CURING OF CONCRETE

Concrete is the most used man made material today for constructing different structures, other than bricks which still dominate building industry. With the development of different grades and types of blended cements coupled with usage of admixtures, it is now possible to produce custom made concrete. Inspite of advances in concrete technology many of its users are not fully aware of the importance of ‘curing’ and its implementation to the specific requirement, so as to achieve desired properties of concrete.

Good curing enables prolonged hydration of cementitious materials and development of well developed microstructure of concrete, to perform at its full potential. It is well known that improper curing may not have noticeable effect on compressive strength, but significantly affect durability of concrete. Portland cement is the primary component of concrete, but the production of 4.1 billion tonnes of cement per year (2018) has environmental impact. In order to reduce greenhouse gas emissions, the usage of supplementary cementitious material such as pulverized fuel ash, ground, granular blast furnace slag for partial replacement of cement is on the increase. Of late High Performance Concrete (HPC) is gaining importance wherein Silica fume is used, which make the concrete more cohesive with little or no bleeding during placement and compaction. The partial replaceable materials can enhance durability, lessen the risk of thermal cracking in mass concrete and possess lower embedded energy than with Ordinary Portland Cement (OPC). However, usage of such blended cements need longer duration of curing to attain desirable strength, than with OPC. Likewise use of HPC needs early commencement of initial curing.

One of the most important parameters influencing the durability of concrete is the permeability, which dictates the extent to which concrete gets affected by external agents, leading to corrosion of embedded reinforcements.

Some of the methods that maintain water level in the concrete mix during early period of hardening are ponding/immersion, spraying/fogging liquid applied evaporation reducers and saturated wet coverage. Out of these spraying/fogging and liquid-applies evaporation reduces are considered as initial curing methods. The methods that reduce loss of mixing water from the surface of concrete include, covering/insulating concrete with imperious paper/plastic sheets or by membrane forming curing compounds. The other methods that accelerate gain in strength consist of supplying heat and additional moisture to the concrete usually with steam or heating coils. A combination of the above methods is chosen depending on dimensions and shape of member, age of concrete and availability of materials adopted more for fast track construction and factory controlled conditions. The timing of each method depends on the degree of hardening needed to prevent the particular procedure from damaging concrete surface.

For rigid pavements and airfield pavements which have a high surface area to volume of concrete wherein early loss of moisture due to evaporation will be rapid and plastic shrinkage cracks shall develop. Continuous loss of moisture with decrease in degree of hydration shall have effect on strength, abrasion resistance and durability of pavement. To avoid plastic shrinkage cracks wind breaks, evaporation reduces of fog spraying shall be initiated, followed by covering the entire exposed surface and keeping it wet until the stipulated time of curing is completed and/or required properties of concrete have developed.

For cast-in situ bridge sub structures and superstructures and retaining walls the surface shall be protected against rapid loss of moisture after completion of curing by replacing wet burlap/hessian with plastic sheets until the surface dries under the sheet.

It is further recommended that water for curing concrete shall be potable, which makes it expensive due to general scarcity of water supply in an urban scenario. In Germany use of recycled water from recycling of unset/discarded concrete as mixing water in the Ready Mix Concrete plants is being practised. However, usage of raw water from sewage plants is not yet gaining acceptance unless chlorides and sulphate levels are reduced by secondary or tertiary treatment and safe use by humans due to presence of microbiological and chemicals causing concern. In other developed countries, the performance criteria for mixing concrete are; strength and setting time with limits on chlorides and sulphates content. However, there is a potential for use of recycled sewage water after secondary and tertiary treatment for curing of concrete. Limited studies made in India indicate a reduction in compressive strength by 6%. India is yet to evolve Standard Specification for Use of recycled water for curing suitable to specific
requirements of different structures built in different environments. While curing with water after final setting of concrete is generally understood, the use of liquid membrane–forming compounds for final curing is left to the Specifications of the Manufacturers.

Such curing materials are sheets or liquid membrane forming compounds placed on concrete to reduce evaporation loss. A combination of plastic film bonded to absorbent fabric help retain and evenly distribute moisture between the film and concrete surface.

Liquid membrane forming compounds may be produced from wax or other organic materials thinned with a solvent. Other similar compounds based on water-soluble solids or a water emulsion are also used. It is recommended that liquid membrane forming compound shall be applied in two applications at right angles to each other. They shall be applied immediately after surface with sheen disappears following final finishing. When using curing compounds reduce moisture loss from surfaces, the exposed surfaces after de-shuttering should be wetted immediately until curing compound is applied.

During cold weather concreting evaporation rate in higher and evaporation reduces can be sprayed onto freshly placed concrete to reduce risk of shrinkage when the evaporation rate equals or exceeds the rate of bleeding.

In hot and dry environments, precautions are taken to ensure that adjacent partly hardened concrete and formwork do not absorb water from freshly placed concrete. The ice cubes and chilled water used to cool the concrete mix should not contain harmful chemicals and the mix shall not be too cool to set off quick evaporation of moisture. When high temperatures with wind and/or low humidity prevail evaporation reducing film may be applied once or twice during finishing operation to reduce the risk of plastic shrinkage cracking. One should adjust placement practices and schedule to evening or night time with sunshades. Continuous water curing is recommended in the first few days to avoid volume changes due to alternate wetting and drying.

Use of accelerators and steam curing is resorted to accelerate gain in concrete strength, for initial prestressing in certain precast members. However, there is a need to specify minimum period of curing when different types of blended cements according to performance specifications.

In mass concrete structures such as piers, abutments and heavy footings, thermal gradients shall be high and further exacerbated when cements with high cementitious materials are used. In such members, the hardened vertical surfaces shall be sprayed with water or when forms are still in place, the form ties may be loosened and water made to run down inside the form.

For unreinforced sections built of only ordinary Portland cement the minimum period of curing shall be two weeks. When ground granulated blast furnace slag or other pozzolana is used, the period of curing shall be extended to three weeks. For RCC piers and abutments continuous curing is recommended for 7 days or until 70% of the specified compressive strength is achieved.

There are a number of in-situ tests to measure the air–void content, temperature (with sensors) and maturity of concrete during period of hardening besides measurement of slump, compaction factor, flow Table tests etc. which will be useful to take corrective steps in the method of curing.

The desired levels of strength and/or durability depend on chemical composition, fineness of cementitious, w/c ratio, proportion of mix, properties of aggregates, chemical and mineral admixtures temperature of concrete and effectiveness of curing methods. Therefore, it is proposed that Thermal Control Plan should be prepared in mass concrete structures which inter-alia cover maximum temperature limit, placement methods, predicted temperature during hardening, insulation and curing methods and corrective methods. Such a plan will take care of the curing requirement of highway projects.

(Sanjay Kumar Nirmal)
Secretary General
India have a Mammoth task of development of Road network which is second largest in the world after USA, where as we have no matching financial resources/budget. To overcome, what is required, is to look for innovative means of Financing in the first instance and secondly promote and pursue use of appropriate Technologies, locally available materials to reduce cost of construction and also reduction in construction period ensuring environmental protection. Use of locally available materials like coir, jute in slope stabilization can bring out reduction in cost of construction. Use of these bio-degradable product will be helpful in protecting our environment besides providing employment opportunities to local people to achieve one of the most important aspect of social equity along with Road construction and Nation Building.

Indian Roads Congress being premier organisation is dedicated to prepare codal provisions/guiding principles of construction, designs, operation and maintenance. It is already working to bring out the changes in design and construction practices with greater emphasis on protection of the environment, reduce consumption of minor minerals, avoiding large scale excavation for earthwork by using soil stabilization technique and stabilization of hilly slopes without disturbing the ecology of different region in mountainous strata especially in the North Eastern region.

We are also committed to shoulder the responsibility of Swachhata hi Seva campaign. The Engineering fraternity engaged in the construction of Highway has greater role to play in use of waste plastics for which codal provisions, executive instruction has already been released. The system of collection through private participation, necessary changes in design of hot mix plants has also been suggested and is now being used on National Highways where periodical renewal or strengthening work is being done. Use of Recycling technologies need more emphasis as we already have sizeable length of national highways which are developed and are fit cases for use of re-cycling technologies for renewal courses. Use of modern maintenance management techniques may be used to reduce cost of maintenance and provide better serviceability conditions. Regular maintenance by taking care of every single patch/potholes and sealing of cracks immediately after it develops may prevent large scale damages to the road surface leading to avoidable expenditure. Use of Micro-surfacing, innovative materials for instant filling of potholes and crack sealing would lead to reduction in cost of maintenance.

In the upcoming 80th IRC Session to be held from 19th-22nd December, 2019, experienced engineers, scientist and academician would be sharing their knowledge and expertise and opine on use of most appropriate Technologies specific to the region. Country as India has varying geology and natural resources giving unique challenges which is specific to a particular region requiring specific solutions for achieving the target of construction cost optimization and reduction in construction period.

As in the past, I am sure, this will provide ample opportunity to all the fellow participants to enrich their knowledge base to enable them to provide safe, cost effective environmental friendly highway infrastructure.

(I.K. Pandey)