilization of these ceramic wastes the test performance has been checked by the concrete, here workability test (by slump cone test), mechanical properties test (compressive strength test, flexural strength test, split cylinder tensile strength) and durability test (water absorption and water penetration test) has been tested in the replacement of the ceramic waste material. The process is done in low water cement ratio and fine dense particle because the ceramic has less specific gravity and fill the porous voids.*

Key words:- OPC, ceramic insulator waste, compressive strength, flexure strength, split tensile strength, NDT (non destructive test), workability and durability.

1. INTRODUCTION

1.1 General

Generation of large amount of ceramic insulator waste has been found in electricity board due to heavy voltage insulator becomes breaks. This ceramic insulator waste has not been reused after breaking, in the research area this ceramic waste has been utilized for the replacement with fine or coarse aggregate.

1.2 Environmental studies or issues

Infrastructure development continuously increasing simultaneously the environmental impact has also increases with. Utilization of high amount of cement and other raw materials has the bad effect in sustainability, due to the high cement used in the construction industries high amount of carbon-dioxides released at the manufacturing time of cement. CO_2 has increases the greenhouse gases and farming the global warming effect. Global warming is the main issue or problem for the world, so it's require to control the global warming and other environmental issue.

In the research field the waste has been used in concrete to reduce the environmental impact. Currently fly ash, silica fume and other waste material has been frequently used as a construction material up to a certain level; similarly in research field ceramic insulator waste has been also used in concrete with the replacement of fine and coarse aggregate. If ceramic waste has been utilized in the concrete than it is environment and eco-friendly for the environment.

1.3 Different activities and test

In the concrete to compare the strength and density of the material different types of test has been adopted i.e. mechanical properties test, durability test and carbonation test, also find micro-structure properties of the material etc. In concrete adopted mechanical properties and durability test of concrete that which amount of ceramic waste material has been used for the replacement with cement, both test has a physical properties of the material that indicate the strength and durability of concrete.

To find mechanical properties of concrete the test of compressive strength test, flexural strength test and split cylinder test also analyse the workability of concrete. Mechanical properties have been related to strength of concrete that define structural stability after years ago. Also the workability of concrete has been important role plays that the concrete has workable or not in the field.

2. LITERATURE REVIEW

2.1 Introduction

Researchers are trying to decrease the used of cement in the concrete and mortar, for that purpose used different types of waste materials in the concrete with partial replacement of cement i.e. fly ash, rice husk, slag, glass waste, industrial waste etc. In this study partial replacement of cement by ceramic waste material 5 to 20 %.

S.M.A. El-Gamalet. al. [2] Sayed have done the research work on the "Ceramic waste as an efficient material for enhancing the fire resistance and mechanical properties of hardened Portland cement pastes". According to this research work deployment of industrial by-products like ceramic waste (CW) for enhancing the microstructure and mechanical properties as well as the fire resistance of hardened ordinary Portland cement (OPC) pastes is the main goal of this research. Different cement blends were prepared by partial replacement of OPC with 5, 10 and 20 CW (mass %).

According to these result the ceramic waste has been replaced up to 15 % based on result of mechanical properties and thermal resistance compressive strength values at 1, 3, 7, 28 and 90 days of hydration

Salman Siddiqueet. al. [3] has done the research work in the "Durability properties of bone china ceramic fine aggregate concrete". According to this research work bone china ceramic fine aggregates (BCCFA) can be used for structural applications up to 40% replacement of BCCFA. In this research work the BCCFA was utilised as 0%, 20%, 40%, 60%, 80% and 100% partial replacement of fine aggregate. The hydration products were assessed by X-ray photoelectron spectroscopy.

The water based properties of concrete such as percentage voids; apparent density, water absorption, water permeability (DIN) and chloride ion permeability were obtained for concrete samples.

Luiz Renato Steineret. al. [4] has performed the research work for the "Effectiveness of ceramic tile polishing residues as supplementary cementitious materials for cement mortars". According to these research work the sludge coming from the polishing process of ceramic tiles, particularly 'porcellanato' and 'monoporosa', results in a large amount of waste that requires disposal in controlled landfills. These ceramic waste materials have been replaced up to 15 % with cement that is based on the result of compressive strength, pozzolanic activity index, thermal behavior (calorimetry) and autogenous shrinkage.

Serkan Subaset. al. [5] have done the research work on the "Utilizing of waste ceramic powders (WCP) as filler material in self-consolidating concrete". According to these research work it can be used up to 15% and it can be concluded that finely ground WCPs could be evaluated up to 15% for production of self-consolidating concretes as a filler material if the strength and flow ability parameters are evaluate collectively. In this research work with filler materials finer than 0.125 mm is quite effective on the fresh condition properties, strength and durability of self-consolidating concrete. In this study, use of granulated waste ceramic powder as filler material in self-consolidating concretes was investigated. property of self-consolidating concretes produced with 550 kg/m3 quantity and cement was replaced with (WCP) in the amounts of 5%, 10%, 15% and 20% (by weight) were determined in the fresh and hardened phases.

3. CHARACTERSTICS OF MATERIAL USED

3.1 Materials used in concrete

3.1.1. Cement

In the mortar and concrete OPC 43 grade of ultratech cement passing through 90 micron sieve is used.

Table 3.1 composition of Cement (OPC 43 grade)

Property	Value
Fineness	3200 cm^2/gm
C_3S	21% - 25%
C_2S	52% - 55%
C_3A	6%
C_4AF	7%
SO_3	3%
Na_2O	0.6%
Gypusum ($CaSO_4.2H_2O$)	2.4%
Specific Gravity	3.10

3.1.2. Ceramic insulator waste

In the electricity board due to high voltage the insulator has been break. Insulator has made by the ceramic material. We can use these waste ceramic insulator material as a cement replacement. Waste Insulator has been taken than break by hammer into the 20 to 40 mm aggregate size. These material has been taken in the Los Angeles abrasion machine for 4 hour than find out the mix form of powder and aggregate size material. Sieving this material by different sieves and use the ceramic material that is sieved by the 90 micron sieve.

Figure 3.1: After Abrasion of ceramic material

Table 3.2: chemical composition of ceramic insulator waste.

Chemical oxides compounds (from test)	Test result (in %)
Al_2O_3	50
ZrO_2	0.0
BaO	7.79
$(NaK)O_2$	2.65
SiO_2	39.25
Rest	0.78

Table 3.3: Physical properties of ceramic insulator waste.

Physical quality parameters	Ceramic waste quality parameter result
Specific gravity	2.29
Loose bulk density (kg/m^3)	610.6

3.1.3. Aggregate

The two type of aggregate have been used for this study namely:-

3.1.3.1. Coarse Aggregate

The experimental program,there are two size of coarse aggregate used

a) 10mm- coarse aggregate
b) 20mm- coarse aggregate

The Coarse aggregate is obtained from locally available source i.e from Gunawata, Jaipur NH-8. Size of 20mm coarse aggregate was looked in normal appearance but size of 10mm coarse aggregate was not looked in normal appearance i.e irregular size of grain was more than normal size.

3.1.3.2. Fine Aggregate

There are mainly four numbers of grading zone for the fine aggregate as per IS-383:1970 and these are Grading Zone I, Grading Zone II, Grading Zone III & Grading Zone IV. These zones are classified as per pecentage passing material from different sieve sizes and there are mainly four zones and they all have different passing percentage limit for different sieves but there is only one seive(600 micron) which is almost common to all Zone specification so the zone can be predicted from there. Designated IS- Sieve for the material passing through Zone-II is found.

3.1.4. Super plasticizer

Aura mix 350 used as a super plasticizer in concrete

4. EXPERIMENTAL PROGRAMME

4.1. Experimental programe in concrete

4.1.1 Workability test

Workability of concrete can be measured by mainly slump cone test. For the field use the slump cone test, as per the IS 7320-1974 (reaffirmed 2000) the slump cone test has been performed.

Table 4.1: Workability of concrete.

S. No.	Ceramic waste replacement with cement in concrete (in %)	Workability of concrete by slump cone test (in mm)
1.	Control – 0 %	110
2.	5 %	108
3.	10 %	100
4.	15 %	95
5.	20 %	85

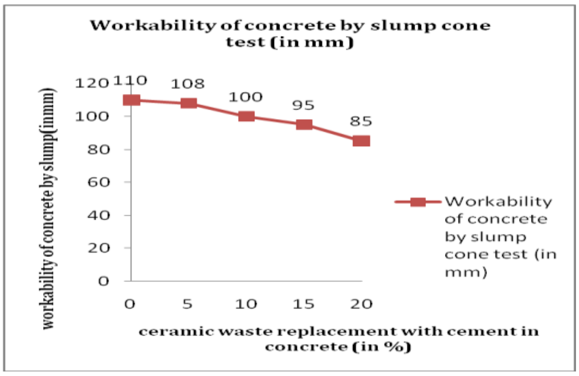

Figure 4.1: Workability of concrete mix with different proportions of ceramic waste.

4.1.2 Mechanical properties test

4.1.2.1. Compressive strength test

Compressive strength of concrete is based on Indian standard BIS 516-1959. According to this code the strength is being carried out at 7 and 28 day. Results are shown the average of 3 cubes reading in MPa and size of the cube is $150*150*150\ mm^3$.

Compressive strength of concrete = P/A

Where P = compressive load (in N) and A = surface area (in mm^2)

Result are showing in the form of compressive strength that is in the ratio of maximum load applied on the cube up to the failure takes place and surface area of the cube.

Table 4.2: Compressive strength result at 7 days

S.No.	Replacement level (in percentage)	Compressive strength at 7 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	25.1	100 %

2.	5% ceramic waste	23.5	93.62 %
3.	10% ceramic waste	22.3	88.84 %
4.	15% ceramic waste	21.8	86.85 %
5.	20% ceramic waste	18.5	73.70 %

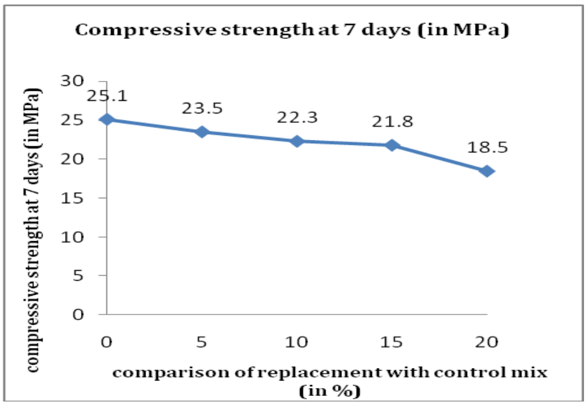

Figure 4.2: Compressive strength of percentage rate of ceramic replacement at 7 days.

Table 4.3: Compressive strength result at 28 days

S.N.	Replacement level (in percentage)	Compressive strength at 28 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	29.5	100 %
2.	5% ceramic waste	27.5	93.22 %
3.	10% ceramic waste	26.16	88.67 %
4.	15% ceramic waste	24.33	82.47 %
5.	20% ceramic waste	21.5	72.88 %

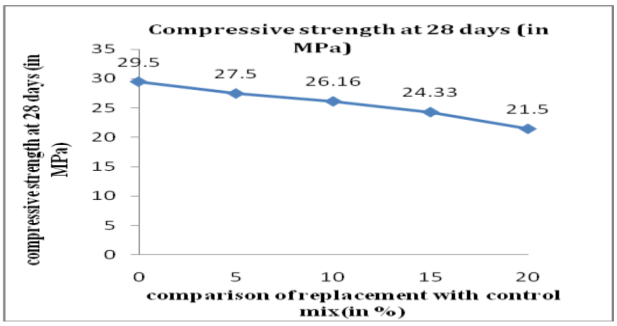

Figure 4.3: Compressive strength of percentage rate of ceramic replacement at 28 days.

4.1.2.2. Flexural strength test

Flexural strength of concrete beam is based on the Indian standard BIS 516-1959 (3-point load). The test is carried out at 28 days and the size of the beam is 700*150*150 mm^3. Flexural strength of beam = PL/Bd^2

Where P = load at which the beam is failed and L = supported length of the beam = 400 mm

Figure 4.4: Flexural testing machine at beam size (700*150*150 mm^3).

Table 4.4: Flexural strength result at 7 days

S.N.	Replacement level (in percentage)	Flexural strength at 7 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	4.88	100 %
2.	5% ceramic waste	4.51	92.41 %
3.	10% ceramic waste	4.11	84.22 %
4.	15% ceramic waste	3.95	80.94 %
5.	20% ceramic waste	3.85	78.89 %

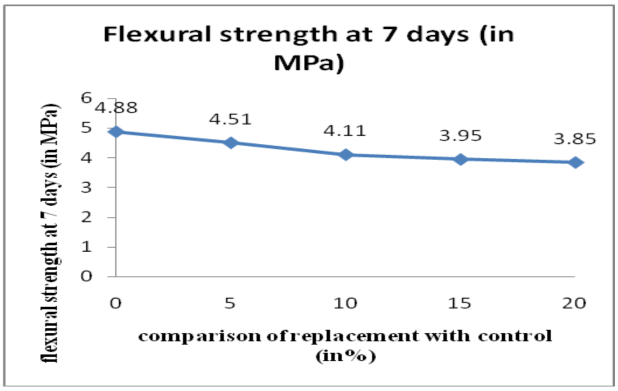

Figure 4.5: Flexural strength of percentage rate of ceramic replacement at 7 days.

Table 4.5: Flexural strength result at 28 days

S.N.	Replacement level (in percentage)	Flexural strength at 28 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	6.71	100 %
2.	5% ceramic waste	6.43	95.82 %
3.	10% ceramic waste	6.27	93.44 %
4.	15% ceramic waste	6.104	90.96 %
5.	20% ceramic waste	6.00	89.41 %

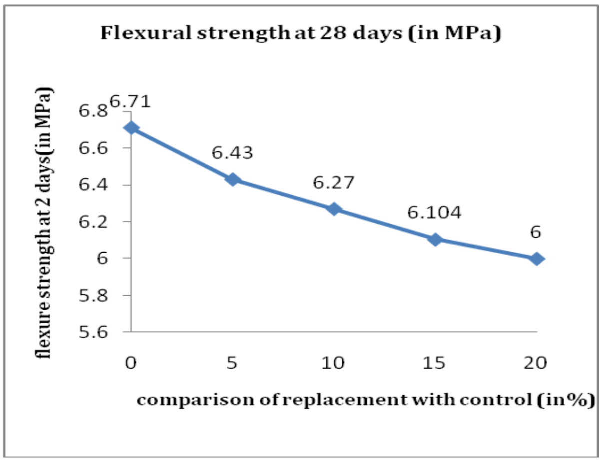

Figure 4.6: Flexural strength of percentage rate of ceramic replacement at 28 days.

4.1.2.3. Split tensile test

As per IS5816 1999 this test has been performed. Split tensile strength of concrete cylinder having 150mm diameter and 300 heights.

The result is calculated the average of three cylinder specimen at 28 days. Formula to calculate the split tensile strength of concrete is given following:

Split tensile strength of cylinder $= \frac{2P}{\pi D L}$

Where P = resulting failure load of concrete in N, L = Length of the cylinder in mm,

And D = Diameter of the cylinder in mm.

Table 4.6: Split tensile strength at 7 days

S.N.	Replacement level (in percentage)	Split cylinder tensile strength at 7 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	2.40	100 %
2.	5% ceramic waste	2.40	100 %
3.	10% ceramic waste	2.26	94.16 %
4.	15% ceramic waste	2.19	91.25 %
5.	20% ceramic waste	2.05	85.41 %

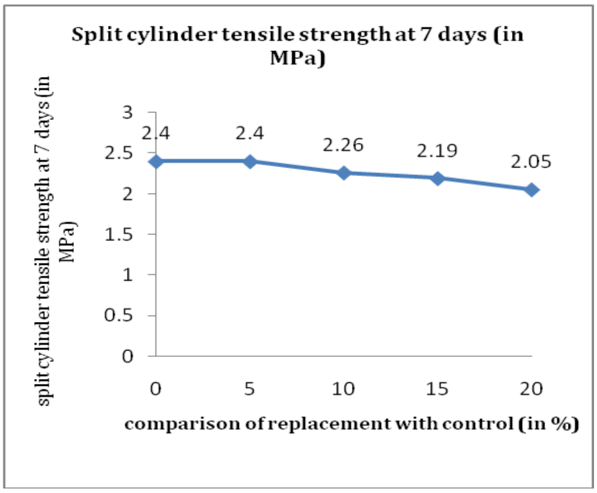

Figure 4.7: Split cylinder strength test of percentage rate of ceramic waste used at 7 days.

Table 4.7: Split cylinder tensile strength at 28 days

S.N.	Replacement level (in percentage)	Split cylinder tensile strength at 28 days (in MPa)	Comparison of replacement with control (in %)
1.	Control (0%)	2.54	100 %
2.	5% ceramic waste	2.47	97.24 %
3.	10% ceramic waste	2.40	94.48 %

4.	15% ceramic waste	2.33	91.73 %
5.	20% ceramic waste	2.12	83.46 %

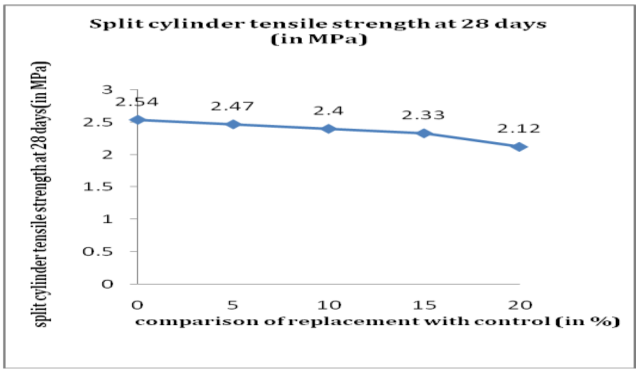

Figure 4.8: Split cylinder strength test of percentage rate of ceramic waste used at 28 days

5. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

In concrete according to the test result of mechanical properties and durability test of ceramic insulator waste material replacement has been successful up to the limitation of 15 % replacement with cement.

Workability

1. Partial replacement of cement by ceramic insulator waste, the slump of the concrete mix was gradually decreased as per replacement is increased (110mm for M25).

2. According to the result the workability of concrete mix is decreases with increase in the percentage of ceramic waste material, means ceramic has been reduces the workability of concrete and less water required for the mixing of concrete.

For 7 Days Compressive Strength

3. According to the result of compressive strength of concrete at 7 days decreases with increase in the percentage of the ceramic replacement. It is more than 80% strength up to the 15% of replacement and at 20% of ceramic waste replacement its less than 80% strength as compare to control.

4. Compressive strength of concrete of control mix is observed 25.1 N/mm^2 (M25) and at 15%replacement of opc with ceramic insulator waste observed is21.8 N/mm^2.

5. At 20% of ceramic waste replacement its less than 80% strength as compare to control. It observed 18.5 N/mm^2.

For 28 Days Compressive Strength

6. According to the result of compressive strength of concrete at 28 days decreases with increase in the percentage of the ceramic replacement. It is more than 80% strength upto the 15% of replacement and at 20% of ceramic waste replacement it's less than 80% strength as compare to control. So the concrete performance is not good at 20% replacement.

7. Compressive strength of concrete of control mix is observed 29.5 N/mm^2 (M25) and at 15%replacement of opc with ceramic insulator waste is observed 24.33 N/mm^2.

8. At 20% of ceramic waste replacement its less than 80% strength as compare to control. It observed 21.5 N/mm^2.

For 7 Days Flexural Strength

9. According to the 7 days flexural strength of control mix (4.88 N/mm^2) decrease with increase the percentage of replacement of ceramic waste. The ceramic waste material strength decrease up to less than 20 %(3.85) at the 20% replacement means the flexural strength of concrete at 7 days less than 80 % and it affect the changes in the performance in the concrete.

For 28 Days Flexural Strength

10. Flexural strength of concrete at 28 days of control mix(6.71 N/mm^2) it decreases with increase in the percentage of replacement of ceramic material. The result has been taken the average of three beam size 700*150*150 mm^3. This result shows that the ceramic material has been gives the flexural strength less than 80% to compare the ceramic waste.

For 7 Days split tensile l Strength

11. According to the 7 days of strength of split tensile strength of concrete decrease with increase the percentage of replacement of ceramic waste. The ceramic waste material split tensile strength at control mix 2.40 N/mm^2 is more than 80 % up to the 15 % (at 15 % strength is 2.19 N/mm^2) of replacement but at the 20% (2.05 N/mm^2) replacement strength of concrete at 7 days more than 80 %, but very less so the concrete performance is not so much affected at 20% replacement.

For 28 Days split tensile Strength

12. According to the 28 days of strength of split tensile strength of concrete decrease with increase the percentage of replacement of ceramic waste. The ceramic waste material split tensile strength at control mix (2.54 N/mm^2) is more than 80 % up to the 15 % (at 15 % strength is 2.33 N/mm^2) of replacement but at the 20% (2.12 N/mm^2) replacement strength of concrete at 28 days more than 80 %, but very less so the concrete performance is not so much affected at 20% replacement.

5.2 Future scope

In the mortar according to the test result cement can be replaced up to 20 percent but for the use of these waste material durability and other test are also required. In future it can be increase the percentage of replacement of ceramic material and also research work has been required for that study. In the concrete ceramic replace up to 15 percent according to test result of mechanical properties and durability test i.e. water absorption and penetration test, but for the confirmation of that replacement other durability test i.e. acid attack test, chloride attack test, carbonation test and micro-structure study are required.

REFRENCES

1. S. Donatello, M. Tyrer and C.R. Cheeseman (2009) "Comparison of test methods to assess pozzolanic activity". Journal paper at Elsevier on Science Direct at Cement & Concrete Composites 32 (2010) 121–127.

2. S.M.A. El-Gamal, F.I. El-Hosiny, M.S. Amin and D.G. Sayed (2017) "Ceramic waste as an efficient material for enhancing the fire resistance and mechanical properties of hardened Portland cement pastes". Journal paper at Elsevier on Science Direct at Construction and Building Materials 154 (2017) 1062–1078.

3. Salman Siddique, Sandeep Shrivastava and Sandeep Chaudhary (2018) "Durability properties of bone china ceramic fine aggregate concrete". Journal paper at Elsevier on Science Direct at Construction and Building Materials 173 (2018) 323–331.

4. Luiz Renato Steiner, Adriano Michael Bernardin and Fernando Pelisser (2015) "Effectiveness of ceramic tile polishing residues as supplementary cementitious materials for cement mortars". Journal paper at Elsevier on Science Direct at Sustainable Materials and Technologies 4 (2015) 30–35.

5. Serkan Subas, Hakan Ozturk and Mehmet EmirogLu (2017) "Utilizing of waste ceramic powders as filler material in self-consolidating concrete". Journal paper at Elsevier on Science Direct at Construction and Building Materials 149 (2017) 567–574.

6. A. Roul, K. Boudeghdegh and N. Boufafa (2009) "Improving usual and dielectric properties of ceramic high voltage insulators" for the XRD test result discussion,Ceramic55 (2009) 206-208.

7. Hong-seok Janga, Seung-young (2015)"The properties of cement-based mortar using different particle size of grinding waste insulator powder",Journal of Building Engineering 3 (2015) 48–57.

8. American society for testing and materials (ASTM) C-125 (2007). Saturated terminology relating to concrete and concrete aggregate; 2007.

9. Caijun Shia, YanzhongWua, Chris Rieflerb, Hugh Wangc(2004)."Characteristics and pozzolanic reactivity of glass powders" USA,Cement, and Concrete Research 35 (2005) 987–993.

10. Frias M, Villar-Cocina E, Sanchez de Rojas MI, Valencia-Morales E (2005). "The effect that different pozzolanic activity methods has on the kinetic constants of the pozzolanic reaction in sugar cane straw-ash/lime systems: application of a kinetic-diffusive model". Cem Concr Res 2005; 35:2137–42.