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Degradation Methodology of Reinforced Concrete in South Asia analyzed using Surface Analysis and other Techniques

N. Karar
CSIR-National Physical Laboratory, Dr K S Krishnan Road, New Delhi, 110012, India

and

S. K. Singh,
CSIR-Central Building Research Institute, Roorkee, Uttaranchal, 247667, India

Reinforced concrete has steady replaced other traditional building materials like brick and mortar in South Asia. It is based on concrete's durability of a few hundred years in Europe and North America. In the South Asian scenario, reinforced concrete was seen to degrade very fast. The reasons were unknown and were a surprise to all those that have used them or put their hopes on its longevity. Whenever feasible, South Asians have always preferred rugged concrete based dwellings to ward off the weather, wild animals and for personal safety. Reinforced concrete is also being extensively used in roads, bridges, tunnels and viaducts. So a detailed analysis was required to understand the reasons for the shortcomings of reinforced concrete. We have attempted to discuss that here for better standardization. Concrete is based on raw materials like cement, steel, large aggregates like stone chips, small coarse aggregates like sand and water to initiate the reaction process. Here, degradation is discussed keeping in mind every constituent materials' properties.

Cement is standardized by usage of certified Indian reference materials (BND) on cement. It is monitored by National Centre for Building Materials, Ballavgarh, Haryana and us through the BND program. Steel rebar quality is standardized by Bureau of Indian Standards (BIS) and CSIR-National Metallurgical Laboratory, through the BND program. Large aggregates like stone chips are not standardized for their chemical content as such stone based civil structures are historically quite stable in the Indian subcontinent.

Degraded concrete samples along with its degraded rebars from areas where there were unusual degradation were collected and the rebars were analyzed across its cross-section using time of flight secondary ion mass spectrometry (TOF-SIMS). It was seen that there were traces of halide and nitride ions in the periphery of the degraded steel rebars. It content were much less at the center of these degraded steel rebars. Such halide and nitride ions were also detected in soluble ground water residue in flake form in the same area. As ground water is used in most construction on sites, and as halide and nitride ions are known to act as wet chemical etchants of steel, it was concluded that ground water

contributed to the steel rebar corrosion in concrete. It was speculated that the ground water slowly moved upwards by capillary action from the ground floor upwards. But it was initially unknown exactly how the capillary action was possible and how the capillaries were formed.

An extensive analysis of the chemical content of sand used for civil construction was undertaken by analyzing the composition of representative sand samples used in civil construction all over the country using X-ray fluorescence (XRF) and powder x-ray diffraction (XRD). It was found that Indian sand always contains an appreciable amount of calcium carbonate. These calcium carbonate constituents of sand are known to be easily soluble in the halides and nitrides of ground water. Thus capillaries can be slowly formed within the concrete after a few years which slowly increases with time and destroys the reinforced concrete structures. In contrast, sand samples in Europe and West Asia seem to be almost pure silica – so these areas are unaffected by the type of problems seen in South Asia. A representative photo of a multi story building is shown where the ground floor is the most affected and as one goes upwards, the extent of problem becomes visibly less. So the effect of capillary action is also confirmed. Usage of potable water for civil construction along with sand free of calcium carbonate is a feasible solution.

Thus, based on our materials analysis, we have been able to evolve a methodology to substantially extend the life of reinforced concrete in South Asia.

References:

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