Analyzing Economic Viability of High-Performance Concrete in Structural Engineering

Rajendra Kumar[1], Mr.Parmeshwar Sahu[2] Mr.Akhand Pratap Singh[3], Mr. Shiva Verma[4]
M.Tech Scholar[1], Assistant Professor[2], Assistant Professor[3] , Assistant Professor[4]
Department of Civil Engineering

Shri Rawatpura Sarkar University Raipur Chhattisgarh

Abstract: High-Performance Concrete (HPC) represents an advanced evolution of traditional cement concrete, where the selection and proportioning of constituent materials are meticulously optimized to enhance performance characteristics in both fresh and hardened states. Among its notable advantages is superior compressive strength, which translates into significant structural efficiencies. This research undertakes a comparative cost assessment of the three principal components involved in structural member construction—namely, concrete, reinforcement steel, and formwork—with the primary objective of evaluating the economic feasibility of adopting higher-grade concrete in structural systems.

The focal point of this study is to validate that utilizing high-strength concrete for critical load-bearing members, particularly columns responsible for transmitting axial loads to foundations, offers a structurally and economically optimal solution. To achieve this, the study examines pivotal mix design parameters influencing concrete strength, such as water-to-cementitious ratio, total cementitious content, cement-to-admixture ratio, and the dosage of superplasticizers, to arrive at efficient mix proportions suitable for high-grade concrete.

While conventional structural design aids cater to concrete strengths up to Fck = 40 N/mm², this work advances the design methodology by developing supplementary design curves through MATLAB programming for concrete grades up to Fck = 70 N/mm² and steel grades Fy = 250 N/mm² and Fy = 415 N/mm². These new curves aim to support structural engineers in adopting high-performance concrete solutions that are both technically sound and cost-effective.

Keywords: High-Performance Concrete, Structural Economics, Vertical Load Transfer, MATLAB Design Curves, Reinforcement Optimization.

1. Introduction

1.1 High Performance Concrete and High Strength Concrete

Concrete has historically played a pivotal role in shaping resilient and enduring infrastructure. Conventional construction practices have largely relied on concrete grades exhibiting compressive strengths between 20 and 40 N/mm². However, the growing demand for structurally refined and long-lasting buildings alongside concerns over the aging and suboptimal performance of traditional concrete has led to an intensified pursuit of advanced alternatives. The emerging need is for concrete that performs exceptionally well across multiple parameters: strength, durability, workability, and cost-efficiency. Addressing this multifaceted demand, High-Performance Concrete (HPC) has emerged as a transformative material in modern structural engineering.

The American Concrete Institute (ACI) defines HPC as a type of concrete that fulfills unique performance requirements and demonstrates consistent quality, which cannot always be attained through standard ingredients and conventional practices of mixing, placing, or curing. HPC's superiority lies in its ability to meet specialized structural demands particularly those related to compressive strength, serviceability under long-term environmental exposure, and crack and deflection control.

When performance is associated with critical structural applications, HPC often implies High-Strength Concrete (HSC), which constitutes a specific category of HPC. HSC is typically employed where weight reduction, compact design, or space efficiency are major considerations. The use of HSC contributes to sustainable construction by reducing concrete volume, minimizing formwork requirements, and enabling slimmer structural profiles especially beneficial in urban and space-constrained environments.

This study investigates the cost-efficiency of implementing HPC in structural design, with a special emphasis on its application in load-bearing components such as columns responsible for transferring axial loads to building foundations. By systematically comparing the primary cost drivers concrete material, steel reinforcement, and formwork this research aims to establish the economic rationale behind the adoption of high-strength concrete. Moreover, it explores the influence of key mix design variables and offers computational tools to aid engineers in making informed and economical design decisions using higher-grade concretes.

Concepts in the Design of High Performance Concrete

In order to achieve high strength for high performance, the various important factors that govern the strength of concrete are to be understood:

- The properties of the cement paste
- The properties of the aggregate
- The various chemical and mineral admixtures that are to be used
- The relative proportions of the constituent materials to be used.
- Paste Aggregate interaction.
- Mixing, Compaction and Curing.
- Testing Procedures.

All these factors need to be optimized in order to obtain concrete with significantly high compressive strength for High performance concrete.

Popularizing the Design of Structures Using High PerformanceConcrete

The use of High Performance Concrete with significantly higher compressive strength of concrete is on increasing trend in the construction industry and is being seen as an optimized solution considering the economics vis-à-vis strength and durability required for special structures. The scope of using High Performance Concrete in our constructional activities lies large, viz Multi-storied buildings, bridges and structures on coastal areas and the like. The primary reasons for selecting High Performance Concrete are to produce a more economical product, provide a feasible technical solution, or a combination of both. The use of HPC 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 are likely to more than offset the premium costs for initial construction. To affect this change from Conventional concrete to High Performance Concrete we will have to revive the designing of structures by encouraging use of High Performance Concrete by introducing the structural and economical advantages offered by High Performance Concrete.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The advantages of using High Performance Concrete particularly with the structural advantages of using high strength concrete have been described in various researches. These include a reduction in member size, reduction in the self-weight and super-imposed Dead Load with the accompanying saving due to smaller foundations, reduction in form-work area and cost construction of High–rise buildings with the accompanying savings in real estate costs in congested areas, longer spans and fewer beams for the same magnitude of loading, reduced axial shortening of compression supporting members ,reduction in the number of supports and the supporting foundations due to the increase in spans ,reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures, superior long term service performance under static, dynamic and fatigue loading, low creep and shrinkage . Achieving high strength concrete by using various chemical and mineral admixtures is also a subject of research and different design mix methods and trial mix approaches have been proposed for the development of high strength concrete. The various parameters that govern the strength of concrete like the different constituent materials required, properties of constituent materials , proportions in which they are to be used and specifications for the production and curing technique to be used for the development of high strength concrete are also being a subject of continuous research for the development of high strength concrete which is now being seen as a logical development of concrete because of the numerous advantages that it is supposed to provide.

Earlier Researches

Some of the earlier studies on the effectiveness in designing of structures like high rise building with high strength concrete are as follows:

J. Hegger (Aachen University of Technology, Institute of Concrete Structures, 52056, Aachen, Germany) (1) studied the economical and constructional advantages of High-strength concrete for a 186 m high office building in Frankfurt, Germany concluded that, for columns designed for a vertical load of 20 MN with a 85 MPa-concrete more than 50 of the reinforcement can be saved compared to a 45 MPa concrete. And in spite of the approximately 60% higher concrete cost the total costs can be reduced by about 15%.

According to a study by Moreno (2), the use of 41 MPa compressive strength concrete in the lower columns of a 23-story commercial building requires a (865-mm square) column whereas the use of (83 MPa) concrete allows a reduction in column size to (610 mm square) .In addition to the reduction in initial cost, a smaller column size results in less intrusion in the lower stories of commercial space and, thereby, more rentable floor space.

Also studies have been made regarding the method for obtaining high strength concrete as regards to the constituents required, the mix design parameters, the effect of various chemical and mineral admixtures on the

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strength of concrete. Whilst a number of studies have considered the development of a rational or standardized method of concrete mix design for high strength concrete no widely accepted method is currently available.

S. Bhanjaa, B. Sengupta(3) on the basis of 28-day strength results have proposed modified strength water–cementitious material ratio relationships for concrete containing cement plus silica fume as a supplementary cementitious material to evaluate the strength of silica fume concrete for obtaining high strength concrete mixes.

Henry H.C. Wong and Albert K.H. Kwan (Department of Civil Engineering, The University of Hong Kong, Hong Kong) (5) introduces the concept of packing density as a fundamental principle for designing HPC mixes. The concept is based on the belief that the performance of a concrete mix can be optimized by maximising the packing densities of the aggregate particles and the cementitious materials and presents a preliminary HPC design method, called three-tier system design.

Papayianni *, G. Tsohos, N. Oikonomou, P. Mavria(Department of Civil Engineering, Aristotle University of Thessaloniki, 54 124 Thessaloniki, Greece)(6) have established the influence of super-plasticizer type and mix design parameters on the performance of them in concrete mixtures for concrete of higher strength.

Scope of the Present Work

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 M20 and M60 using a concrete mix achieved in the laboratory .The effect of silica fume dosage and the dose of super plasticizer on the strength of concrete have been evaluated using an experimental programme aimed at achieving a High strength concrete mix. Design of a multi storied reinforced building has been done using both M20 and M60 using Staad Pro2004 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. Design curves for M60 and M60 have also been generated using MATLAB and given in the report for use in design using the grades of concrete as they are not given in the design aid presently available.3. Study of Cost Effectiveness

Cost Calculation and Comparison for M20 and M60

The cost calculation for concrete M20 and M60 was done and found out to be:

Details of cost of 10 Cum of cement concrete(M60): 1: 0.812 : 2.088						
Materials	Unit	Quantity/Nos			Rate	Cost
Stone agg	Cum	4.78			765.7	3660.046
sand	Cum	2.03			89.34	181.3602
cement	Quintal	57			360	20520
silica fume	kg	300.25			30	9007.5
Superplast	kg	60.24			50	3012
				Total cost per 10cum		36380.91
				Total cost per cum		3638.091

Table 3.1.Cost calculation for M60

Details of cost of 10 Cum of cement concrete(M20): 1:1.5:3						
Materials	Unit	Quantity/Nos			Rate	Cost
Stone agg	Cum	8.52			765.7	6523.764
sand	Cum	4.41			89.34	393.9894
cement	Quintal	40			360	14400
				Total cost per 10 cum		21317.75
				Total cost per cum		2131.775

Table 3.2.Cost Calculation for M20

Design of A Reinforced Concrete Building Frame Using M20 and M60 and Comparison

Introduction

A reinforced concrete building frame which was taken to be a library building has been analyzed and designed using Staad.Pro 2004 using concrete of grade M20 and M60 and has been compared as regards to the beam and column concrete consumption, steel reinforcement required and the cost aspect for concrete consumption and steel reinforcement required.

Analysis Design Using Staadpro 2004:

Creating the Model

The model of the Reinforced concrete building frame was created using the graphical model generation mode, or graphical user interface (GUI).

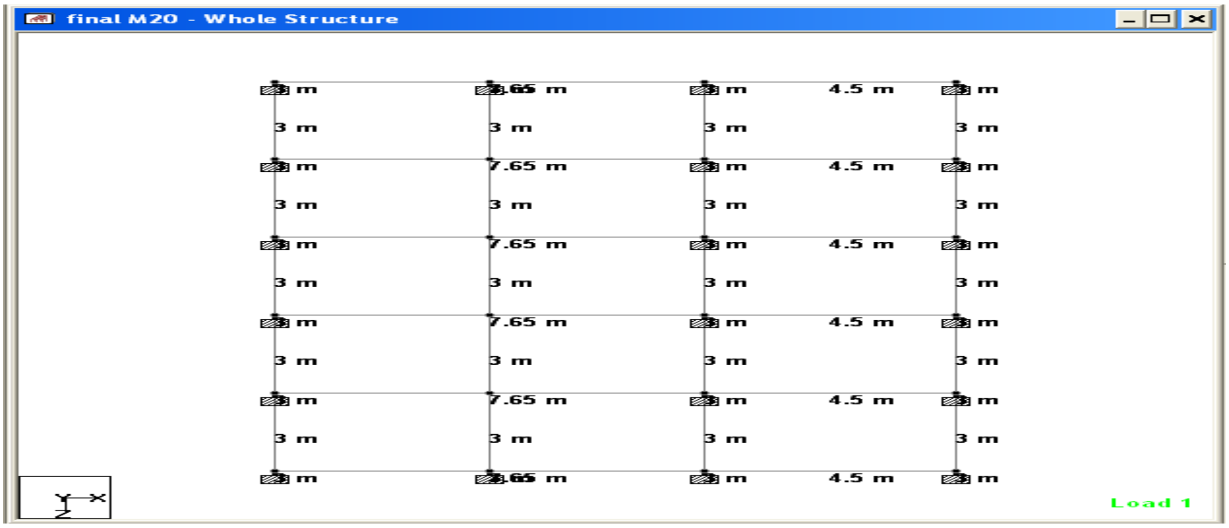

Figure 4.1:- Key Plan of slab beam of the building

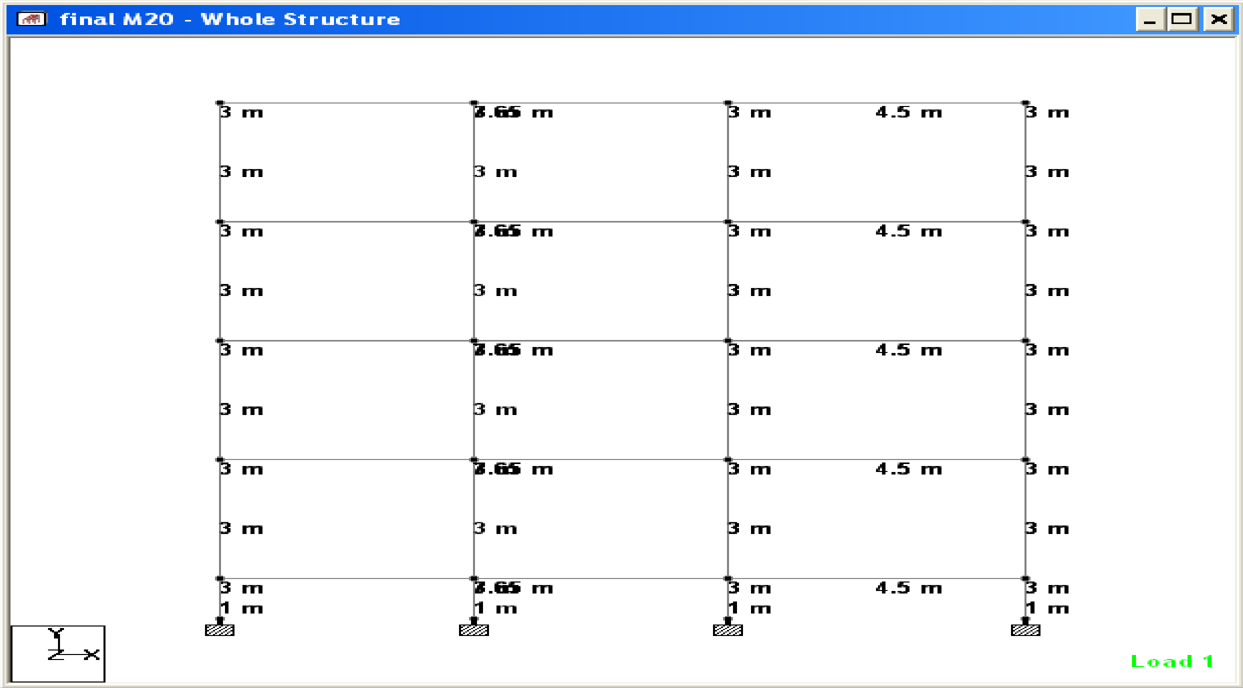

Figure 4.2:- Front View of the Building

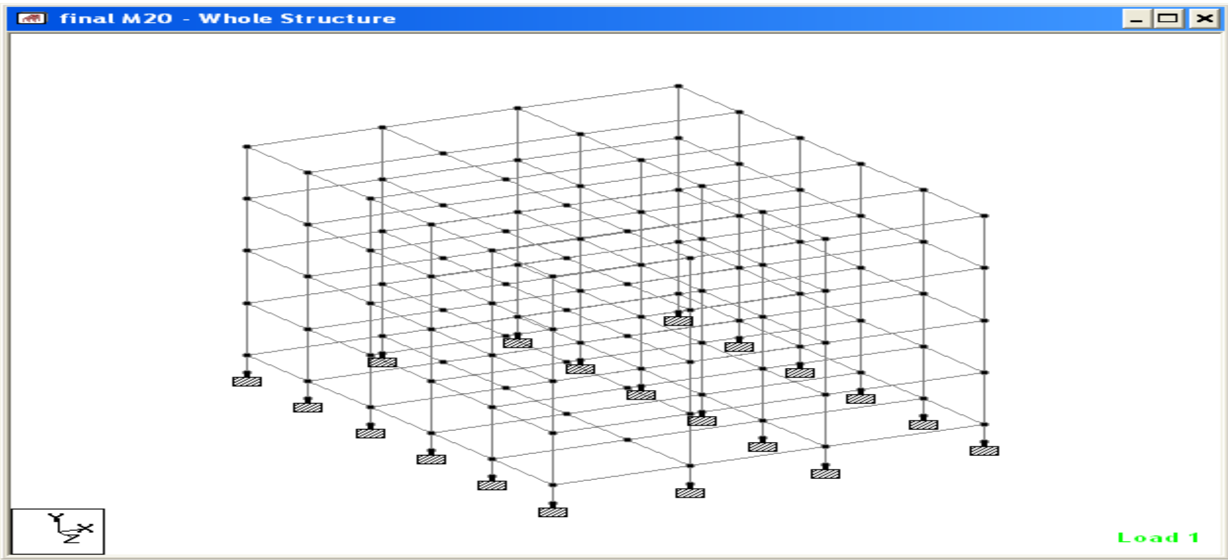

Figure 4.3:- Model of the Building

Generation of Member Property:

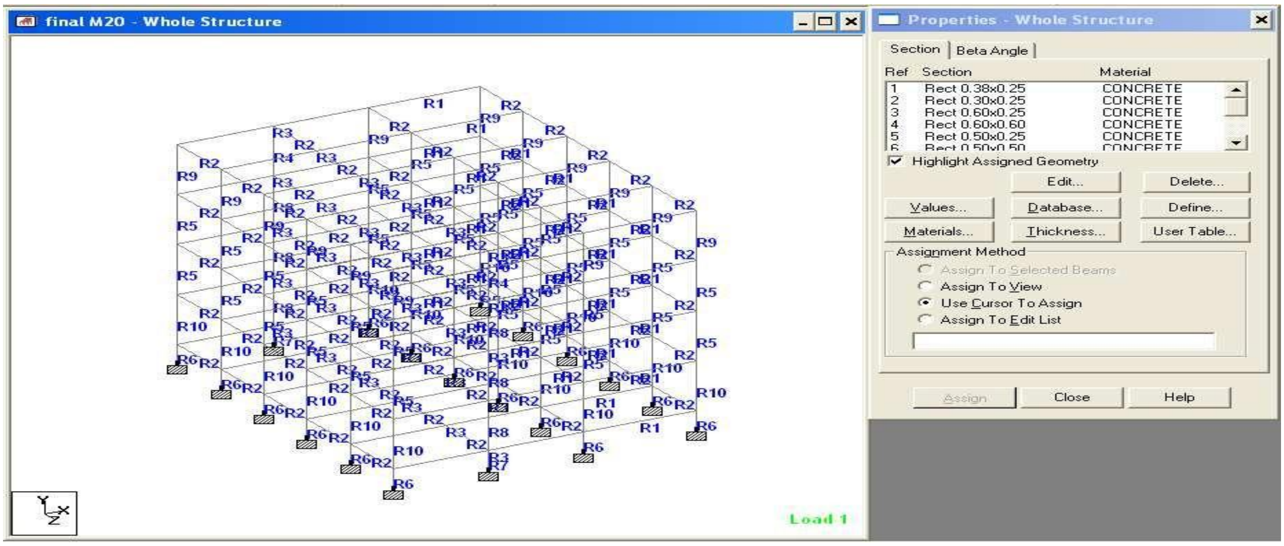

Figure 4.4:- Generation of Member Property

*R1 = 375mm*250mm R2= 300mm*250mm R3=600mm*250mm R4=600mm*600mm R5=500mm*250mm R6=500mm*500mm R7=600mm*600mm R8=500mm*500mm R9=350mm*250mm R10=450mm*450mm*

Materials for the Structure

The materials for the structure were specified as concrete with their various constants as perstandard IS code of practice.

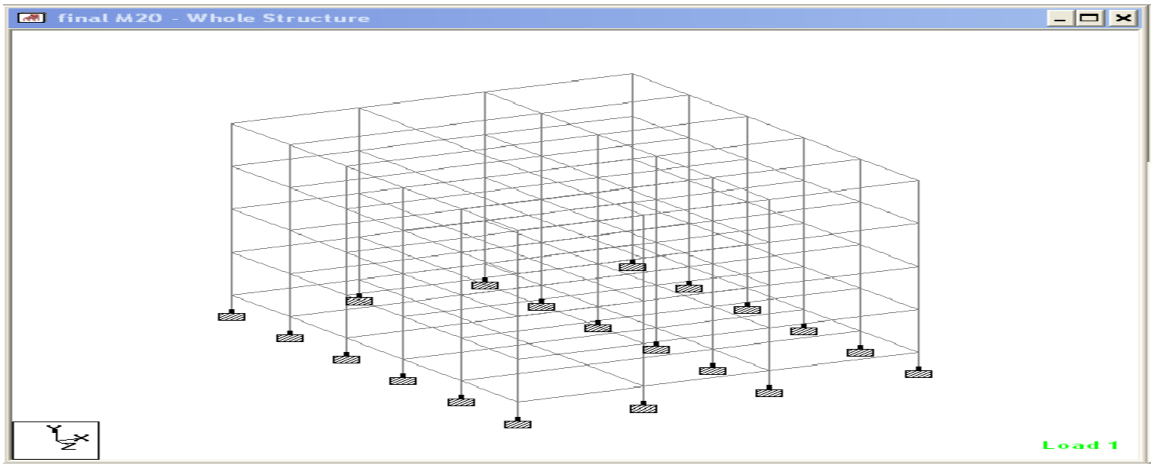

Figure 4.5:- Supports

Loading

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The frame was analyzed under a repeat load of 1.5 Dead Load + 1.2 Live Load.

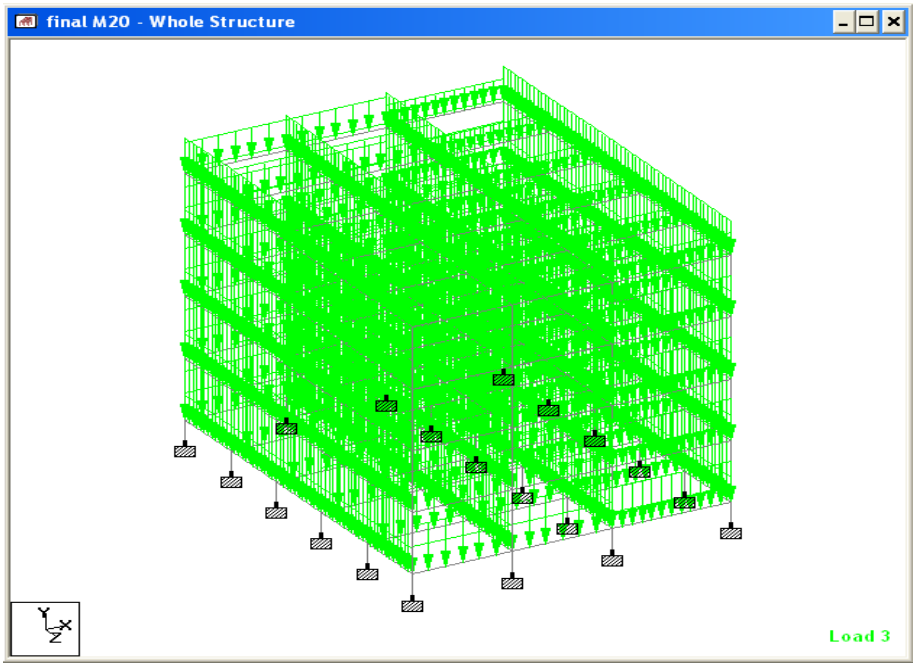

Figure 4.6:- Loading

Design Specifications

The structure was designed for concrete in accordance with IS code. The parameters such as clear cover; Fy, Fc, etc were specified. Then it has to be specified which members are to be designed as beams and which member are to be designed as columns. The specification for grade of concrete was first taken as Fc=20 N/sqmm for case 1. And then it was changed to be Fc=60 N/sqmm was taken in case 2 and then Fc=60N/sqmm with reduced section were taken in case 3.

Analysis and Design Results

Two beams, Beam no 109 and Beam no.132 and column no.177 were analyzed .Beam no.109 forms the beam B2 at exterior roof level at the second floor. Beam no 132 forms the beam B1 at the exterior roof level of the second floor whereas the Column no.177 forms the column of second floor were analyzed and the reinforcement required were obtained.

Case 1.Design Using M20

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C O L U M N N O. 177 D E S I G N R E S U L T SM20 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 252.1

TOTAL DESIGN MOMENTS: 40.82 27.16

REQD STEEL AREA: 904.46 Sq.mm.

B E A M N O. 132 D E S I G N R E S U L T S M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 7650.0 mm SIZE: 250.0 mm X 600.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)
SECTION 0.0 mm 1912.5 mm 3825.0 mm 5737.5 mm 7650.0 mm

TOP REINF.	1295.36 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	1421.61 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	380.93 (Sq. mm)	939.69 (Sq. mm)	323.65 (Sq. mm)	79.29 (Sq. mm)

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==*B E A M N O. 109 D E S I G N R E S U L T S*

M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4500.0 mm SIZE: 250.0 mm X 375.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)
SECTION 0.0 mm 1125.0 mm 2250.0 mm 3375.0 mm 4500.0 mm

TOP REINF.	524.91 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	176.66 (Sq. mm)	878.86 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	176.66 (Sq. mm)	262.44 (Sq. mm)	176.66 (Sq. mm)	74.87 (Sq. mm)

Case 2. Design Using M60:

C O L U M N N O. 177 D E S I G N R E S U L T S

M60 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu): 252.1

TOTAL DESIGN MOMENTS: 40.82 27.16

REQD. STEEL AREA: 519.93 Sq.mm.

B E A M N O. 132 D E S I G N R E S U L T S M60 Fe415 (Main) Fe415 (Sec.)
LENGTH: 7650.0 mm SIZE: 250.0 mm X 600.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)
SECTION 0.0 mm 1912.5 mm 3825.0 mm 5737.5 mm 7650.0 mm

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TOP REINF.	1116.62 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	1238.01 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	362.76 (Sq. mm)	854.88 (Sq. mm)	310.17 (Sq. mm)	0.00 (Sq. mm)

B E A M N O. 109 D E S I G N R E S U L T S M60 Fe415 (Main) Fe415 (Sec.)
LENGTH: 4500.0 mm SIZE: 250.0 mm X 375.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)

SECTION	*0.0 mm*	*1125.0 mm*	*2250.0 mm*	*3375.0 mm*	*4500.0 mm*
TOP REINF.	*480.31 (Sq. mm)*	*0.00 (Sq. mm)*	*0.00 (Sq. mm)*	*176.66 (Sq. mm)*	*765.58 (Sq. mm)*
BOTTOM REINF.	0.00 (Sq. mm)	176.66 (Sq. mm)	250.86 (Sq. mm)	176.66 (Sq. mm)	0.00 (Sq. mm)

Case 3. Design with M60 and reduced sections

C O L U M N N O. 177 D E S I G N R E S U L T S

M60 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 450.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)

DESIGN AXIAL FORCE (Pu) : 247.1

TOTAL DESIGN MOMENTS : 39.89 26.90

REQD. STEEL AREA: 605.66 Sq.mm.

B E A M N O. 132 D E S I G N R E S U L T S
M60 Fe415 (Main) Fe415 (Sec.)

LENGTH: 7650.0 mm SIZE: 250.0 mm X 550.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)
SECTION 0.0 mm 1912.5 mm 3825.0 mm 5737.5 mm 7650.0 mm

TOP	1290.49	0.00	0.00	0.00	1422.24
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
BOTTOM	0.00	359.24	897.27	302.33	0.00
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)

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B E A M N O. 109 D E S I G N R E S U L T S
M60 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4500.0 mm SIZE: 250.0 mm X 350.0 mm COVER: 25.0 mmSUMMARY OF REINF. AREA (Sq.mm)

SECTION	*0.0 mm*	*1125.0 mm*	*2250.0 mm*	*3375.0 mm*	*4500.0 mm*
TOP	531.46	0.00	0.00	163.86	790.30
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
BOTTOM	0.00	163.86	277.35	163.86	0.00
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)

===

Column section (250*500) with Grades M50, M60, M70, M80, M90, M100

C O L U M N N O. 259 D E S I G N R E S U L T S
M20 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mmCOVER: 40.0 mm

DESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 33.54

REQD. STEEL AREA : 2047.36 Sq.mm.

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C O L U M N N O. 259 D E S I G N R E S U L T SM50 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA : 1049.64 Sq.mm.

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C O L U M N N O. 259 D E S I G N R E S U L T SM60 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA : 892.20 Sq.mm.
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C O L U M N N O. 259 D E S I G N R E S U L T SM70 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA : 794.73 Sq.mm.
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C O L U M N N O. 259 D E S I G N R E S U L T SM80 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA : 721.63 Sq.mm.

C O L U M N N O. 259 D E S I G N R E S U L T SM90 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA: 676.44 Sq.mm.

C O L C O L U M N N O. 259 D E S I G N R E S U L T S
M100 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 250.0 mm X 500.0 mm COVER: 40.0 mmDESIGN FORCES (KNS-MET)
DESIGN AXIAL FORCE (Pu) : 585.3

TOTAL DESIGN MOMENTS : 104.92 34.37

REQD. STEEL AREA : 629.79 Sq.mm.
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Comparisons of the results

Comparison in concrete and reinforcement required

For column no.177:

1. M20 and (250*500) section A_{st} required =904.46 mm²
2. M60 and (250*500) section

A_{st} required =519.93 mm²

3. M60 and (250*450) section A_{st} required =605.66 mm²

Difference in steel requirement between 1 and 2=384.53 mm² . Difference in steel requirement between 1 and 3=298.8 mm² . Difference in concrete requirement between 1 and 3 per m=.0125 cum.

For beam no 109:

1. M20 and (250*375) section A_{st} required = 2271.03 mm²
2. M60 and (250*375) section A_{st} required =2026.73 mm²
3. M60 and (250*350) section A_{st} required =2090.69 mm²

Difference in steel requirement between 1 and 2=244.3mm² Difference in steel requirement between 1 and 3= 180.34 mm²
Difference in concrete requirement between 1 and 3 per m= .00625 cum

For beam no.132

1. M20 and (250*600) section A_{st} required =4440.53 mm²
2. M60 and (250*600) section A_{st} required = 3882.44 mm²
3. M60 and (250*550) section A_{st} required = 4271.57 mm²

Difference in steel requirement between 1 and 2=558.090 mm² Difference in steel requirement between 1 and 3=168.960 mm² Difference in concrete requirement between 1 and 3 per m=.0125 cum

Cost Comparison:

Case 1 : (a)Beams and columns designed using M20:

************** Concrete Take Off			**************			
(For Beams And Columns Designed					M20)	
Total Volume Of Concrete =			105.01 Cu.Meter			
	Bar Dia	Weight				
	(In Mm)	(In New)				
	--------	--------				
8	25757.25					
10	7067.31					
12	21867.72					
16	12128.28					

20 48254.73			
25 10003.06			

*** Total= 125078.35			

Table 3.3 Concrete and steel requirement for beams and columns using M20

Case 1 : (b)Beams and columns designed using M60:

	************** Concrete Take Off **************					
	(For Beams And Columns Designed Using M60)					
	Total Volume Of Concrete = 105.01 Cu.Meter					
	Bar Dia	Weight				
	(In Mm)	(In New)				
	--------	--------				
	8	26132.00				
	10	12145.68				
	12	21411.84				
	16	14008.50				
	20	18511.27				
	25	2313.20				

	*** TOTAL= 94522.48					

Table 3.4 Concrete and steel requirement for beams and columns using M60

*Cost of concrete and steel reinforcement in case 1 (a) =(105.01*2131.775) +(12507.835*50)*
= Rs 849249.4428

*Cost of concrete and steel reinforcement in case 1 (b) =(105.01*3638.091) + (9452.248*50)*
= Rs 854648.335

Difference in Cost between Case 1 (a) and Case 1 (b) = Rs 5398.89311 Increase in Cost = 0.6% with high strength concrete

Case 2(a):Columns designed using M20

**** Concrete Take Off **************					
(For Columns Designed Using M20)					
Total Volume Of Concrete = 41.09cu.Meter					
Bar Dia	Weight				
(In Mm)	(In New)				
--------	--------				
8	5936.43				
12	15846.64				

16	6813.58				
20	31347.51				
25	302.38				

*** Total=	60246.55				

Table 3.5 Concrete and steel requirement for columns using M20

Case 2(b):Columns designed using M60:

************** Concrete Take Off **************						
(For Columns Designed Using M60)						
Total Volume Of Concrete =			41.09 Cu.Meter			
	Bar Dia	Weight				
	(In Mm)	(In New)				
	--------	--------				
	8	6277.90				
	12	13826.64				
	16	5822.52				
	20	15673.75				

	*** TOTAL= 41600.82					

Table 3.6 Concrete and steel requirement for columns using M60

*Cost of concrete and steel reinforcement in Case 2(a) = (41.09*2131.775)+(6024.655*50)*
=Rs 388827.3848

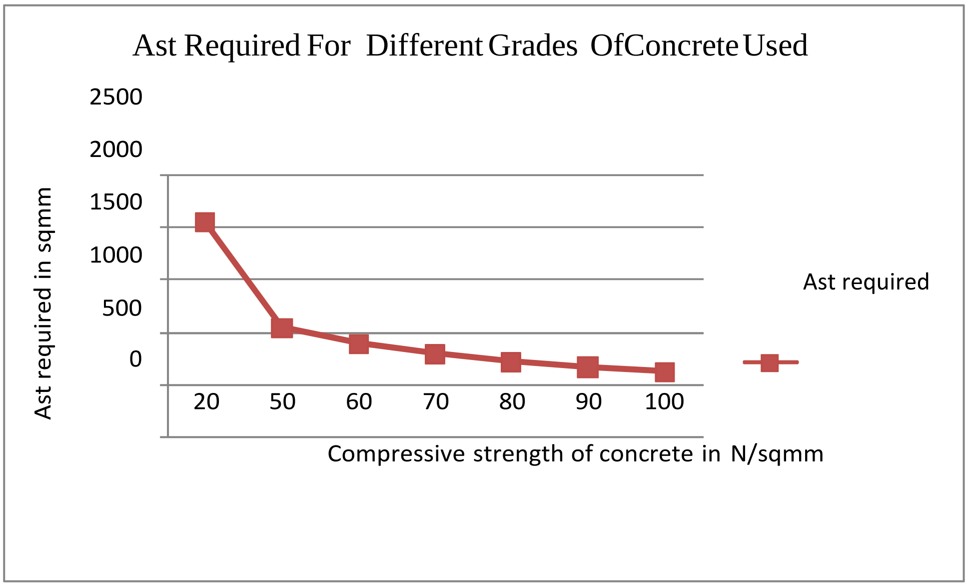
*Cost of concrete and steel reinforcement in Case 2(b) = (41.09*3638.091)+(4160.082*50)*
=Rs 357493.2592

Cost difference between Case 2(a) and Case 2(b) = Rs 31334.1256Savings = 8% on the previous cost.

The column no.259 is designed for concrete with compressive strength of 50 N/sqmm,60 N/sqmm,70 N/sqmm,80 N/sqmm,90 N/sqmm,100 N/sqmm respectively using the same column section of (250*500 mm) and the steel area required is found out .The steel areas required for column is found to reduce with a corresponding increase in the strength of concrete used.

Fc (N/sqmm)	Ast required in sqmm
20	2047
50	1050
60	892
70	795
80	722
90	676
100	630

Table 3.7. Ast required for columns with high strength concrete



Graph 3.1. Variation of steel area required with increase in the strength of concrete to be used

Conclusion

At the present time, a cubic metre of High Performance Concrete is found to be more than a cubic metre of conventional concrete. High Performance Concrete requires additional quantities of materials such as cement, silica fume, and high-range water-reducers to ensure that the concrete meets the specified strength and performance which increase the cost of High Performance Concrete. But overall the use of concrete with higher compressive strengths offer economically viable solution in columns and other load bearing members Also the use of High Performance Concrete with concrete compressive strength higher than conventional concrete is found to offer structural advantages viz, more efficient floor plans through smaller vertical members (columns) and also proves to be the most economical alternative by reducing both the total volume of concrete and the amount of steel required for a load bearing member besides providing resistanceto long term deteoriation ,lower maintenance etc.

High Performance Concrete with higher compressive strength provides the most economical way for designing the load bearing members and to carry a vertical load to the building foundation through columns by a reduction in the quantity of steel required and also concrete which contribute mainly to the cost of the structural member. The mix design variables affecting the concrete strength which are the most critical in the strength development of concrete including water-cementitious material ratio, total cementitious material, cement-admixture ratio amount of super plasticizer dose are to be analyzed and optimum values of the critical mix design variables are to be taken for obtaining the mix design for the required High Performance Concrete

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 are likely to more than offset the premium costs for initial construction. To affect this change from

Conventional concrete to High Performance Concrete we will have to revive the designing of structures by encouraging use of High Performance Concrete.

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