



Letters to the Editor

Cement content, exposure conditions and grades of concrete

This has reference to the papers by Mr S.A. Reddi titled "Section 2 - An overview" on pp. 114-119, and "Cement content and grades of concrete" on pp. 129-135, published in the February 2001 issue of *The Indian Concrete Journal*.

Both the papers explain the recent additions in IS 456 : 2000 and give deep insight into the background of the additional material.

But in practice, design engineers are facing many difficulties in applying section 2 of the code. The first thing to be decided before beginning the structural design is to fix the nature of exposure zone as per Table 3 of the code. There are many situations given under each exposure zone from mild to extreme conditions. A colleague of mine has suggested the inclusion of a map of India with exposure zones clearly marked therein, based on the analogy of earthquake zones, in order to ease this problem. Further, Table 3 may suggest one concrete mix for floors and another one for roof in a given exposure zone. It may also require one concrete mix for internal columns and another one for external columns. For basement walls and foundations, concrete mix has to be different. This way we shall end up with four to five concrete mixes for a given building. This is just not practical in the field and it will cause confusion at the site during both execution and supervision. The present practice is to have a general concrete mix for all RC work except for the columns in the lower storeys, where richer

concrete mixes have to be used to save steel consumption in columns. In my view, we should stick to this time-honoured practice.

The following prominent changes from the previous code IS 456 : 1978 are made in the IS 456 : 2000.

- Concrete mix is changed from M 15 to M 20, M 25, M 30 in respect of mild, moderate and severe exposure zones, respectively.
- Clear cover to outer bars has been increased. Previously, the clear cover was specified over main bars.
- Minimum slab thickness has to be 110 mm for 1-1½ hour fire resistance whereas previously minimum slab thickness, in practice was 100 mm.
- Clear cover over outer slab bars has been increased from 15 mm to 20 mm, taking both Tables 16 and 16A into account.

Table 1, gives requirements of IS 456 : 2000 for durability and fire resistance in design of buildings and it is based on Tables 3,5,16 and 16A of IS 456 : 2000. This table will be helpful to designers in applying IS 456: 2000 to the structural design of buildings.

Mr S. A. Reddi has rightly advised the restriction of cement consumption in buildings in order to achieve economy. But IS 456 : 2000 tends to increase both the

quantity and the quality of concrete, leading to an increase in cement consumption in buildings. This aspect will increase cost of RC buildings.

U. H. Varyani
Chief Structural Engineer
Kothari Associates Pvt Ltd
G-65, Connaught Circus
New Delhi 110 001

Mr Reddi replies:

The author thanks Mr U.H.Varyani for his perceptive comments.

Table 3 of IS 456 : 2000 deals with environmental exposure conditions. It may please be noted that the environment is related to the concrete surface in contact with or protected against the designated exposure conditions. These are certainly not related to purely climatic conditions based on which a map of India with exposure zones marked as has been suggested by Mr Varyani. It is true that different concrete mixes may be required for internal/external columns, basement walls and foundations. It should not really be a problem. However, if the designer wishes to streamline and reduce the number of mixes to minimum, this is certainly welcome but it is required to be carried out without violating the requirements of environmental exposure conditions.

Clear cover is required to protect the reinforcement from corrosion. Thus it is more rational to specify the clear cover to reinforcement nearest to the surface of the concrete.

Table 1: Requirements of IS 456 : 2000 for durability and fire resistance in design of buildings

Exposure zone	Where applicable	Minimum concrete mix	Nominal cover for members, mm		Minimum thickness of slab, mm	Remarks
Mild	Concrete surface protected against weather or aggressive conditions in non-coastal regions	M 20	Slabs	20	110	For buildings in mid land areas like Delhi, etc
			Beams	25		
			columns	40		
			footings	50		
Moderate	Concrete surface sheltered from saturated salt air in coastal areas.	M 25	slabs	30	110	For buildings in coastal areas like Mumbai, Chennai, Kolkata, etc
			(20 to use in practice)			
			beams	30		
			columns	40		
			footings	50		
Severe	Concrete exposed to coastal environment or completely immersed in sea water.	M 30	slabs	45	140	For structures immersed in sea water
			(30 to use in practice)			
			beams	45		
			columns	45		
			footings	50		

Notes : 1. The other two exposure zones, very severe and extreme, have not been given here, being applicable to special situations.
 2. Slab covers have been reduced by us in moderate and severe exposure zones in order to restrict crack width and also to reduce dead load of buildings.

The cement consumption per unit volume of concrete can certainly be reduced by adopting proper methods of concrete mix proportioning and the same is facilitated in IS 456 : 2000. A reference may please be made to clause 9.2 of the code. The constructor is free to adopt any method of mix design and get the mix approved by the employer. The acceptance criteria has also been simplified. The standard deviation to be used for initial mix design has also been rationalised, vide Table 8 of the code. With judicious mix proportioning and proper quality assurance, it has been possible to operate on the standard deviation of not more than 4 MPa. In such a situation, the cement content in the concrete mix will be the same as or close to the minimum cement content specified in Table 5 of the code, that is, in the range of 300 to 320 kg/m³ for mild to severe exposures. It may be appreciated that this cement content is equal to or even less than the cement contents now being used in many cases. As such, there will not be any increase in cement content per unit volume of concrete as per the revised IS code. There may be a marginal increase in the volume of concrete, which is required from durability considerations. The author has found that the two factors, namely, unit cement content and quantity of concrete result in compensating effect and as such the author does not expect any increase in the cost of buildings.

S.A. Reddi
 Deputy Managing Director
 Gammon India Limited
 Gammon House, Prabhadevi
 Mumbai 400 025

The Guest Editor summarises :

Introduction of exposure conditions is the important addition to IS 456:2000. A location or even a building can have more than one exposure condition. For example, a building in a locality may be an office type and another building in the same locality may be a restaurant or a factory. The exposure conditions of the building in the same locations are different. Even in ordinary building, elements inside are exposed to mild environment whereas the elements such as chajjas are exposed to medium environment. Therefore, it is not possible to divide the country into exposure conditions or zones as was done in wind or earthquake zones. There is some element of confusion in the exposure conditions as mentioned in the letter but the designer has to make the decision at the very beginning of the design. Even though the code recommends minimum grade of the concrete as M 20, the minimum grade practicable for a building is M 25 because of the different exposure conditions in the same building. This is because bathroom and kitchen exposure condition is different from the living room or bedroom exposure. That is why in my editorial I emphasised that it is reasonable to start with M 25 grade concrete. In fact, many countries have this grade as the minimum acceptable for reinforced concrete.

The cover requirement based on fire rating and durability is also another area where the designer has to pay attention.

(Note from the Editor: With this, we wish to bring a closure to discussions on IS 456 : 2000.)

The commentator has given a useful table combining all the aspects.

Even though there is no change in the design methodology in IS 456:2000 when compared with that of 1978, but the specifications on fire and durability influence the final details. The minimum thickness of some members will increase as the revised code is implemented. An example already mentioned is the electrical line posts in the coastal towns and areas. Some of the earlier prestressed concrete posts are as thin as 100 mm but today these are not acceptable. Similarly the thickness of ribs in waffle slabs were as low as 50 mm. This is too small and not acceptable by the new code. Even though some may say the cost is not going to be affected, it is not true in some or even in many cases. Many common builders still think in terms of nominal mixes of concrete. Many government and public sector undertakings are setting the nominal mix design specifications in the tender schedule. There is an urgent need to change the departmental standard specifications and rate schedules. Even though the 1978 code version recommended weigh batching for M 20 and M 25 grades, organizations, even big departments have been using nominal mixes for these grades of concrete. The country has to go a long way to forget about the nominal mix designs.

Prof P. Dayaratnam
 1-5-21/7 Road No 8/23
 Habsiguda
 Hyderabad 500 007

