

Study of phase composition of Ordinary Portland Cement Concrete using X-Ray Diffraction.

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Abstract— An experimental study is performed on powder ordinary Portland cement concrete samples using X-ray diffraction (XRD) which reveals a promising approach for phase composition of concrete structures. Conventional X-ray diffractometer was used for XRD analysis of concrete samples. The potential presence of cement content and silica in hardened ordinary Portland cement concrete can be determined by X-ray diffraction analysis. This approach may replace the traditional chemical analysis of hardened concrete which is tedious and time consuming. An attempt has been made to quantify the phases present in ordinary Portland cement concrete. The results of phase quantification obtained from XRD analysis has shown good agreement with the experimental values.

Index Terms— Ordinary Portland cement concrete, X-Ray diffraction, phase analysis, structures, composition.



1 INTRODUCTION

Ordinary Portland cement concrete has been widely used in buildings, highways, airports, bridges, fly-overs and other infrastructural engineering structures. Use of poor quality of concrete in structural and constructional works causes loss of lives and properties. So, quality assurance of ordinary Portland cement concrete structures (RCC infrastructures) has become an important and critical factor (Tulliani *et al.*,2002). This approach of phase composition by XRD have been pointed out as an alternative to various chemical

methods. The main objective of research study is to determine the different phases (compositions or constituents) of ordinary Portland cement concrete samples. The quality assurance of concrete structures is more and more becoming a serious concern (Anderoglu *et al.*,2004). X-ray diffraction technique has a large potential to cope up with such concerns without damaging the structural members and leaving the structures in acceptable condition for the client (Qian *et al.*,2014).

2.0 Results and discussion of scientific principles

Water-cement ratio (W/C) of 0.55 is chosen. 300 grams of cement, 793 grams of natural sand, 140

grams of pozzolana flyash and 1021 grams of coarse aggregates is taken for the mix. Cement present in the mix is 13.30% by weight. The XRD analysis of ordinary Portland cement (Fig.1) revealed the

presence of compounds which may be expressed as given in Table 2.

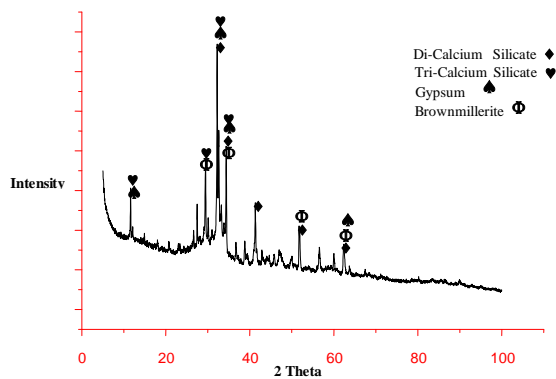


Fig.1 XRD of Ordinary Portland cement sample

Table 2 Compound composition of Ordinary Portland cement sample by XRD

Composition	Ordinary Portland cement sample (wt.%)
Di-Calcium Silicate (C ₂ S)	42.5%
Tri-Calcium Silicate(C ₃ S)	39.30%
Brownmillerite (C ₃ A and C ₄ AF)	12.50%
Gypsum	5.70%

When water is added to cement each of compounds undergoes hydration and contributes to final concrete product (Korpa *et al.*,2009).Only the calcium silicates contributes to strength (Hamou *et al.*,2005). Tri-calcium silicate (C₃S) is responsible for most of the early strength (first 7 days).Di-calcium silicate (C₂S) which reacts more slowly contribute only to strength at later times. Upon addition of water , C₃S rapidly reacts to release calcium ions, hydroxide ions and large amount of heat (Shetty,*Concrete Technology*,2006). Reaction slowly continues producing calcium and hydroxide ions until the system become saturated. Once this occurs , calcium hydroxide starts

to crystallize . Simultaneously , calcium silicate hydrate begins to form. The formation of the calcium hydroxide and calcium silicate hydrate crystals provides seeds upon which calcium silicate hydrate can form. The calcium silicate hydrate crystals grows thicker making it more difficult for water molecules to reach the unhydrated tricalcium silicate. The speed of reaction is now controlled by the rate at which water molecules diffuse through the calcium Silicate hydrate in concrete (Gambhir,*Concrete Technology-Theory and practice*,2010).This coating thickens over time causing the production of calcium silicate hydrate to become slower and slower.C₂S reacts with water in a similar manner compared to C₃S but much more slowly(Mertens *et al.*,2007).The products from the hydration of C₂S are same as those from C₃S (Korpa *et al.*,2009).Other major compounds Tri-calcium aluminate (C₃A) and Tetra-calcium alumino ferrite (C₄AF) also react with water (Kannan *et al.*,2014).These reactions do not contribute significantly to strength so they will be neglected in this discussion (Shafiq *et al.*,2011). Concrete powder used is microscopically heterogeneous (Marinoni *et al.*,2008). XRD analysis of ordinary Portland cement concrete samples (Figs.2 and3) showed that the concrete is composed of the following compounds :

- Calcite.
- Silica.

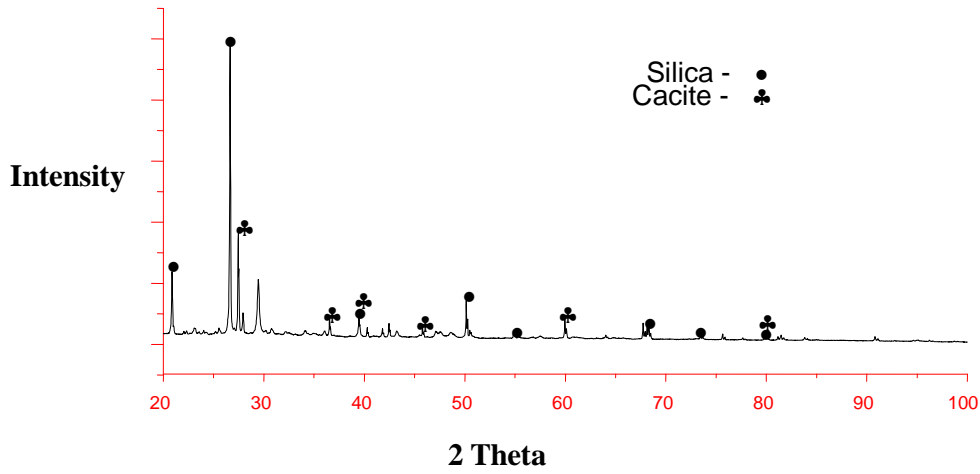


Fig.2 XRD of Ordinary Portland cement concrete sample-1

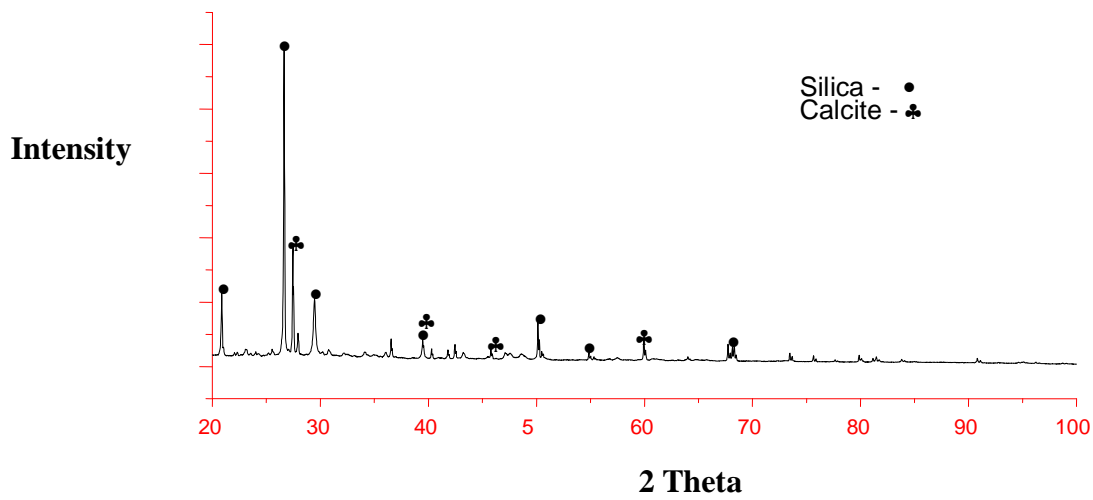


Fig.3 XRD of Ordinary Portland cement concrete sample-2

Analysis reveal that cement content is 15 % and 14% by weight in concrete samples 1 and 2 , respectively . It can be seen that there is good agreement between the measured phase composition and experimental values. Using advanced software package (X-pert High Score), it is possible to obtain reliable results of phase composition. The scale factor and the reference intensity ratio [RIR] values also termed as (I/I_0) values from the database are used to perform the calculations. Quantitative result is automatically calculated when all required data are available (Murty *et al.*,2012).Meaningful quantitative results are achieved, when the accepted phases represent 100% of the phases of the sample (all phases must be identified). If not all phases are identified, the result is still

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a good estimate of the relative mass

fractions of the identified phases (Murty *et al.*,2012).

3.0 Conclusion and Practical Application

This technique may be applied to concrete mixes which contains aggregates or admixtures and liberate soluble silica under the condition of the analysis such as slag, sodium silicate etc; (Qureshi *et al.*,2014).Experimentally, percentage cement is 13.30% by weight in concrete-mix.X-ray diffraction analysis reveals that the percentage cement in sample-1 and sample-2 is 15% and 14% by weight ,respectively. Average 14.5% cement is finally worked out in concrete mix. Percentage error of 9.02% may only due to unhydrated calcium silicate (Fernandes *et al.*,2009). X- ray diffraction technique may prove to be an effective tool for phase composition in practice to widen the knowledge concerning the concrete being studied.

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