# Petrographic Studies of Concrete Aggregate in Engineering Geology Applications

V.V. Sesha Sai*, R. Ananthanarayana* S. Bhattacharjee,
K.Chakraborthy and S.T.Narahari

**Abstract**

*Two important constituents of the concrete that is commonly used in engineering constructions, are the portland cement and a silicious aggregates. Alkali aggregate reaction causes concrete cracking that results in significant damage to the concrete structures. There are two types of alkali aggregate reactions, the alkali-silica reaction and the alkali-carbonate reaction, depending on the presence of certain silicious or carbonate aggregates respectively, in concrete. The former is most common. Product of the reaction is a gel that absorbs water and increases in volume and the swelling pressure ruptures the aggregate particles and causings cracks. Some strained quartz may cause a deleterious alkali-silica reaction if present in sufficient amounts in concrete aggregate. Petrographic techniques help in study of deleterious constituents, including the strained quartz which is a constituent of many rock aggregates used in engineering constructions, and for identification of microscopic features indicating deformation and alteration.*

## Introduction

Petrographic studies can be applied to study the mineralogy and texture of the aggregate rocks, the deleterious constituents, to understand the nature and degree of strain in quartz which forms an important constituent of the various aggregate materials used in engineering constructions, and for identification of microscopic features indicating deformation and alteration.

## Strain quartz studies

In rocks that are subjected to brittle-ductile deformation, the orientation of optic axis in plastically deformed quartz crystals differ by a few degrees in different parts of a single crystal. This results in progressive or wavy extinction as the crystal is rotated between crossed Nicols and this is a feature that indicates the presence of strain in such quartz grains. In recent years the study of nature and degree of strain in quartz has attained importance as an engineering geological applications in the field of large scale constructions. Alkali-silica reaction is the most common form of alkali aggregate reaction and results from the presence of certain siliceous aggregates in the concrete which are found in some granites, gneisses, volcanic rocks, greywackes, argillites, phyllites, hornfels, tuffs, and siliceous limestones (Grattan and Mitchell, 2002). Some strained quartz may cause a deleterious alkali-silica reaction if present as a constituent of concrete aggregate in sufficient amounts (Sudhindra et al., 1987). The criterion for reactive strained quartz is suggested to be more than 20% strained quartz with an average undulatory extinction angle greater than 15° (Buck, 1983). Shape of a grain changes due to strain. During the course of deformation at low confining pressures the rocks will "fracture" due to brittle deformation, while at higher confining pressures the rock responds by "flow" due to ductile deformation (Hibbard, 1995).

Petrology Division, Geological Survey of India, Bandlaguda, Hyderabad – 500068
e-mail: seshubb@yahoo.co.in

For strain quartz determination crushed material of a particular mesh size or a rock thin section can be studied. The strain extinction angle of elongated quartz grains is determined to derive data on strain quartz.

Features indicating deformation: Brecciation, fracturing, faulting and displacement, and displaced cleavage and twin lamellae are some of the very characteristic features resulting due to brittle deformation. Closely spaced fractures and minor displacements are noticed on microscopic scale. Typical microscopic features resulting due to ductile deformation are progressive extinction (Fig. 1a &1b), development of deformation lamellae

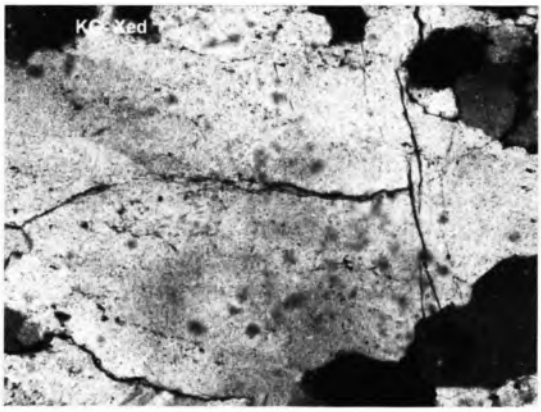


Fig. 1a & 1b : Progressive extinction in deformed quartz

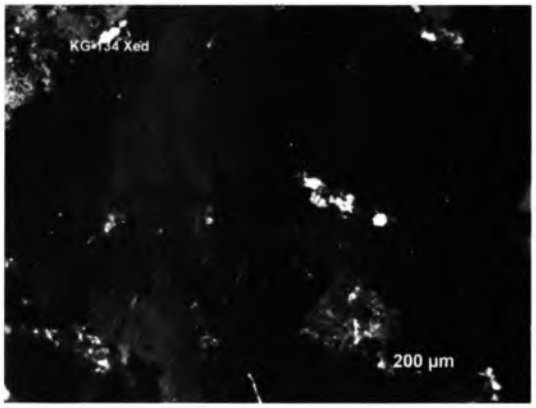


Fig.2 a : Deformation lamellae in quartz.

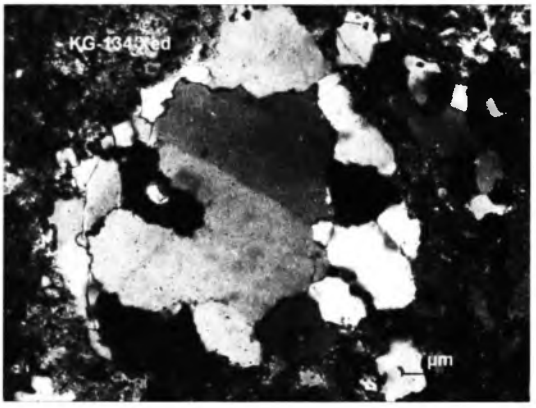

Fig. 2 b : Polygonised quartz grain. Individual sub grains show serrated grain boundaries and wavy extinction. These more or less strain free crystals are formed due to recrystallisation

Fig. 3 : Development of quartz ribbons indicating intense ductile deformation

(Fig. 2a) and quartz ribbons (Fig.3), neoblast development and polygonisation (Fig. 2b).

Study of biotite granite samples from Sripadasagar Project, Andhra Pradesh indicated the presence of distorted twin lamellae in plagioclase and stretched quartz grains showing deformation bands, indicating that the rock is subjected to intense deformation (Sesha Sai and Chakraborty, 2007). Deformation bands and deformation lamellae in quartz result due to intracrystalline strain (Hibbard, 1995). However in polygonised quartz individual sub grains show serrated grain boundaries and wavy extinction. These are more or less strain free new crystals formed due to recrystallisation.

## Alteration features

Alteration phenomenon that has to be recorded in granitic aggregates is sericitisation and kaolinisation. In granitic rock feldspar is one of the essential mineral. At the initial stage of alteration feldspar (K-feldspar and / or sodic plagioclase) is partially altered to sericite - a hydrous K-Al silicate and at an advance state of alteration the feldspar is altered to kaolin.

## Alkali-carbonate reaction

In alkali-carbonate reaction, certain dolomitic limestone aggregates react with the hydroxyl ions in the cement (or other sources such as de-icing salts) and cause swelling. The swelling of the limestone particles causes the concrete to expand and crack (Grattan and Mitchell, 2002). Staining test carriedout on core samples pertaining to Pulichintala Dam site, Andhra Pradesh indicated the presence of calcite and ferron-calcite (Bhattacharjee and Sesha Sai, 2006). Limestone aggregates may be susceptible either to alkali-silica reaction or alkali- carbonate reaction or a combination of the two (Gratten and Mitchell, 2002). Presence of carbonate minerals is to be recorded also for susceptibility to solution activity.

## Other deleterious constituents

Presence of minerals like mica, altered amphibole / chlorite, cryptocrystalline silica aggregate like chert, and iron oxide material also needs to be identified petrographically and specified in terms of modal proportions in the rock material, since, these are considered to be deleterious. Recent study of a quartz arenite from Macherla area, Andhra Pradesh, indicated the presence of 7 % chert and ~ 8% iron oxide material (Sesha Sai, 2008).

## Discussions

With the advancement in concrete technology it is important to make in depth study into the mineralogical composition, nature and degree of deformation and alteration of the rock material used as aggregate in engineering constructions. For this purpose systematic sampling of the construction material quarry is to be carried out so that representative samples can be studied to ascertain the petrographic characters of the silica aggregate. With further research for prevention of concrete deterioration aided by chemical, petrographic and geotechnical studies, it will be possible to take more precise steps to avoid or minimise the damage occurring to the concrete structures due to alkali aggregate reaction.

## References

Bhattacharjee, S.and Sesha Sai, V.V. (2006). Report on core samples pertaining to Pulichintala Project, Andhra Pradesh. *Unpub. Service Rep. Pet.Div. GSISR, Hyderabad*

Buck, A.D. (1983). Alkali Reactivity of Strained Quartz as a Constituent of Concrete Aggregate *Jour. of Cement, Concrete and Aggregates Volume 5, Issue 2 (January 1983) pp.3*

Grattan-Bellew P.E. and M. Lyndon (2002). Preventing Concrete Deterioration Due to Alkali-Aggregate Reaction *Construction Technology Update No. 52, March 2002*

Hibbard, M.J. (1995). *Petrography to Petrogenesis. Princeton Hall Publication*

Sesha Sai, V.V. & Chakraborthy, K. (2007) Report on granitic rocks from Sripadasagar Project, Andhra Pradesh. *Unpub. Service Rep. Pet. Div .GSISR, Hyderabad*

Sudhindra, C., Suri, S.B., Nair, K.N. (1987) "Strained quartz – a menace for durability of concrete for hydraulic structures" International Symposium on New Materials and Techniques for Dam construction, 5-7 March, 1987, Madras, pp. 133-138.