Generally, the cement content itself would not have a direct role on the strength of concrete; if cement content is required to increase the workability of concrete mix for a given water-cement ratio, then the compressive strength may increase with the richness of the mix. However, for a particular water-cement ratio there would always be an optimum cement content resulting in 28-day compressive strength being the highest (see Fig. 24’3. Increasing the cement content above the optimum value may not increase the strength of concrete specially for mixes with low water-cement ratio and larger maximum size aggregate’.

Recommendations for making durable concrete in various codes of practices envisage limits for maximum water-cement ratio, minimum cement content, cover thickness, type of cement and amount of chlorides and sulphates in concrete, etc. All these recommendations taken together tend to result in concrete being dense, workable, placeable and having as low a permeability as possible under the given situation. Therefore, adherence to one limit without considering others, or uniform application of these recommendations with no regard to the situation of placing, for example, congestion of reinforcement, cover thickness, workability of concrete or the characteristics of the aggregates, may not ensure the fulfillment of the objectives.

In addition, the cement content is chosen by two other considerations.

Firstly, it should ensure sufficient alkalinity (PH value of concrete) to provide a passive environment against corrosion of steel, for example, in concrete in marine environment or in sea water, a minimum cement content of 350 kg/m3 or more is required for this consideration.13+28

Secondly, the cement content and water-cement ratio is so chosen as to result in sufficient volume of cement paste to overfill the voids in the compacted aggregates. Clearly, this will depend upon the type and nominal maximum size of aggregate employed. For example, crushed rock or rounded river gravels of 20 mm maximum size of aggregate will, in general, have respectively 27 and 22 percent of aggregate
voids. A cement content of 400 kg/m³ and water-cement ratio of 0.45 will result in paste volume being 30 percent which may be suitable for the former (that is crushed rock of 20 mm maximum size aggregate), whereas cement content of 300 kg/m³ and water-cement ratio of 0.50 will result in 25 percent paste volume (Fig. 37) being sufficient to overfill the voids in 20 mm rounded gravel aggregates. Increasing cement content will result in higher workabilities.

IS : 456-1978R3 lists the requirements for durable concretes in terms of minimum cement content, type of cement and maximum water-cement ratio required for reinforced concrete structures to ensure durability against: (a) specified conditions of exposure, and (b) different concentration of sulphates present in soil and ground water. These are reproduced in Tables 23 and 24 respectively. Similar requirements for prestressed concrete structures as per IS : 1343-1980 are reproduced in Tables 25 and 26. The purpose of specifying a minimum cement content is to ensure reasonable durability as discussed above. The values specified in Tables 23 and 24 are in general for 20 mm nominal maximum size of aggregate. The cement content has to be reduced or increased as the nominal maximum size of aggregate increases or decreases, respectively.

MINIMUM CEMENT CONTENT REQUIRED IN CEMENT CONCRETE TO ENSURE DURABILITY UNDER SPECIFIED CONDITIONS OF EXPOSURE

NOTE 2 - The minimum cement content is based on 20 mm aggregate. For 40 mm aggregate, it should be reduced by about 10 percent; for 12.5 mm aggregate, it should be increased by about 10 percent.

NOTE 4 - For severe conditions such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water-cement ratio, and if necessary an increase in the cement content to ensure the degree of workability needed for full compaction and thus minimum permeability. The requirements of durability are achieved by limitations in terms of minimum cement content, the type of cement and the maximum water-
cement ratio, as discussed in detail in Section 3. In appropriate circumstances, the maximum limit of cement content in the concrete may also have to be specified. This is because concrete mixes having high cement content may give rise to shrinkage, cracking and creep of concrete also increases with the cement paste content. In thick concrete sections restrained against movements, high cement content may give rise to excessive cracking caused by differential thermal stresses due to hydration of cement in young concretes. For high strength concretes, increasing cement content beyond a certain value, of the order of 550 kg/m$^3$ or so, may not increase the compressive strength. From these considerations as well as those of overall economy, the maximum cement content in the concrete mixes was limited to 530 kg/m$^3$ for prestressed concrete structures (see IS : 1343-1980) and for reinforced concrete liquid retaining structures [seeIS : 3370 (Part I)-1%5Lo].

Extracted from SP:23 Handbook on Concrete Mixes.

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