appeared in 2003

Builders' dreams take concrete shape

Cement and concrete have surely done as much to create our modern world as the motorcar, electric power and wireless, suggests S.Ananthanarayanan.

Highways, bridges, dams and skyscrapers, the signposts of our times, became possible with modern cement, concrete and the idea of reinforcement with steel.

The active agent is lime

Limestone and marble are hard, water resisting forms of chalk, or the carbonate of calcium. When limestone is heated to 'white heat', carbon dioxide content is driven off and what is left behind is pure lime, or the oxide of calcium. As a creation with the use of so much energy, pure lime is in a state to combine violently with other substances and give away some of its energy store. This it does this most readily with water, with fizzing and emitting much heat, to form slaked lime, or '*chuna*'.

During the making of pure lime, if the lime is heated to even higher temperatures with silica and alumina, which are oxides of silicon and aluminum, typically in the form of clay, the calcium atoms form bonds with the other substances. The compound so formed, which is cement, also reacts readily with water, but the product is not slaked lime, it is a complex of the hydrates (ie, product of combing with water) of calcium and silicon, which form a network of bonds and connections that set to great strength.

Rock in shapes of choice

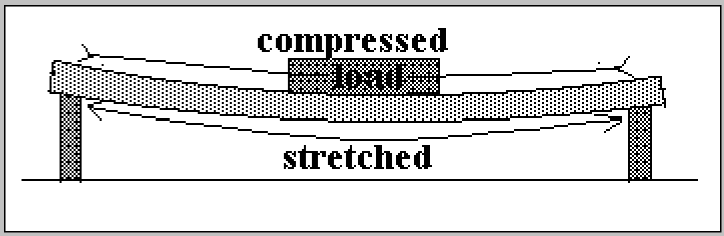
While cements are used to hold stones or brick together, concrete is a cement slurry mixed with an 'aggregate' of stones and sand. The larger pieces form the bulk, while the smaller particles fill the spaces. The cement fills the whole volume, between small and large particles and when it sets, the mass gains the strength of stone.

The aggregate and cement can be intimately mixed and poured into moulds to cast the very shapes of stone required for civil engineers' work. Pouring to create shapes eliminates weeks of bricklaying.

Strength and weakness

During 'setting', the cement combines with water to form the mesh has binds the aggregate together. This requires plenty of water, both for the reaction as well as to cool the mass, which gives off heat. The setting becomes slow if the temperature is allowed to rise. Cement prematurely dry also begins to crack. But if the concrete is kept well watered and allowed to 'cure' before it is loaded, it acquires great compressive strength and hardness.

This strength is mainly to resist 'compression' or crushing loads. Concrete does not have much strength to resist tension, or 'stretching'. Now, when a beam is loaded in the center and the beam begins to bend, what is happening is that the upper portion of the beam is getting compressed, but the lower part is getting stretched, like shown in the picture. A concrete beam then begins to crack in the lower part.



The great solution to this Achilles' heel of concrete has been to add 'reinforcement', by steel bars, to the concrete. The steel binds securely to the concrete and adds its own strength when the concrete is stretched. It may come as a surprise that steel is less elastic that concrete. The steel thus stretches less that concrete, when subjected to tension, and keeps the concrete from breaking.

Steel is suited as a reinforcement material because steel and concrete expand or contract to almost the same extent when the temperature changes. This makes sure that there are no stresses set up from night to day or from winter to summer.