Understanding Nominal and Design Mixes of Concrete

Cement concrete in India on large scale is being used since the last about 70 years. In the early days the following nominal ratio by volume for concrete were specified.

Cement	:	Sand	:	Aggregate	
1	:	2	:	4	Correspond to M-15 Grade
1	:	1.5	:	3	Correspond to M-20 Grade
1	:	1	:	2	Correspond to M-25 Grade

IS : 456-2000 has recommended that minimum grade of concrete shall be not less than M-20 in reinforced concrete work. Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used for any reason on the work for grades of M-20 or lower, nominal mixes may be used with the permission of engineer-in-charge, which however is likely to involve a higher cement content.

Accordingly all concrete of above M-20 Grade for RCC work must be of design mixes. The code allows nominal mix for RCC work of M-20 Grade, but what shall be the nominal mix, the reader will find from the following table that it is better to adopt design mix, rather than to go for M20 nominal mix which is too cumbersome to determine a fixed nominal mix value.

Nominal mixes as per IS : 456-2000 if fine aggregate is of Zone II as per IS : 383-1970.

Grade of Concrete	As per IS:383-1970 Maximum size of graded coarse aggregate	Mix Ratio by Weight			Max W/C Ratio	Max cement: Aggregate ratio by mass
		Cement	Fine Aggregate	Coarse Aggregate		
M-20	10	1 : 1.8 : 2.7			0.60	1.5
M-20	20	1 : 1.5 : 3.0			0.60	1.5
M-20	40	1 : 1.3 : 3.2			0.60	1.5

Proportions by weight can be converted to proportions by volume, by dividing with the bulk density of the materials available for use at site. The bulk density of cement may be taken 1.44 kg/lit.

The above nominal mixes are worked out for Zone II fine aggregate. As per IS: 383-1970 there are three more zone of sands. Therefore, the total nominal mixes shall be 12 for 10, 20 & 40 mm maximum size of coarse aggregate.

Thus, it could be seen that nominal mixes cannot have a fix conventional proportions such as 1:2:4 or 1:1.5:3, but may vary according to maximum size of coarse aggregate and grading of fine aggregate. Hence nominal mixes are also needed to be designed according to the sizes of aggregates available at site. However, the ultimate aim must be to get the specified properties of concrete.

As per IS: 456-2000, volume batching may be allowed only where weight batching is not practical and provided accurate bulk densities of materials to be actually used in concrete have earlier been established. Allowance for bulking shall be made in accordance with IS: 2386(Part 3). The mass volume relationship should be checked as frequently as necessary.

The exposures of Indian Construction sites at most places are Moderate for which IS: 456-2000 specified that minimum grade of concrete for reinforced concrete should be M25. Accordingly for durability consideration the structural concrete must not be below M-25 grade. The high strength benefits obtained should be taken into account in the design consideration of the concrete structure.

If for practical purpose, we go deeper than we will find that for all reinforced concrete structures we must have concrete from design mixes.

In the IS: 456-2000 there is nothing mentioned of 1:1:2 ration for M-25 grade of concrete. Concrete of above M-20 must be design mixes. If one takes 1:1:2 ratio then the cement content comes to 528 kg/m^3. Where as IS: 456-2000 on page 19 clause 8.2.4.2 mentioned that OPC in excess of 450 kg/m^3should not be used.

The concrete surfaces of the structure exposed to severe rain, alternate wetting and drying such as RCC OH water tank comes to severe exposure environment for which the minimum grade of concrete shall be M-30, minimum cement content 320 kg/m^3 and maximum free W/C ration 0.45. The following table will show the compression of nominal and design mixes for RCC work.

Materials : OPC 43-grade, River sand of Zone II and 20 mm graded crushed stone aggregate. Specific gravity of sand and aggregate 2.65. Workability of design mixes 50±10mm slump.

Grade of Concrete	Mix. Free W/C ratio	Min. Cement content kg/m^3	Nominal mixes by weight C:S:A	Design mixes by weight C:S:A	Saving in cement
M-20	0.55	300	1:1.5:3 Cement= 392kg/m^3	1:2.22:3.48 Cement= 327kg/m^3	65 kg/m^3
M-25	0.50	300	1:1:2 Cement= 528kg/m^3	1:1.93:3.17 Cement= 360kg/m^3	168 kg/m^3
M-30	0.45	320	—	1:1.67:2.84 Cement= 400kg/m^3	—

Note: For high strength concrete plasticizer/superplasticizer should be used which will reduce water and with the same W/C ratio reduction in cement content.

From the above table it can be calculated in nominal mixes of M-20 and M-25 how much extra cement is used in the construction, its total cost and how much CO2 is emitted in the production of this extra cement.
When a mix is referred for designing, it is design for target strength. For example M-30 (by Vol. ratio) is design for:

30 + 1.65 x 6 = 39.9 N/mm^2 at 28 days age
The above is design target strength of the consultant Laboratory. When this mix is used at construction site, its concrete shall have strength as per table 11 of IS : 456-2000.

30 + 4 = 34 N/mm^2 at 28 days age
For starting the work a construction site cannot weight for 28 days. Therefore according to various literatures, if at 7 days its strength is about 65% (22 N/mm^2) the work may be started. However in all the cases 28 days cube compressive strength shall alone be the criterion for acceptance and rejection of the concrete.

Source: https://civilsolution.wordpress.com/category/concrete-mix-design/