Study of Cost Involved in Design of Building Structures with Different Grades of Concrete and Steel

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Abstract **- Steel & Concrete are the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength, is particularly useful. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. A Building can be modified according to its nature and type of material used in its construction process. The objective of the present work is to study the cost effectiveness of designing structures with High Performance Concrete by giving a cost comparison between concrete M25, M60 and Steel structure.**

1. INTRODUCTION

India is a developing country. Construction is a basic requirement for development. Concrete has been since long a major material for providing a stable and reliable infrastructure. High performance concretes (HPC) are concretes with properties or attributes which satisfy the various performance criteria. Generally, concretes with higher strengths and attributes superior to conventional concretes are called High performance concrete. The use of HPC with its greater durability is likely to result in less maintenance and longer life, the long-term economic benefits are likely to more than offset the premium costs for initial construction. Steel Structures are also very much popular now days.

Design of a multi storied reinforced building has been done using both M25, M60 and with steel structure using Staad Pro v8i and the differences in the quantity of concrete and steel required for different beams and columns have been calculated and analyzed and compared with respect to their cost. M60 concrete is prepared by using silica fume as a partial replacement material for cement.

Using silica fume in concrete not only it will be cost effective, but also provide considerable strength to the concrete. The silica fume will also show more in the following mix design of M60 grade concrete and their respective calculation has been done.

2. MIX DESIGN DETAIL

The mix design for M60 grade concrete is done as recommended in IS 10262-1982 and ACI. According to IS 10262-1982 the following data is required for concrete mix design.

1.	Characteristic compressive strength at 28 days	60N/mm2
2	Cement	Cement used is PPC 43(fly ash based) according to IS 1489 : 1991(part 1) Fineness – 1.1 Compressive strength of 28 days – 43MPa Soundness according to Le Chatelier method – 10mm. Initial setting time- 60 min Final setting time- 250 min
3	Coarse Aggregate .	Crushed ceramic tile aggregate of maximum nominal size of 20mm. With Specific gravity- 2.65 Fineness modulus- 2.7 UC- 3.30

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4	Fine aggregate	River sand was used as the fine aggregate conforming to grading zone II as per IS 383:1970 Specific gravity- 2.65 Fineness modulus- 6.2 UC- 1.25
5	Maximum free water cement ratio	0.45
6	Workability corresponding to compaction factor	100mm slump.
7	Admixture	No admixture added.

3. PROCEDURE FOR MIX DESIGN

Following is the procedure for mix design as recommended in IS 10262-1982 as prescribed below.

Mix design aims to achieve Good quality concrete at site economically. Quality concrete means: i) Better strength, ii) Better Imperviousness and durability, iii) Dense and homogeneous concrete. Water demands for aggregates sizes are summarized in relation to the concrete workability (consistence) required. This leads to an estimate of cement content and aggregate content from an assumed concrete plastic density. The rounded bulk volume for the course aggregate is estimated from tables giving the fineness modulus of the fine aggregate and the coarse aggregate size, hence the split between course and fine aggregate calculated. Determination of cement content.Computation of total absolute volume of aggregates. Determination of fine and coarse aggregate content.

4. DESIGN MIX

Target mean strength for M60 mix design(Ft) is given by

Ft = Fck + k.S ,

where Fck is characteristic compressive strength,

K is constant and is taken as 1.65

S is standard deviation.

Therefore, Ft= 25 + 1.65*5.0 =68.25MPa.

Free water cement ratio for target mean strength of 68.25MPa is 0.45.

Now according to IS 10262 - 1982 , for w/c ratio of 0.60 and max. nominal size of aggregate of 10mm, Water content per cubic metre of concrete with respect to nominal maximum size of aggregate of 20mm is 186kg.

For 100 mm slump Water content = 186+(6/100)x186 = 197 Kg.

Cement content = (197/.45) = 437.7 Kg/CuM (>320 Kg/CuM-Table 5-IS456)

Vol of coarse and fine aggregate can be calculated by below method. Rate of propertion of vol of coarse aggregate is increased at the rate of -/+ 0.01 for every +/- 0.05 change in W/C ratio.

Vol of coarse aggregate corresponding to 20 mm size for w/c ratio 0.5 = 0.60

So, for 0.45 W/C ratio, vol of coarse agg. = 0.60+0.01 = 0.61

Vol of fine aggregate = 1-0.61= 0.39

Mix calculation for 1 CuM of concrete.

Vol of Concrete = 1 CuM

Vol of Cement = (437.7/3.15)*0.001 = 0.139 CuM

Vol of Water = (197/1)*0.001 = 0.197 CuM

Vol of Aggregate = a-(b+c)

= 1-(0.138+0.197)

= 0.665 CuM

Mass of coarse aggregate = 0.665*0.61*2.65*1000 = 1075 Kg

Mass of Fine aggregate = 0.665*0.39*2.65*1000 = 687.2 Kg

5. RESULT

Based upon the above mix design,following mix proportion has been calculated :

Mass of cement (Kg/)	Mass of water (Kg/)	Mass of fine aggregate (Kg/)	Mass of coarse aggregate (Kg/)
437.7	197	687.2	1075
1	0.45	1.57	2.45

The final mass ratio of cement, fine aggregate and coarse aggregate is 1:1.57:2.45

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6. EXPERIMENTAL INVESTIGATION

The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. The average compression strength of the specimens using 0% silica fume replacement is shown in the table . It was identified that the required strength was not achieved.

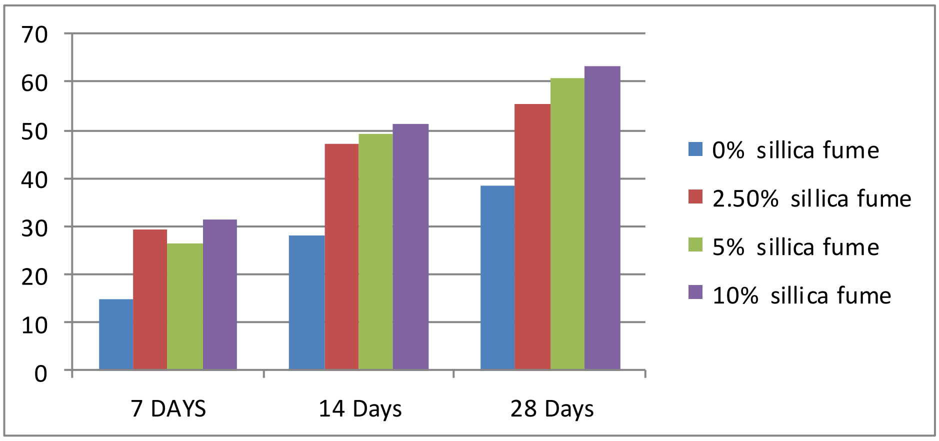
To achieve the required strength, 2.5%, 5% and 10% of cement is replaced by silica fume . Result of replacement is shown in the table .

Test Result of Cube for Compression

S. No	Curing days	Average Compressive strength in N/mm²		
		2.5 % replacement of Silica fume	5 % replacement of Silica fume	10 % replacement of Silica fume
1	7	29.43	26.2	31.4
2	14	47.16	49.13	51.10
3	28	55.5	60.78	63.12

From the above experimental Result, we found that after 10% replacement of silica fume , we got the required value of strength.

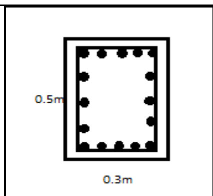
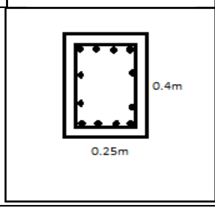
Below graph shows the actual changes takes place in strength after replacement of silica fume.



Compressive strength(N/mm^2) after 7, 14 & 28 days of curing.

After the calculations of M60 mix design, We took an example of a Building and design and analysis of building structure was done by Staad Pro v8i.The same building design was done with M60, M25 & Steel Structure. And the total estimated value of concrete and steel used in all these 3 types of structures were found out. Then Cost analysis was done based on the data .

Example of a Perticular column was taken to show the difference of cost involved in M25 & M60 concrete .

M25	M60	Design Parameter		
500	500	Fy	M25	
25	60	Fc		
4955	3740	As Required		
3.35	3.76	As %		
20mm	20mm	Bar size	M60	
16	12	Bar No.		
5060mm2	3768mm2	CS Area of Steel		
144940mm2	96232mm2	CS area of Concrete		

From the above data that ,we got from Staad Pro design, for the same type of loading , the reduction in Steel(in M60) was found to be 25% and Reduction in amount of concrete was found to be 33% approximately with compared to M25 grade. 1 CuM of M25 concrete is equivalent to 0.67 CuM of M60 Concrete. Addition of 10% of silica fume in the place of cement makes the cost of binder material slightly higher and cost of concrete in M60 is 10% less than the cost in M25 grade concrete.
The same column was also designed by taking Steel Sections and we found that the cost of the column is nearly 30% higher than the Concrete M25 Column.Detail cost estimation was done for the above structure and Results we got that HPC structures are Cost effective and durable.

We also recommend for HPC structures.

7. CONCLUSION

The following conclusions have been drawn:

(1) By using HPC, we get higher strength structure with lower cost as compared to M25 concrete.
(2) Use of steel structure are more costiler but ease in construction and recycle facility is there.
(3) There are many merits and demerits involed in all these types of structures, we must use according to our requirments.

8. RECOMMENDATIONS

The use of High Performance high strength concrete offers numerous advantages in the sustainable and economical design of structures and gives a direct savings in the concrete volume saved , savings in real estate costs in congested areas, reduction in form-work area and. The use of High Performance Concrete with its greater durability is likely to result in less maintenance and longer life and with the introduction of life-cycle costing, the long-term economic benefits.

REFERENCES

[1] IS 10262- 2009 /1982
[2] Mohd Mustafa Al Bakri, H. Kamarudin, Che Mohd Ruzaidi, Shamsul Baharin, R. Rozaimah, Nur Khairiatun Nisa. Concrete With Ceramic Waste and Quarry Dust Aggregates. 5th Annual Conference Management in Construction Researchers Association, 2006: 383-388.
[3] Basri HB, Mannan MA, Zain MFM. Concrete Using Waste Oil Palm Shells As Aggregate. Cem Concr Res 1999(29): 619–22.
[4] IS 456, Plain And Reinforced Concrete : Code of Practice, *Bureau of Indian Standards*, Fourth Revision,2000
[5] IS 1893 (Part 1), Criteria for Earthquake Resistant Design of Structures, *Bureau of Indian Standards*, Fifth Revision, Edition 6.1 ,2002.
[6] IS 875 (Part 1-4), Code of Practice for Design Loads (Other Than Earthquake Loads) for Buildings and Structures, *Bureau of Indian Standards*, ,1987 (Reaffirmed 2003).
[7] Indian Concrete Journal , December 2006 ,p 23-26 . Maiti, S C, Agarwal, Raj K, and Rajeeb Kumar,“Concrete mix proportioning.”
[8] Santhakumar.A.K.S, “concrete technology” Oxford Publication, New Delhi, 2006
[9] Gambhir.M.L.,“concrete technology” Tata McGraw-Hill Publishing company Ltd, New Delhi,2004.
[10] Mehta, P. K., and Aïtcin, P.C., “Principles Underlying Production of High-Performance Concrete,”
[11] ACI 211.4R-Concrete Mix Proportioning - Guidelines