

## Case studies on Alkali-Aggregate Reactions in Concrete

[Excerpts from <http://csmrs.nic.in/Monograph%20on%20Alkali%20Aggregate%20Reaction%20in%20Concrete.pdf>]

### 1.0 ASR in Hirakud Dam, Odisha

Hirakud dam is composite structure of earth, concrete and masonry across river Mahanadi upstream of Sambalpur, Odisha. The type of damage noticed in structure was spalling, spillway gate jamming, and cracking after 30 years of operation. The following manifestations of distress were observed and experienced after completion of the dam:

- Horizontal cracks in the operation gallery, gates haft, sluice barrel and to a small extent in the foundation gallery in all right spillway block. Width of cracks varying from hair cracks to a max. of 6 to 9 mm at the surface. Some of the cracks were found to extent to a maximum depth of about 2 meter. Extensive horizontal cracking on the U/S face of the dam with width of cracks up to 12 mm.
- Deflection in the Adit gallery in block No. 47.
- Buckling of embedded frame of manhole opening on the roadway slab over pier in block No. 35.
- Shearing and Snapping of bolts fixing the guide rails of sluice gates.
- Buckling of steel frame fixed above collapsible gate in entrance of operation gallery.
- Horizontal cracks at various levels on the D/S face of right spillway and vertical cracks in two blocks viz. No. 37 & 38 and the width of cracks increasing slowly.
- Binding of radial crest gates.

#### 1.1 Studies Carried out on Concrete

A petrographic examination and Scanning Electron Microscope study carried out on concrete obtained from the locations where alkali silica reaction was noticed reveals that; River shingles/ quartzite pebbles used in concrete shows occurrence of cryptocrystalline silica like chert and chalcedony as well as diorite and granite. Presence of grano-diorite in crushed rock aggregate was identified as reactive. These owed their reactivity mainly to strained quartz having undulatory extinction.

Also, an examination on hardened concrete revealed that the concrete had adequate cement content and not attacked by sulphate, acid waters etc. Concrete core samples from the right spillway were found to have undergone alkali silica reaction. The presence of such deleterious reaction being manifest by the occurrence of white, translucent to opaque reaction products on the surface of the aggregate, in the cracks and voids in the concrete, dark reaction rims and alteration of the borders of aggregate.

### 2.0 ASR in Rihand Dam, UP

It is a concrete gravity dam, located on river Rihand (UP). The construction of dam was completed in year 1962. The

types of coarse aggregate used were granite, gneiss, (muscovite, biotite reach). The following manifestations of distress were observed and experienced since 1972 nearly 10 years after completion of the dam:

- Longitudinal cracks on U/S face (RL- 830ft). Mostly along the lift joints and minor cracks between lift joints. Width of cracks varied from 1mm to 25 mm and approximate depth of cracks at various locations were found to vary from 7cm to 45cm by ultrasonic pulse velocity test. Horizontal cracks have also been observed in the walls of the foundation gallery, the sluice operating gallery and the hoist operating gallery.
- Horizontal and vertical cracks observed in scroll casing wall of all the six generating units.
- Cracks in all the 24 columns of penstock gallery. In one column in 1984, nine out of ten 45 mm dia. bars snapped.
- Map cracking in the spillway piers and radial gate pedestals.
- Horizontal and vertical swaying of the gantry crane rails of the power house thereby rendering the crane out of use.
- Vertical cracks at abutments adjacent to spillway crest.
- Cracks in passenger and freight elevator shafts.
- Cracks at tainted gate pedestals.
- Tilting and deformation of draft tube structure and cracking of generator supports.

#### 2.1 Operational Problems

- Going out of alignment of rails of gantry crane of draft tube deck slab.
- Fouling of spillway gates with their wall guides creating difficulty in operation of spillway gates.
- Fouling of the cage of the passenger and freight lift with walls of the elevator shaft.
- Difficulty in operation of draft tube gates due to shifting of guide rails.
- Improper sealing of gates of intake structure.
- Ripping of the generating units due to reduction in vertical labyrinth clearance.

#### 2.2 Studies Carried Out

Aggregates obtained from the body of the dam and also from the quarry contained strained quartz and alkali feldspar. Investigations carried out on concrete cores by electron microscopy revealed the presence of alkali aggregate reaction. Concrete core samples in both the main dam as well as power house structure were found to have undergone alkali silica reaction. The presence of such deleterious reaction being manifest by the occurrence of gel type products inside the concrete. Dark and white reaction rims and alteration of borders of aggregates and presence of micro cracks in the mortar phase as examined visually, petrographically and in the scanning electron microscope. Long term observations up to 200 days in moist alkaline environment indicated further expansion of concrete core samples of the order of 0.1%.