Design mix concrete – Economy & Environmental issues

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1. Concrete is most commonly used material in civil construction work all over the country. There is hardly any major original civil construction work where structural concrete is not used.

2. Nowadays concrete is produced in batch mixing plants located either at site of construction or away from the site in a location from where concrete is carried in transit mixers to the site. The later one is commonly called Ready Mix Concrete (RMC).

3. The proportion of various ingredients of concrete made in batch mixing plants mentioned above is usually determined in laboratory. This process is called designing (proportioning) of concrete mix and such a concrete is called design mix concrete. The designing process is a trial and error method in which right proportion of ingredients is sought to be determined so as to achieve targeted mean strength which is kept somewhat higher than the characteristic compressive strength of the concrete. Besides achieving the targeted strength, the workability and durability requirements are also required to be ensured while designing the concrete mix. All this has to be done keeping in mind the objective of achieving overall economy by reducing the content of costliest material in the concrete, i.e. the cement.

4. The designing process in most of the major projects is usually carried out through reputed laboratories. IS 10262:2009 is the relevant Indian standard stipulating guidelines for concrete mix proportioning.

5. Some important economy and environmental issues pertaining to design mix concrete are discussed hereunder: -

a) **Use of fly ash**: Fly ash is a waste product in thermal power generation. Besides occupying a large space in coal based thermal power plants, fly ash pollutes the air. Extremely fine particles of fly ash are a source of respiratory disease as these particles settle on the human lungs. Disposal of fly ash is a cause of concern from environmental consideration. Fortunately this harmful material is a very useful material in civil construction since it has got very good pozzolanic properties and up to 35% of the cement content in concrete can be substituted with fly ash without sacrificing strength and achieving durability and economy in the construction. The quality parameters of flyash for use in concrete are laid down in IS 3812(part 1). There should be uniform blending of flyash with ordinary Portland cement. In all civil construction in the vicinity of thermal power plants, the fly ash should be used as environmental friendly measure and for economizing construction cost. While selecting concrete items at the time of preparing estimates for construction works, provision should be kept for use of fly ash along with ordinary Portland cement. The tender documents should not discourage use of fly ash in concrete as the same approach is not backed by any scientific reasoning. The use of fly ash in concrete should be promoted not only from environmental consideration but also for economizing construction cost.

b) **Use of PPC**: IS Code permits use of flyash based Portland Pozzolana Cement (PPC) conforming to IS1489 (part 1) in concrete. The PPC many a times is available at lesser cost than OPC. Besides it is more environmental friendly compared to OPC since it utilizes the fly ash in its manufacturing. Use of PPC in concrete helps in environmental conservation and for economizing construction cost without sacrificing strength and achieving durability and economy in the construction.

c) **<u>Specifying high quantity of cement in tender documents</u>**: Quantity of cement in design mix concrete depends upon several factors, chiefly on workability requirement. Workability requirement (slump values) should not, therefore, be prescribed unnecessarily high but as given in table under Para 7.1 of IS 456-2000. Further, higher workability requirement should be met by use of suitable chemical admixtures (super plasticizers / water reducing admixtures) to reduce water requirement in the concrete. The design process takes care of various factors affecting strength, durability and workability of concrete. Still there is a tendency on the part of some NIT approving authorities to stipulate much higher cement content in the concrete than specified in Table 5 of IS Code 456 given below: -

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nomination maximum Size

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content Kg/cum	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content Kg/cum	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	-	300	0.55	M 20
ii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very Severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of Mineral Admixtures, i.e. Pozzolanas, fly Ash, silica fume, rice husk ash, Metakaoline, Ground Granulated Blast furnace slag. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the

suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

Thus, the minimum cement content specified ranges from 300 to 360 kg per cum of concrete for various exposure conditions and for various grades of concretes. It is the prerogative of the designer to find out the correct quantity of cement over and above these minimum values in Table 5 of IS456. The maximum cement content in concrete in normal course is also limited to 450 kg. per cum of concrete as per Para 8.2.4.2 of IS 456. By specifying cement content much higher than the stipulation in IS 456, the entire purpose of designing is defeated. Very often designer may be easily able to achieve required targeted mean strength in lesser cement than specified in the agreement but he has to perforce specify the higher quantity given in the agreement as intimated to him by client (project authorities). Thus, the entire purpose of designing concrete in economical and environmental friendly manner is lost. Unnecessary damage to the environment is caused by emission of greenhouse gases in the environment in the process of manufacturing of wasted cement. Besides wastage / pilferage, this approach also gives rise to scope for wastage and pilferage of cement in actual execution. .

d) **<u>High quantity of cement in Mix Design Report</u>**

It has also been noted that very high quantity of cement is sometimes specified in the design mix by the laboratory. The design mix report issued by the laboratory should not be directly used at site without approval of project Engineer. The Engineer should be made responsible for approval of design mix report. He should not instantly approve any design mix report which shows abnormally high cement content. In such cases, he should thoroughly check the design mix report particularly from economy angle.

He should check if the use of water reducing admixtures or plasticizers can help in reduction of water cement ratio and subsequent reduction in high quantity of cement prescribed in the design mix report particularly for higher grade of concrete where reduction in water cement ratio to value of 0.30 to 0.45 is needed. Thus, a design mix report showing very high cement content should not be readily accepted at its face value but after critical scrutiny only. The engineer should check the calculated design mix proportion by means of trial batches as per para 5 of IS10262-2009.

The author has come across a number of concrete design mix reports in various part of the country. In the opinion of author, following are the cement contents for various grades of concrete beyond which design mix report should be critically examined and rechecked: -

Grade of concrete	Cement content in kg. per cum of concrete
M 15	250 to 300
M 20	280 to 330
M 25	310 to 360
M 30	340 to 390
M 35	360 to 420
M 40	380 to 450
M 45 to M 55	400 to 450

Note: The above cement content (if OPC used) can be further reduced up to 35% by use of fly ash.

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