

ECONOMIC FEASIBILITY STUDY FOR ADOPTING ALUFORM IN HIGHRISE BUILDING

A Thesis

Submitted in partial fulfilment of the requirements for the award of
Master of Architecture degree in Building Management

By

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**DEPARTMENT OF ARCHITECTURE
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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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ABSTRACT

The project involves cost and duration analysis of a building constructed by Conventional formwork building and MIVAN formwork building. The main aim of this project is to determine which type of formwork is suitable for type of construction and which have less effect in project duration and cost.

The valuation of real estate is expected when calculating the market value of a property according to its qualitative characteristics. Based on the basic needs of human housing, real estate prices increase day by day as the population increases. However, predicting the approximate rate will be a very complex problem. Since then, all states have many different characteristics due to the location and use of it. Therefore, the calculation of the exact valuation of any property is becoming a prerequisite.

On other hand analyzing revenue potential of any property plays an important role. This can be done by using suitable valuation models. Aspects to be covered in calculating revenue potential of property are calculating IRR, Payback period, Capitalization rate, ROI and project feasibility. However this can be done during project planning stage or during preparation of feasibility study.

In this project I will be able to evaluate various valuation models and choose specific model that will help government in calculating revenue potential and profit recovered from investment. I will also evaluate the feasibility models pertaining to five aspects like Economical, Technical, Operational, Legal and Scheduling.

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

The Most Effective Means Available For The Construction Of High, Medium And Low Rise Mass Housing R/C Structures.

It Is A Precision-Engineered Formwork Fabricated In Aluminium Monolithic Pouring.

Walls, Columns, Slabs & Beam Are Poured Together. Speed - Induces A Disciplined & Systemized Approach To Construction, Which Creates A Daily Work Cycle, The Essence Of The Productivity.

The Productivity Generates A Overall Work Cycle, That Can Achieve 4/5 Day Per Floor Outputs Or Other Cycle Times To Suit Your Project Requirements.

1.2 AIM

The Aim Is To Propose Mixed Use Development In Thirumalisai Using The Aluform Technology, It Is A Precision-Engineered Formwork Fabricated In Aluminium And How The Uses Of Aluform, Can Save Time And Money For A Multi-Crore Project.

Benefits Of Aluform Technology Will Be Explained By Comparing It With Conventional Technology.

1.3 RESEARCH OBJECTIVES

Quantity Estimation Of Construction Material Required For Building By Both MIVAN Formwork And Conventional Formwork.

To Determine Complete Time Required For Completion Of The Building By Both The Above Methods.

To Compare The Cost Of Buildings Based On The Cost Of Materials Required In Each Of Them.

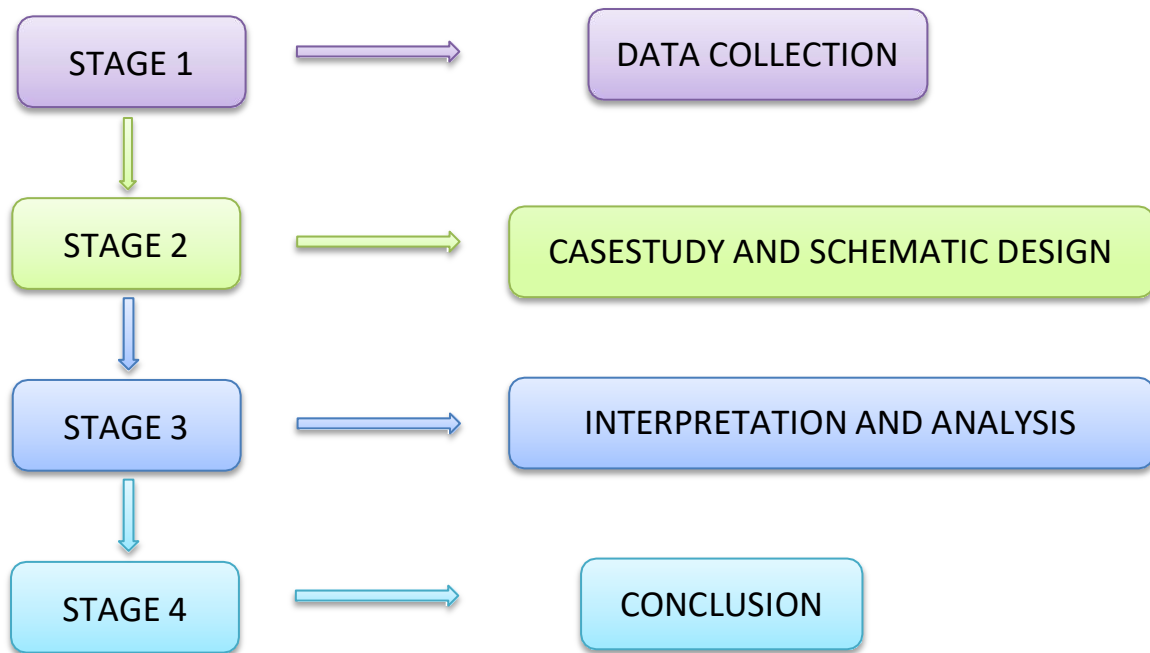
To Carry Out The Comparative Analysis Between The Mentioned Two Methods Of Construction And Define Suitability Difference Between Them.

1.4 SCOPE OF WORK

Many Of The Accidents Take Place In Reinforced Cement Concrete (RCC) Construction Because Of Inferior Formwork And Scaffolding.

Now Focus Has To Be Shifted To Other Key Factor "Formwork", To Face The Challenges For The Completion Of Fast Track Projects. By Going In For System Formwork, Substantial Savings Are Possible By Faster Return On Investments.

1.5 RESEARCH METHODOLOGY



1.6 ABOUT THE SITE:

The Site Is Located In Thirumazhisai With An Extent Of 311.05 Acres.

The Tamilnadu Housing Board Is Planned To Develop A Massive Township For 12,000 Peoples About 30 Kms From The City Is Exploiting The Commercial Space For The Purpose.

The THNB Has 127 Acres Of Land At Thirumazhisai, Of Which About 30 Acres Would Be Utilized For Infrastructure Facilities Within The Township.

About 20 Acres Has Been Earmarked For Commercial Space.

Located On Chennai — Bengaluru Highway, The Land Parcel Falls Under The Chennai Metropolitan Area.

The Demand For Housing At Thirumazhisai Would Be From Those Working At The Industrial Belt Of Irungattukottai And Sriperumbadur.

1.7 MERITS OF ALUMINIUM FORMWORK

In Contrast To Most Of The Modern Construction Systems, Which Are Machine And Equipment Oriented, The Formwork Does Not Depend Upon Heavy Lifting Equipment And Can Be Handled By Unskilled Labors.

Fast Construction Is Assured And Is Particularly Suitable For Large Magnitude Construction Of Respective Nature At One Project Site.

Construction Carried Out By This System Has Exceptionally Good Quality With Accurate Dimensions For All Openings To Receive Windows And Doors, Right Angles At Meeting Points Of Wall To Wall, Wall To Floor, Wall To Ceiling, Etc, Concrete Surface Finishes Are Good To Receive Painting Directly Without Plaster.

System Components Are Durable And Can Be Used Several Times Without Sacrificing The Quality Or Correctness Of Dimensions And Surface.

As All The Walls Are Cast Monolithic And Simultaneously With Floor Slabs Requiring No Further Plasters Finish. Therefore The Time Required In The Conventional Method For Construction Of Walls And Plastering Is Saved.

CHAPTER 2

LITERATURE REVIEW

2.1 COMPARISON OF ALUMINUM FORM CONSTRUCTION TECHNIQUE OVER CONVENTIONAL FORMS:

More Seismic Resistance: - The Box Type Construction Provides More Seismic Resistance To The Structure.

Increased Durability: - The Durability Of A Complete Concrete Structure Is More Than Conventional Brick Bat Masonry.

Lesser Number Of Joints Thereby Reducing The Leakages And Enhancing The Durability.

Higher Carpet Area- Due To Shear Walls The Walls Are Thin Thus Increasing Area.

Integral And Smooth Finishing Of Wall And Slab- Smooth Finish Of Aluminium Can Be Seen Vividly On Walls.

Uniform Quality Of Construction – Uniform Grade Of Concrete Is Used.

Negligible Maintenance – Strong Built Up Of Concrete Needs No Maintenance.

Faster Completion – Unsurpassed Construction Speed Can Be Achieved Due To Light Weight Of Forms.

Lesser Manual Labour- Less Labour Is Required For Carrying Formworks.

Simplified Foundation Design Due To Consistent Load Distribution.

The Natural Density Of Concrete Wall Result In Better Sound Transmission Coefficient.

2.2 COMPARATIVE ANALYSIS ON COST AND DURATION OF MIVAN FORMWORK BUILDING AND CONVENTIONAL FORMWORK BUILDING - GANAR A. S.

2.2.1 Abstract:

The Project Involves Cost And Duration Analysis Of A Building Constructed By Conventional Formwork Building And MIVAN Formwork Building. The Buildings Are Of G+12 Floors And Area Of Both The Buildings Are 771.92 Sq.M With 2.95 M As The Height Of Each Floor. The Analysis Involves The Quantity Calculation For Cost For Both Buildings And Duration Comparison Of Conventional Formwork Building And MIVAN Formwork Building.

2.2.2 Main Objective:

To Compare The Cost Of Building By Using Conventional Formwork Technique & By Using MIVAN Formwork Technique.

To Compare The Duration Of Building By Using Conventional Formwork Technique & By Using MIVAN Formwork Technique.

2.2.3 Casestudy:

This World-Class Project Is Being Designed On 400 Acres Of Land At Dhanori, Which Is To Be The Center Of Greater Pune Having 1, 2 & 3 BHK Flats/ Apartments.

2.2.4 Inference:

Cost Of MIVAN Formwork Building Is 14.04 Percent Cheaper Than The Conventional Formwork Building. The Construction Of MIVAN Building Can Be Done In Half Duration Of Construction Of Conventional Building Of 12 Floors. From The Results Of The Case Study It Can Be Concluded That Quality And Speed Must Be Given Precisely Consideration With Regards To Economy.

2.3 PLANNING AND SCHEDULING OF SHUTTERING SYSTEM FOR MULTISTOREYED BUILDING - NAVEEN V.CHIKKAVEERAYANAVAR, NARESH PATIL

2.3.1 Abstract:

The Standard Of The Construction Industry Is Raised With The Use Of Aluminum And Prefabricated Formwork. The Main Aim Of This Project Is To Determine Which Type Of Formwork Is Suitable For Type Of Construction And Which Have Less Effect In Project Duration And Cost.

2.3.2 Main Objective:

The Main Objective Of This Study Is To Plan, Schedule And Track A Residential Building Project With The Use Of MSP 2013 Software, Analyzing The Result And Which Method Is Suitable For Residential Building Project Is Determined And Measure Are Recommended To The Organization For Enhancing Their Project Planning Skills.

2.3.3 Casestudy:

Project:- Residential Building Location:- Mumbai Design Consultant:- JW Consultant
Built Up Area:- 675.779sqm Number Of Storey:- G+21 Floors

2.3.4 Inference:

A Case Study Was Conducted On A Residential Project And Comparison Between The Conventional Formwork And Mivan Technology Was Analyzed And Results Were Determined. Even Though The Initial Investment Of Mivan Technology Is High, It Provides Cost Efficient Project And Eliminated The Need Of Plastering Work As It Gives A Good Surface Finish Compared To Conventional Type Of Formwork. The Duration Of Project Can Be Minimized By Adopting Mivan Technology. And Hence It Is Concluded That Mivan Technology Is Not Suitable For Small Scale Projects.

2.4 TIME AND COST OPTIMIZATION OF CONSTRUCTION PROJECT USING MIVAN TECHNOLOGY - AKSHAY GULGHANE , NIKHIL PITALE , SANKET SANGHAI

2.4.1 Abstract:

Construction Is One Of The Significant Sectors And Integral Part Of Indian Economy. Also, It Mivan Is Comparatively A New Construction Technology Upcoming For Successful Completion Of Mass Project Especially Repetitive In Nature. In This Paper We Have Discussed About Cost As Well As Time Comparison Of Mivan Technology With Conventional Formwork Technology.

2.4.2 Main Objective:

Quantity Estimation Of Construction Material Required For Building By Both MIVAN Formwork And Conventional Formwork.

To Determine Complete Time Required For Completion Of The Building By Both The Above Methods.

To Compare The Cost Of Buildings Based On The Cost Of Materials Required In Each Of Them. To Carry Out The Comparative Analysis Between The Mentioned Two Methods Of Construction And Define Suitability Difference Between Them.

2.4.3 Tools Used For The Project:

1. Cubic Contents Method ,
2. Formwork Planning,
3. Aluminium Formwork System,
4. Ccpm Framework Technique Is Used For Scheduling.

2.4.4 Detailed Material Used

Table No 2.4.4 Detailed Materials Used

SR.NO	CONTENT	MIVAN	CONVENTIONAL
1	Concrete Grade	M15,M20, M25	M15,M25, M40
2	Thickness Of The Wall	140mm , 160mm	160mm, 200mm,230mm
3	Steel	8mm, 12mm ,16mm	8mm, 12mm, 16mm, 25mm, 32mm
4	Slab	130mm	150mm, 175mm

2.4.5 Duration Using Mivan Technology

Table No 2.4.5 Duration Using Mivan Technology

SR.NO	ACTIVITY	NO.OF DAYS
1	All Shuttering	18
2	Conceal ElectrificationAnd Plumbing	18
3	Steel Reinforcement	6
4	AlignmentChecking	3
5	Buffer Time	2
6	ConcretePlacing	3
7	Removal OfVertical Formwork	2
8	Removal OfOther Formwork	14
9	Lifting Of WallPanels	2
10	Gypsum Plastering &Painting	30
	Total	98

2.4.6 Duration Using Conventional Techniques

Table No 2.4.6 Duration Using Conventional Techniques

SR.NO	ACTIVITY	NO.OF DAYS
1	Column Shuttering	12
2	Column SteelReinforcement	12
3	Buffer	2
4	Beam & SlabShuttering	15
5	Beam & SlabSteel Placing	12
6	Leveling	3
7	ConcretePlacing	6
8	Removal OfOther Formwork	15
9	Brickwork	30
10	Plastering	30
11	Finishing	30
	Total	167

CHAPTER 3 LITERATURE CASE STUDY

3.1 CASE STUDY ON A MULTI STORY BUILDING AT CHENNAI FORMWORK SYSTEM USED TUNNEL FORM WORK.

3.1.1 Project Description:

Project Name : Proposed Construction Of Staff Quarters At Chennai

Configuration : Piling. RCC Framed Buildings

Structure : G+18

Total No. Of Villa : 144

Project Duration : 8 Months

Form Work System : Tunnel Form Work

Buildup Area : 181351 sft

3.1.2 Form Work System:

A Formwork System Signifies The Molds Used To Store And Hold Wet Concrete Until Curing Is Achieved. Concrete Has Been Demonstrated To Be The Most Suitable Construction Material For Buildings And Foundations Since It Withstands Fire And Ensures Protection Against Storms And Extreme Temperatures. In Addition, Concrete Contributes To The Creative Modern Architectural Design.

3.1.3 Conventional/Traditional Formwork:

The Formwork Is Built On Site Out Of Timber And Plywood Or Moisture-Resistant Particleboard.

3.1.4 Mivan Formwork:

The Formwork System Is Engineered Formwork System Fabricated In Aluminium.

3.1.5 Tunnel Form Systems:

Tunnel Form Systems Are Used To Construct Repetitive Cellular Structures (Such As Hotels And Apartment Blocks) And Enable The Construction Of Horizontal And Vertical Elements (Floors And Walls) Together.

Each Unit Is In The Form Of An Inverted L.

Several Units Are Erected Together To Create The Formwork For A Number Of 'Tunnels' Consisting Of Walls And Ceiling Slab.

The Normal Dimensions Of Tunnel Form Units Are 8 To 11m Long And 2.4 To 6.8m Wide, But Individual Units Can Be Joined To Give Tunnels Of Greater Length.

3.1.6 Advantages Related On Time& Cost Bases:

The Production Cycle 1-3 Days / Floor Can Be Archived.

The Project Can Be Completed With Short Period Compared To Conventional & Aluminium Formwork System.

Labour Obtain Specialization & “Zero Defect” Production Pattern Is Possible.

Repetitive Nature Of Buildings Provides Effectiveness In Production And Minimization Of Labour Work.

Formwork Cost Per Sqm Can Be Reduced By Using Formwork Up To 500 Cycles.

3.1.7 Challenges Faced Based On Design And Architectural Aspects

Dimension Limitation Must Be Considered,

Minimum Room Size 2000mm (Approx.) Minimum Wall & Slab Thickness 150mm.

It's Not Convenient For Theatres & Hall, That Contains Large Span.

Load Bearing Walls Must Be Designed Continuously On The Same Axial System Due To The Resistance Requirements Against Horizontal Forces.

Continuous Footing Or Raft Required.

3.1.8 Conclusion:

Different Formwork Systems Provide A Wide Range Of Concrete Construction Solutions That Can Be Chosen To Suit The Needs Of A Particular Development.

Traditional Formwork For Concrete Construction Normally Consisted Of Bespoke Solutions Requiring Skilled Craftsmen.

This Type Of Formwork Often Had Poor Safety Features And Gave Slow Rates Of Construction On-Site And Huge Levels Of Waste – Inefficient And Unsustainable.

Modern Formwork Systems, Which Are Mostly Modular , Are Designed For Speed And Efficiency.

They Are Engineered To Provide Increased Accuracy And Minimize Waste In Construction And Most Have Enhanced Health And Safety Features Built-In.

The Main Systems In Use Are Mivan Technology And Tunnel Form.

This Guide Sets Out Their Key Features — Process Efficiency, Safety, Sustainability And Other Considerations – In Order To Help Construction Professionals To Take Advantage Of Them To Achieve Modern, Efficient Concrete Construction.

3.2 SPHAGETTI @ KHARGHAR

The City And Industrial Development Corporation And Organization (CIDCO) Of Maharashtra Are Responsible For The Development Of Navi — Mumbai. It Has Undertaken Massive Projects To Achieve This Goal And Has Encouraged Use Of Latest Technologies To Complete The Projects.

3.2.1 Completed Project With Mivan Formwork

Location: Navi – Mumbai.
Country: India.
Client: Cidco And L&T Ecc
Scope: 4 No. Blocks On Each Floor Of 4, 5, 6, And 7 Storey Apts.
Design: Load Bearing Wall & Slab.
Cycle: 8 Days Per Floor.
System Formwork: 6000 Sq.Mt.
Contract Start Date: November 2003.
Project Type (S): High Rise, Residential Building Having 16 Buildings In All.
Architect: Hafeez Contractor.

3.2.2 Discussion About This Project:

The Building In Plan Made An Angle Of 172° , 168° And 161° With Each Other.

The Quality Of Construction Is Maintained At The Site With The Use Of RMC.

The RMC Plant Has A Capacity Of Producing 90 Cubic Meter Of Concrete Of Concrete Per Hour.

The Concrete Used Was Of 25 Grades.

The Construction From Foundation Up To Stilt Is Done With Conventional Practice While The Upper Floors Are Constructed Using 'MIVAN' Technology.

The Construction Company Has Imported Three Sets Of Aluminium Forms.

The Cost Is About Rs.500/- Sq.Ft As Against Rs.650/- Sq.Ft Using Conventional Methods.

Thus It Can Be Said That Even Though The Cost Of Construction Is Little Bit High It Has An Unmatched Quality Compared To The Conventional Method.

MIVAN Formwork Played A Vital Role In The Construction Of The Project.

The Project Was Completed Not Only On Stipulated Period Of Time But Also Paid Off With Its Attributes.

Speedy & Quality Dwelling Units Were Provided To The People Of Low Income Groups At Very Reasonable Costs.

MIVAN Is A Definitely Future Of This Ever Growing Construction Industry With Lots Of Project Still Awaiting Its Touch Of Excellence.

3.2.3 Inference About These Case Studies:

We Have Tried To Cover Each And Every Aspect Related To Aluminium(MIVAN) Form Construction.

We Thus Infer That MIVAN Form Construction Is Able To Provide High Quality Construction At Unbelievable Speed And At Reasonable Cost.

This Technology Has Great Potential For Application In India To Provide Affordable Housing To Its Rising Population.

Thus It Can Be Concluded That Quality And Speed Must Be Given Due Consideration With Regards To Economy.

Good Quality Construction Will Never Deter To Projects Speed Nor Will It Be Uneconomical.

In Fact Time Consuming Repairs And Modification Due To Poor Quality Work Generally Delay The Job And Cause Additional Financial Impact On The Project.

Some Experts Feel That Housing Alternatives With Low Maintenance Requirements May Be Preferred Even If At The Higher Initial Cost.

3.2.4 Benefits And Concerns:

The Biggest Benefit Include Savings On Both Cost And Time.

Experts Point That Using Various Materials And Techniques Can Help Reduce The Cost Of Construction manifold. "It Is Cost Effective Because Firstly Time Is Money".

So What You Can Do In One Year, You Can Do In One Fourth Of That Period.

Secondly, The Quality Control Is Much Better As Everything Is Produced In Factories And Thereby It Is Standardised.

Everything Is Produced In A Factory Including The Panels, Curing Is Done By Steam And Not By Conventional Way Where An Individual Throws Water On The Walls And There Is Also Less Wastage, Better Quality And Consistency In Terms Of Strength,".

3.2.5 Analysis

Aluminium Formwork System Is A Construction System For Forming Cast InPlace Concrete Structure Of A Building.

This Method Has Several Benefits In Construction Industry Pertaining To Cost And Time.

In This Analysis Part, I've Prepared A Cost Table Comparing ALU FORMWORK & AAC BLOCKWORK Of A Building Which Is 15,000 Sq.Ft Of Floor Plate And Those Comparisons And Results Will Be As Follows:

Table No 3.2.6 Comparison Table

BUILT UP AREA PER FLOOR	15,000 SQ.FT
TOTAL NO OF FLOORS	14
TOTAL FLOOR AREA	2,10,000 sq.ft
AAC BLOCK WORK COST	2,100 rs PER sq.ft
TOTAL COST FOR AAC BLOCK WORK	2,100rs * 2,10,000 sq.ft = 44,10,00,000 rs
TOTAL DURATION	694 DAYS
ALU FORM WORK COST	2,400 rs PER sq.ft
TOTAL COST FOR ALU FORM WORK	2,400rs * 2,10,000 sq.ft = 50,40,00,000 rs
TOTAL DURATION	384 DAYS
COST DIFFERENCE	6,30,00,000 rs (+14%)
TIME DIFFERENCE	310 DAYS (-45%)

CHAPTER 4

LIVE CASE STUDY

4.1 NAVIN'S Starwood Towers – Medavakkam, Chennai

4.1.1 General Information

This Apartment Has A Plot Area Of 1 Lakh Sq.Ft

It Has Three Towers – Redwood, Oak & Pine.

Redwood & Oak Has Done With Alu-Formwork Technique &

Pine Tower Employed Conventional Floor Slab With AAC Blocks For Walls For The EWS People.

Redwood & Oak Tower Has 8 Flats On Each Floors And Each Tower Has 14 Floors.

Pine Tower Has 14 Flats On Each Floors And Each Tower Has 14 Floors.

M30 Grade Concrete Were Used For The Whole Tower Upto 14 Floors.

Only Stilt Floor Was Constructed By Conventional Beams & Columns System.

It Took 125 Days To Complete The Whole Structure And Another 95 Days For Entire Completion.

4.1.2 Construction Information

Internal walls – 100mm.

Exterior walls – 160 mm.

Balcony parapet walls – 75 mm.

Beam – 200 mm in width, 450 mm in height.

Aluminium panel thickness – 75 mm.

Aluminium sheet thickness – 5 mm.

Panels available for every 5 mm.

Jockey placed at a distance of every 1 m.

Oil & Grease were mixed to coat the shuttering.

20mm rods were used for Reinforcement.

Total manpower engineered – 1,49,958.

Total man hours employed – 11,99,664 hrs.

400 cu.m of concrete poured for each floor.

4.1.3 Project Unique Features

The Structure Is Founded On Soil With SBC Of 150 T/Sq.M.

The Structure Is Built With The Latest Alu-Form Construction Technology, Eco-Friendly Features, Elegant Architecture And Sustainable Design.

The Structure Is A IGBC Gold Certified Project.

4.1.4 Alu-Formwork – Technique

3S – System Of Construction – Speed, Strength, Safety.

Column And Beam Construction Are Eliminated.

Walls And Slabs Are Cast In One Operation.

Specially Designed, Easy To Handle Light Weight Pre-Engineered Aluminum Forms.

More Strength By Monolithic Concrete.

Carrying Out Concreting Of The Walls And Slabs Together.

4.1.5 Advantages of Alu-Formwork

More Seismic Resistance

Increased Durability Of Structure

Monolithic Casting Results - No Leakages - Enhancing The Durability.

Higher Carpet Area- Due To Thin Shear Walls

Integral And Smooth Finishing Of Wall And Slab

Uniform Quality Of Construction

Negligible Maintenance

Faster Completion.

Less Manpower Engagement.

Simplified Foundation Design Due To Consistent Load Distribution.

The Natural Density Of Concrete Wall Result Better Sound Proof.

4.1.6 Limitations of Alu-Formwork

Concealed services become difficult due to small thickness of components.

It requires uniform planning as well as uniform elevations to be cost effective.

Modifications are not possible as all members are cast in RCC.

Large volume of work is necessary to be cost effective i.e. at least 200 repetitions of the forms is necessary.

Due to box-type construction shrinkage cracks are likely to appear.

Heat of Hydration is high due to shear walls.

4.1.7 MIVAN Formwork - Assembly

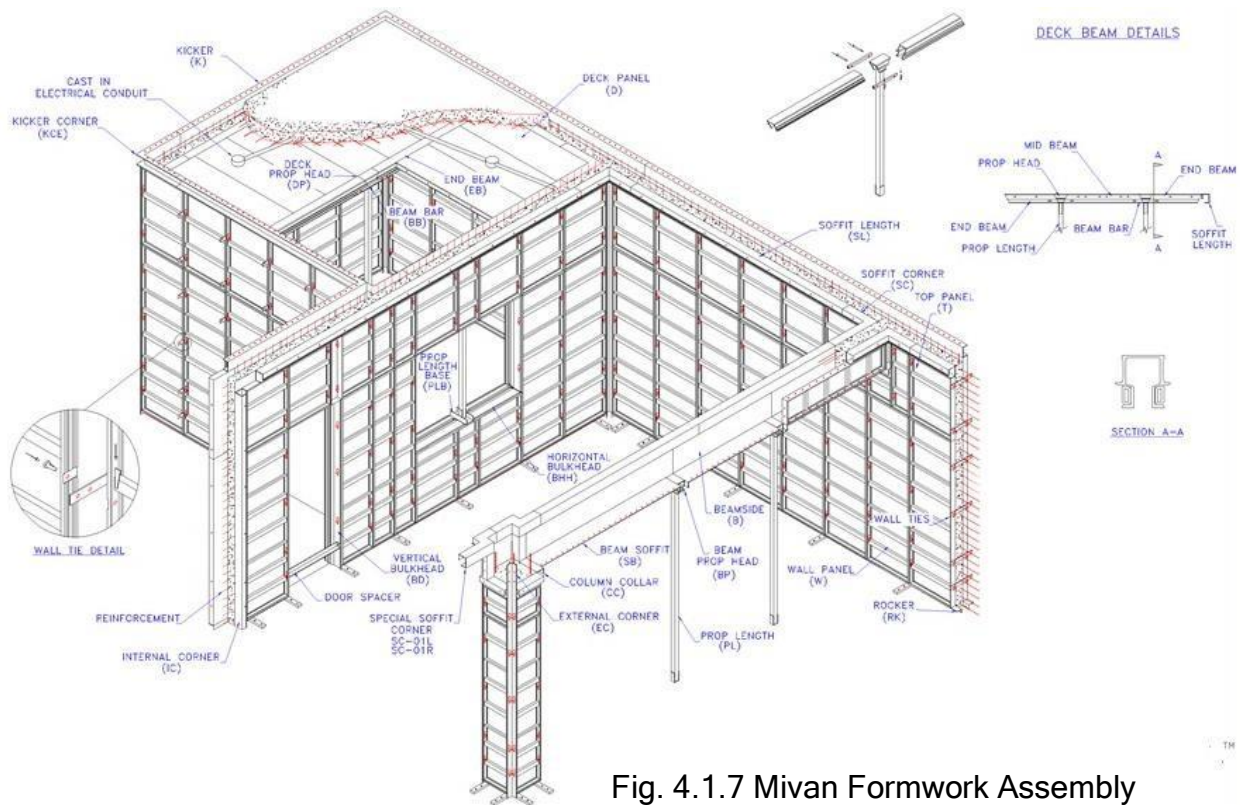


Fig. 4.1.7 Mivan Formwork Assembly

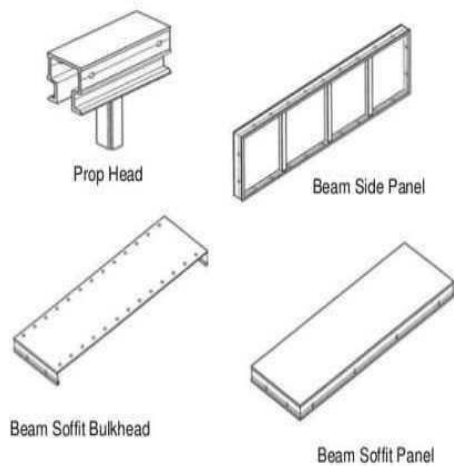
4.1.8 Floor Plans:



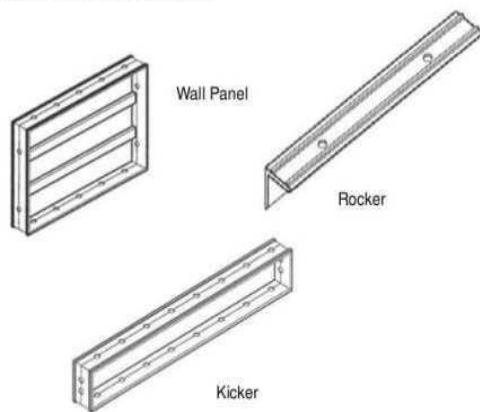
Fig. 4.1.8 Floor Plans

4.1.9 Mivan Formwork System : Materials

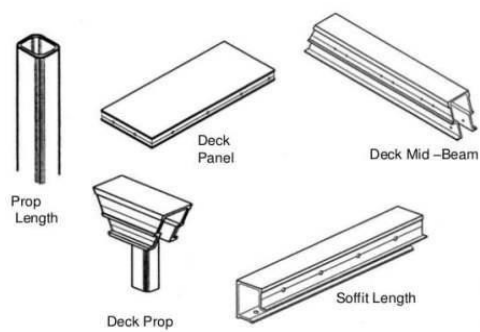
BEAM COMPONENTS



WALL COMPONENTS



DECK COMPONENTS



OTHER COMPONENTS

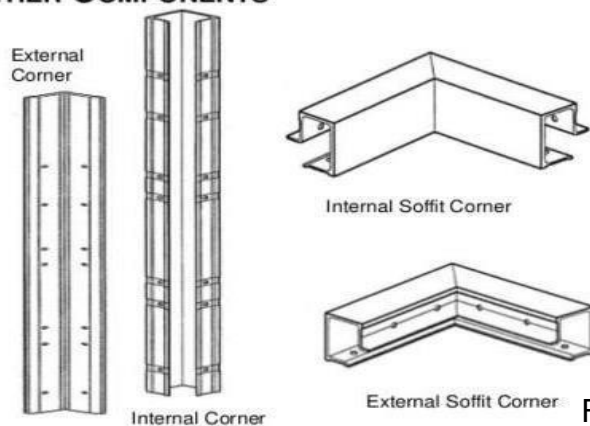


Fig. 4.1.9 Mivan Formwork Materials

4.1.10 Conclusion

Technique	Total Area	Floor	ConstructionCost Per Sq.Ft	Total Project Duration
Conventional	15000*14 = 2,10,000		2000	Approx. 36 Months
AluformWork	15000*14 = 2,10,000		2200	Approx.10Months

Even Though This Technique Is 10% Costlier Than The ConventionalOne, The Speed And Quality Of Construction Cannot Be Compared With Each Other.

4.1.11 Site Pictures



Fig. 4.1.11 Site Pictures

4.2 CASESTUDY ON RAHEJA IT PARK @ PALLIKARANAI

Table No 4.2 Client & Contractors Details

No.	Designation	Company Name
1	Client	Sycamore Properties Pvt. Ltd
2	Architects	Nataraj & Venkat Architects
3	Pmc	Cbre South Asia Pvt. Ltd.
4	Str	Designtree Service Consultants Pvt. Ltd
5	Str	Somadev Nagesh Structural Consulting Engineer
6	Mep	Sunil Nayyar Consulting Engineers Llp
7	Design And Build Division	Shapoorji Pallonji & Co. Pvt. Ltd.

4.2.1 Construction Information

Internal Walls – 100mm.

Exterior Walls – 160 Mm.

Balcony Parapet Walls – 75 Mm.

Beam – 200 Mm In Width, 450 Mm In Height.

Aluminium Panel Thickness – 75 Mm.

Aluminium Sheet Thickness – 5 Mm.

Panels Available For Every 5 Mm.

Jockey Placed At A Distance Of Every 1 M.

Oil & Grease Were Mixed To Coat The Shuttering.

20mm Rods Were Used For Reinforcement.

Total Manpower Engineered – 1,49,958.

Total Man Hours Employed – 11,99,664 Hrs.

400 Cu.M Of Concrete Poured For Each Floor.

4.2.2 Logistics Plan

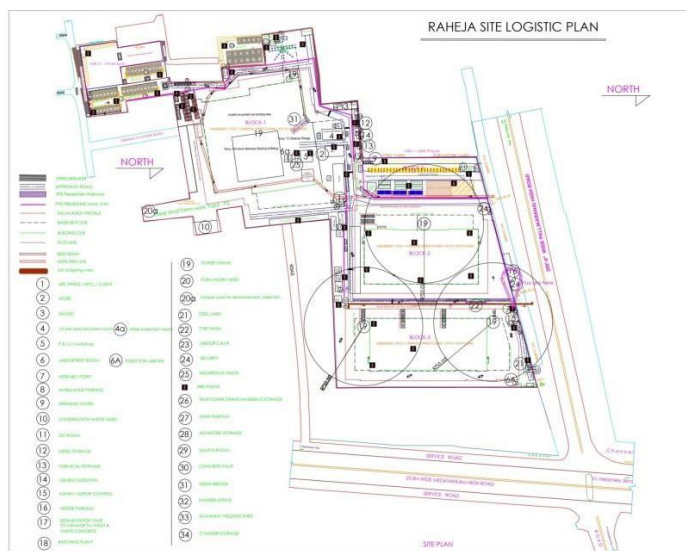


Fig. 4.2 Logistics Plan

Logistics Plan

The Main Benefits Of Good Practice Material Logistics Will Contribute To Improved Project Programming, Best Practice Environmental Performance And Reductions In The Build Cost.

Financial Benefits: Ordering Materials That Are Not Used In The Project Due To Loss, Wastage Or Being Surplus To Requirements Has A Cost Which Is Often Over Looked As It Is Built Into The Project Price And Paid By The Client. The Total Cost Of Poor Material Logistics Includes The Cost Of Purchase And Delivery, Storage And Handling.

Labour Efficiency: The Efficiency Of The Labour Force On The Site Contributes To The Project Costs, Duration And Quality. Implementing Efficient Material Logistics Will Reduce The Number Of Times Materials Are Handled And Prevent Skilled Craftmen Being Taken Away From The Core Tasks To Handle The Material.

Environmental Benefits: Improving The Project Environmental Performance Helps Clients And Contractors Demonstrate Their Commitment To Reduce Their Impact In The Environment.

4.2.3 Project Execution Stages

1. Setting-out



2. Wall / Column Reinforcement



3. Installation Of Wall Form



4. Installation Of Beam Soffit



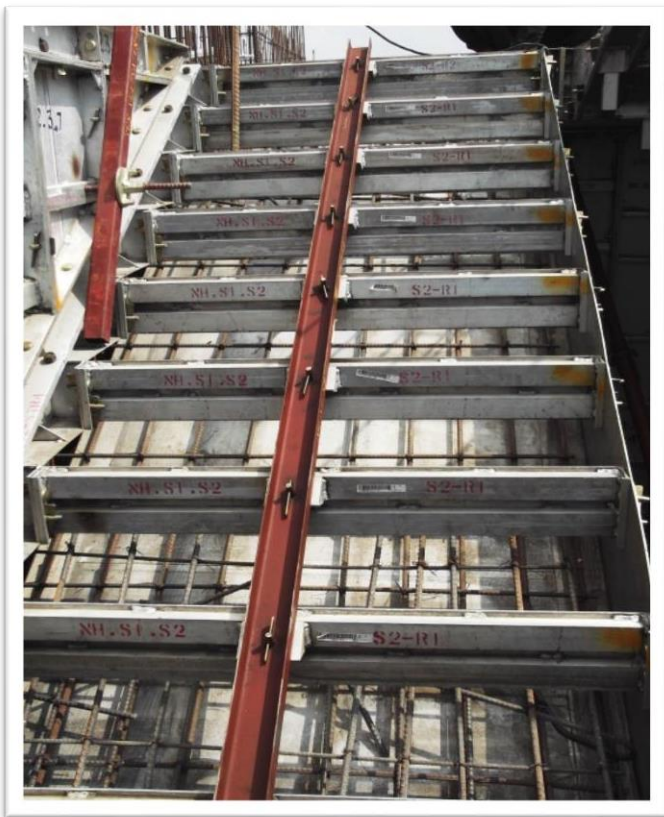
5. Installation Of Slab Soffit



6. Slab Reinforcement



7. Staircase Formwork



8. Electrical Wall Conduits



9. Cutouts For Plumbing Inlets & Outlets Wall Sleeves



10. Transit Box Cut Out For Lifting Mivan Panels To The Next Floor



11. Formwork Alignment & Level Checking



12. Concrete Flow Test



13. Concreting



14. Removal Of Wall Forms



15. Removal Of Slab Forms



16. Removal Of Wall Ties & Sleeves.



17. Grouting Of Wall Tie Holes With Anti-Shrinkage Waterproofing Grout



18. Support With Back Props



19. Curing



20. Lifting The Formwork To Next Floor



Fig. 4.2.3 Project Execution Stages

4.2.4 Pre-Pour Check List

PROJECT :

FLOOR LEVEL & SECTION :

DATE :

Pre-pour check Items

Acceptable: YES / NO

1 All Formwork has been cleaned and coated with an approved release agent. Yes _____/No _____

2 All Flat Wall Ties installed in good condition. Yes _____/No _____

3 All P.E. wall tie sleeves correctly installed. Yes _____/No _____

4 External & internal wall verticality adjusted accordingly. Yes _____/No _____

5 Verticality and alignment of Door openings completed. Yes _____/No _____

6 Alignment of all internal walls completed. Yes _____/No _____

7 All required Pins and Wedges are installed and secure. Yes _____/No _____

8 All Props positioned vertical. Yes _____/No _____

9 Ensure there is no vertical movement in the Prop lengths. Yes _____/No _____

10 Slab soffit formwork level. Yes _____/No _____

11 Door spacers installed as per Drawings issued. Yes _____/No _____

12 Alignment Walers installed as per Drawings issued. Yes _____/No _____

13 Vertical Soldiers installed as per Drawings issued. Yes _____/No _____

14 All Kickers have been lined and adjusted accordingly. Yes _____/No _____

15 All Kickers Bolts installed correctly. Yes _____/No _____

16 All Rockers have been installed. Yes _____/No _____

17 All excessive spaces between Rocker and floor level have been sealed. Yes _____/No _____

18 All Working Platform Brackets installed as per Drawings issued. Yes _____/No _____

Remarks:

Inspected By : (Name)

Company :

Date : (Signature)

.....

4.3 QUESTIONAIRES

1. How Fast Is Mivan Compared To Traditional Construction Methods?

The Traditional Construction Methods Will Take Up To A 17-Day Cycle To Complete A Floor Whereas Mivan Takes Only Up To 7 Days.

2. What Is The Building Process Of Aluminum Formwork Technology?

The Set-Up Of Formwork Is Used In The Following Stages.

Pre-Concrete,
Concreting,
Post-Concrete.

3. Need For Mivan Construction Technology

Any Innovation Has A Valid Reason For Its Emergence. Likewise, The Real Estate Sector Is Also

Subjected To Gradual Changes To Meet The Requirements.

At Present, The Demand For Housing And Commercial Spaces Are At An Increased Rate.

The Lucrative Jobs Along With Home Loan Facilities Have Created The Affordability To Own A House For The Middle-Class Group.

Key Factor For Adopting Is The Cost Factor For Mivan Shuttering. Components, Labour & Material Cost Better Than The Traditional Or Conventional Methods.

4. What Are The Major Features Of Mivan Construction Technology?

Simple

Fast

Adaptable

Cost-Effective

5. Application Of Formwork

Mivan Formwork Can Be Applied To Both Residential And Commercial Ventures.

The Residential Developments Include Affordable Housing Projects, High Rise Buildings, Townhouses, Single Or Multi-Floor Structures.

Apart From These, Commercial Spaces Include High-Rise Offices, Hotels, Storeyed Parking Floors.

4.4 LIMITATIONS OF ALU-FORMWORK

Concealed Services Become Difficult Due To Small Thickness Of Components.
It Requires Uniform Planning As Well As Uniform Elevations To Be Cost Effective.
Modifications Are Not Possible As All Members Are Cast In RCC.
Large Volume Of Work Is Necessary To Be Cost Effective
I.E. At Least 200 Repetitions Of The Forms Is Necessary.
Due To Box-Type Construction Shrinkage Cracks Are Likely To Appear.
Heat Of Hydration Is High Due To Shear Walls.

4.5 FACTORS THAT AFFECT CONSTRUCTION QUALITY MANAGEMENT

In Any Project, Every Stakeholder's Intention Is To Have The Best Quality In Order To Minimize Rework. But There Are A Few Hurdles That Come Up During The Tenure Of A Project That Can Compromise The Quality If Not Handled Wisely. 10 Such Factors Are Discussed Hereafter.

1. Complex Design
2. Supplier and Vendor Failures
3. Low Quality Materials
4. Poor Project Management
5. Miscommunication Between Teams
6. Failure to Document Changes and Practices
7. Subcontractor Mishandling
8. Scope Creep
9. Ignored Audits and Testing
10. Last-Minute Changes

4.6 BIGGEST FACTORS AFFECTING YOUR CONSTRUCTION COSTS?

Managing Your Budget Is A Really Important Part Of Realising Your Dream Project. There Are Lots Of Things That Can Have A Big Impact On The Cost Of Your Project. I've Outlined Some Of The Key Ones Below.

Site access constraints

Site slope

Size

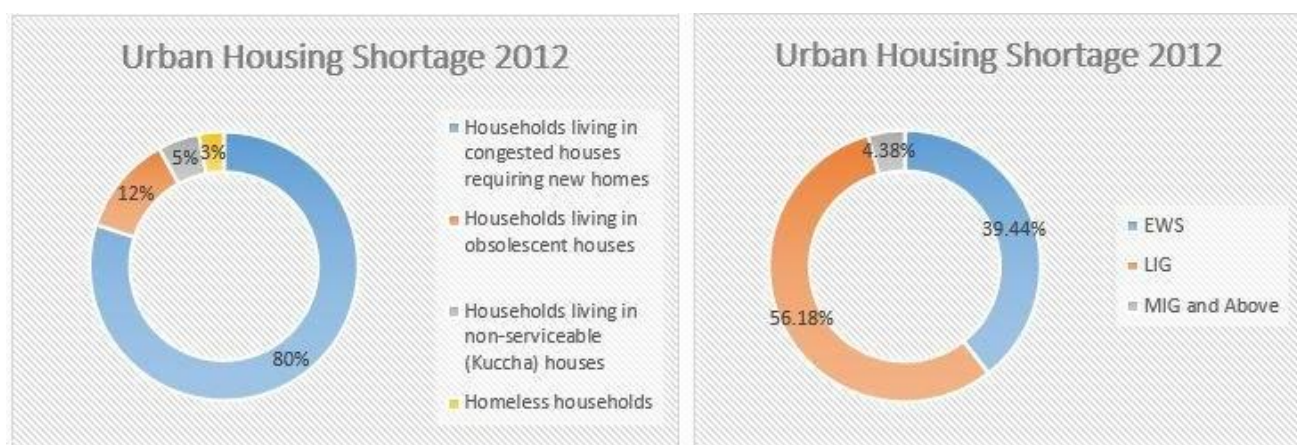
Complexity

Construction method

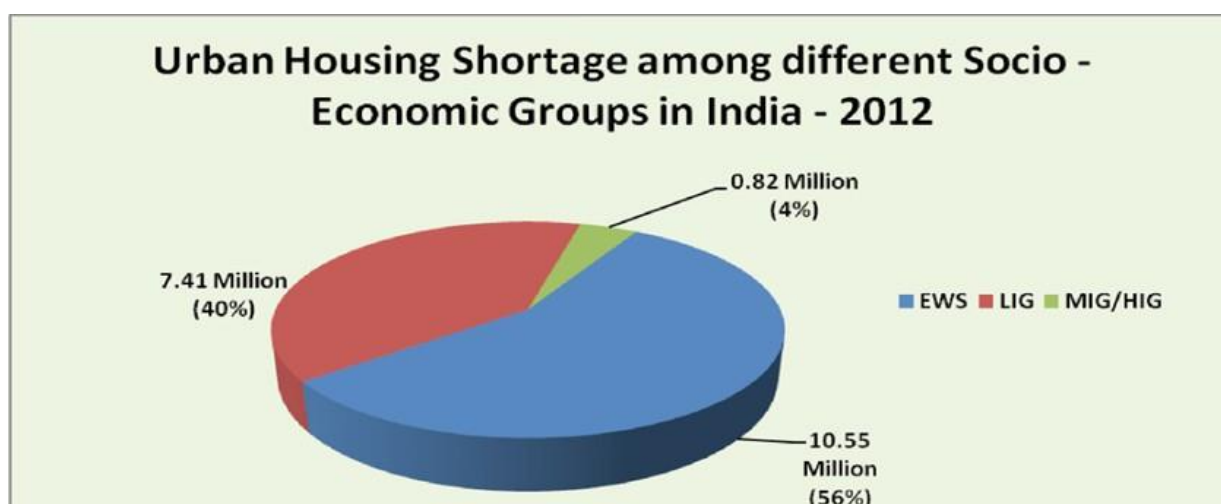
Finishes

CHAPTER 5 ANALYSIS & FINDINGS

5.1 HOUSING SHORTAGE DATA OF INDIA



CATEGORY	URBAN HOUSING SHORTAGE IN MILLIONS
EWS	10.55
LIG	7.41
MIG	0.82
HIG	
TOTAL	18.78

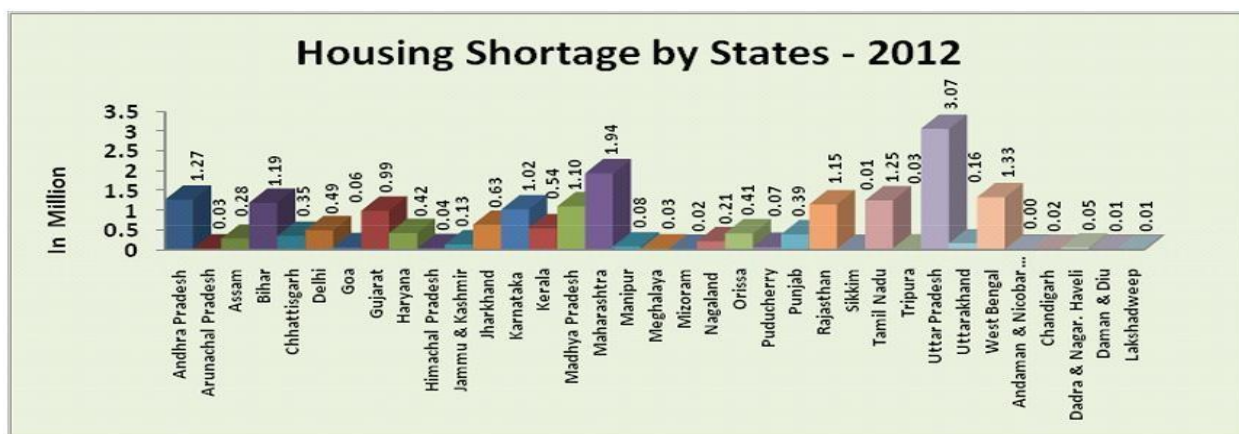


Source: Report of Technical Group (TG-12) on Estimation of Urban Housing Shortage 2012, National Buildings Organisation, Ministry of Housing & Urban Poverty Alleviation.

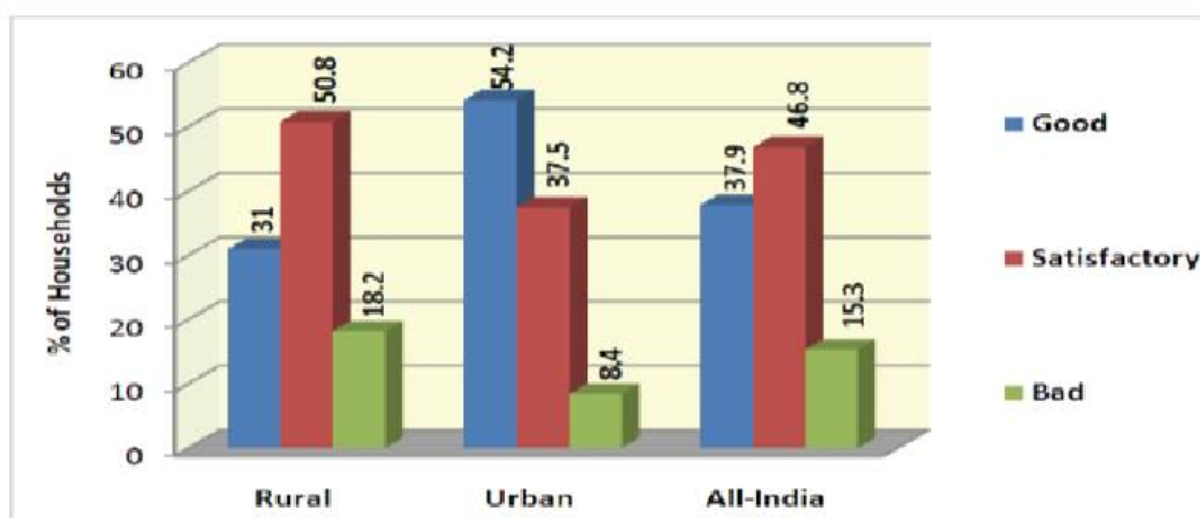
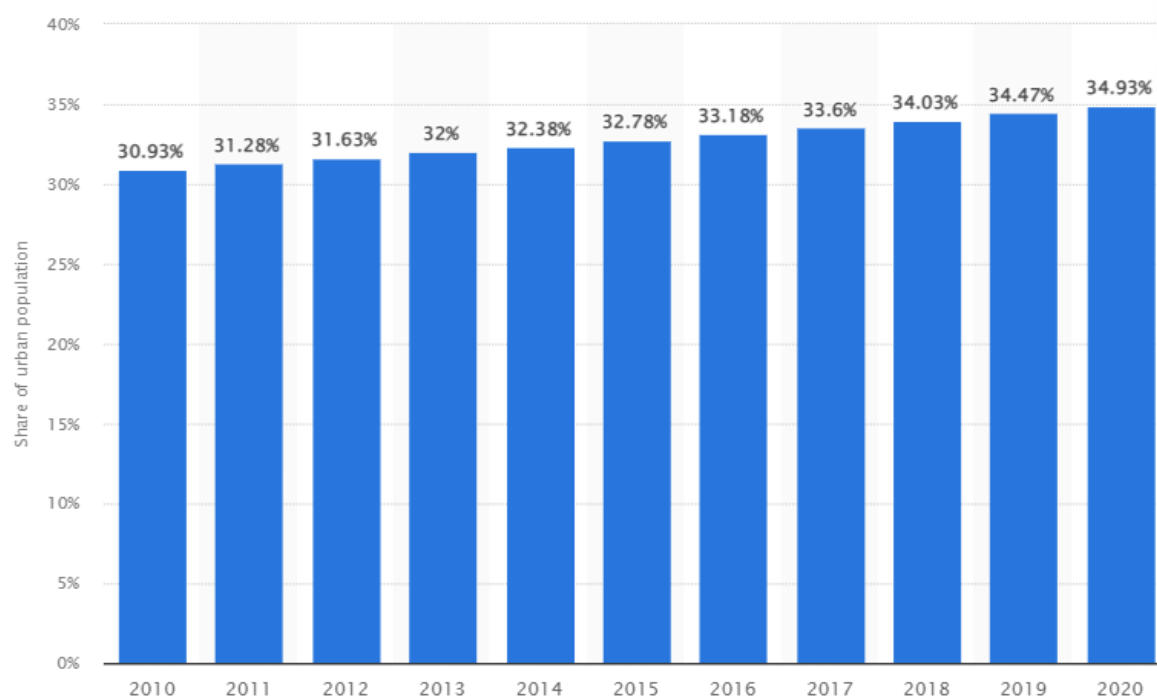
Fig. 5.1 Housing shortage in India

Table No 5.1 Housing Shortage Data Of India

SI NO	NAME OF THE STATES	HOUSING SHORTAGE
1	Andhra Pradesh	1.27
2	Arunachal Pradesh	0.03
3	Assam	0.28
4	Bihar	1.19
5	Chhattisgarh	0.35
6	NCT of Delhi	0.49
7	Goa	0.06
8	Gujarat	0.99
9	Haryana	0.42
10	Himachal Pradesh	0.04
11	Jammu & Kashmir	0.13
12	Jharkhand	0.63
13	Karnataka	1.02
14	Kerala	0.54
15	Madhya Pradesh	1.10
16	Maharashtra	1.94
17	Manipur	0.08
18	Meghalaya	0.03
19	Mizoram	0.02
20	Nagaland	0.21
21	Orissa	0.41
22	Puducherry	0.07
23	Punjab	0.39
24	Rajasthan	1.15
25	Sikkim	0.01
<u>26</u>	<u>Tamil Nadu</u>	<u>1.25</u>
27	Tripura	0.03
28	Uttar Pradesh	3.07
29	Uttarakhand	0.16
30	West Bengal	1.33
31	Andaman & Nicobar Island	0.00
32	Chandigarh	0.02
33	Dadra & Nagar Haveli	0.05
34	Daman & Diu	0.01
35	Lakshadweep	0.01
	<u>India</u>	<u>18.78</u>



Source: Report of Technical Group on Estimation of Urban Housing Shortage 2012



Source: NSS Report No.535: Housing Condition and Amenities in India: July, 2008-June, 2009

5.2 COMPARISON BETWEEN ALUMINIUM & CONVENTIONAL FORMWORK SYSTEM

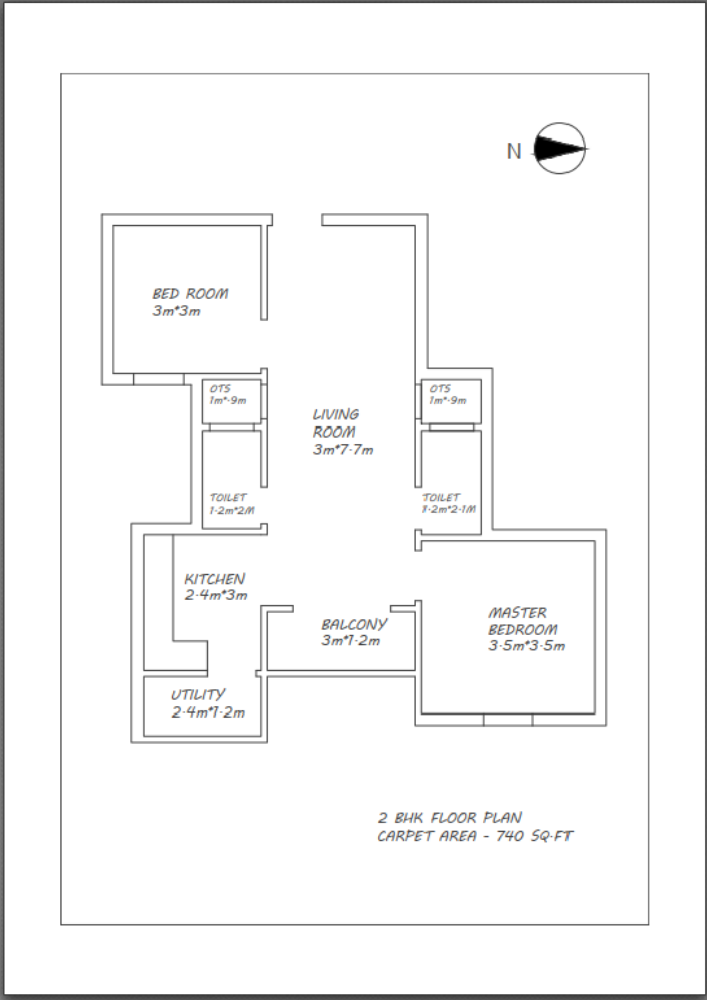
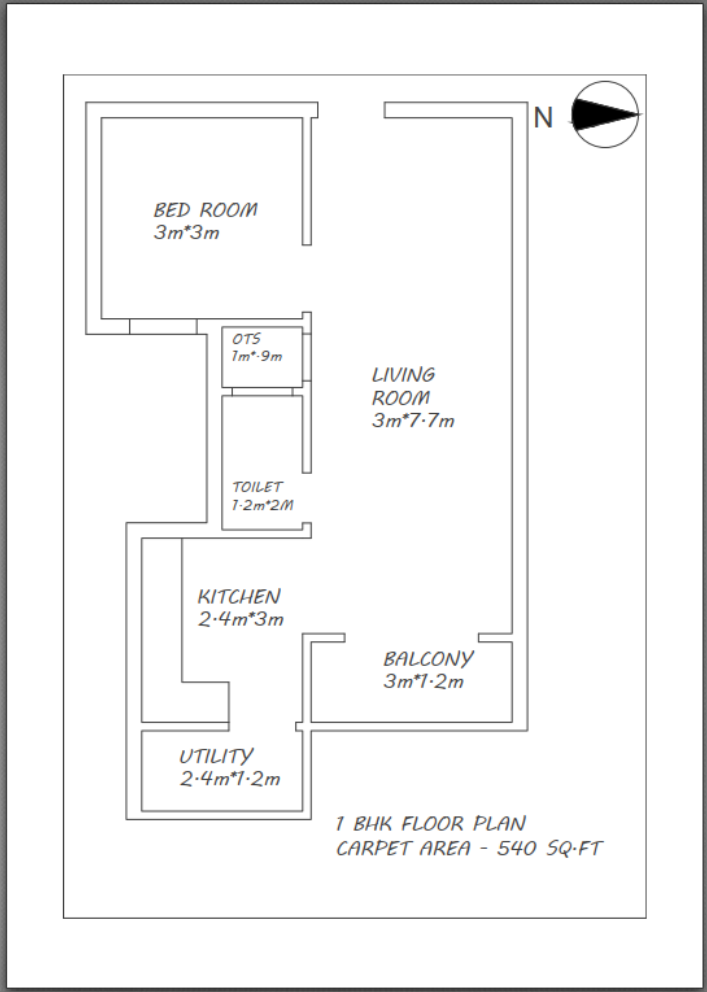
Table no 5.2 Comparison Between Aluminium & Conventional Formwork System

SI No.	Description	Aluminium Formwork System	Conventional Formwork System
A	SAFETY		
1.	Strength Related		
a.	Type Of Construction	Box Type Construction As Per IS 4326-1998	Framed Structure As Per IS 4326-1998
b.	Design Life Of The Building As Per IS 875-1987	60 Years	50 Years
c.	Fire Rating Capacity As Per IS 1642-1989	150mm Wall Thickness – 2 Hours Rating	200mm Thick Solid Block – 4 Hours Rating
d.	Wall Thickness As per IS 13920-1993	Thickness Of Any Part Of The Wall Shall Preferably, Not Less Than 150 Mm.	Minimum Dimension Of The Member Shall Not Be Less Than 200mm.
2.	Earthquake Resistance	All Walls Are Reinforced Concrete Walls Which Increase The Stiffness & Lateral Load Carrying Capacity Of Overall Structure.	Column & Beam With Reinforced Concrete Member, Block Works Are Used To Fill The Space Between The Two Column Which Gives Less Stiffness & Lateral Load Carrying Capacity Of The Structure.
		No Separate Bracing Elements Required	Brick Infill's Acts As A Bracing Elements
3.	Methodology	Integrated Safety Arrangement Available Such As Working Platform Brackets With Catch Net & Walkways.	Additional Arrangements Required To Ensure The Safety Working At Heights Such As Scaffolds And Personal Protective Equipment.
4.	Accident Rate:) Fatality) Unsafe Conditions) First Aid Cases) Accident Potential Rate	Total Man Hours Engaged – 9.28 Millions a) Nil b) Number Of Unsafe Conditions – 3926 c) Number Of First Aid Cases – 39 d) Average Accident Potential Rate – 458 (Reference : Site Data)	Total Man Hours Engaged – 6.64 Millions a) Nil b) Number Of Unsafe Conditions – 4857 c) Number Of First Aid Cases – 182 d) Average Accident Potential Rate – 848 (Reference : Site Data)

B	QUALITY		
.	Method Of Construction	Monolithic Construction (Vertical & Horizontal Elements Casted Together In Single Pour). No Construction Joint In Single Floor Which Reduces The Seismic Effects.	Two Stage Construction (Stage 1: Vertical Elements Casting, Stage 2: Horizontal Elements Casting). Construction Joints At Column & Beam Junctions Which Are More Vulnerable To Seismic Effect.
2.	Surface Finish	Form Finish (No Plastering Is Required).	Surface Finish Depends On The Quality Of Plastering.
3.	Durability Of Formwork	This System Is Made Up Of Aluminum Alloy (6061-T6) & Having High Tensile Strength Of 260 N/Mm ² (ASTM B22`M-02, Table 2) Very High Corrosive Resistant Which Increases The Lifespan Of The Materials.	This System Works With The Combination Of Plywood, Timber & Steel Members. Tensile Strength Of The Plywood Is 22.5 N/Mm ² (IS 4990-1993, Clause 10.1.6) & For Steel, It Ranges From 290-590 N/Mm ² (IS 2062-2000, Table 2, Clause 5.10.3 & 10.3.1) Corrosion Resistance Is Poor In This System Which Leads Lesser Life Of The Material.
4.	Accuracy	High Precision In Fabricating The Formwork, Which Results In Accurate & Consistent Formation Of Structure. Average Deviation In Verticality Of The Building Absorbed At The Site Is 25mm For The Height Of 51mm In Navin's Project.	Very Less Precision Since The Formwork Is Made At Site Itself With The Available Resources Which Leads To Poor Quality Of Work & Also Reduces The Strength Of The Building. Average Deviation In Verticality Of The Building Absorbed At The Site Is 55mm For The Height Of 51m Commander's Court.

C	STRENGTH PARAMETER		
1.	Bending Moment	Bending Moment Capacity For Sheathing Member Is 0.29 Kn.M (BS 8118-1990, Part 1).	Bending Moment Capacity For Sheathing Member Is 0.20 Kn.M (IS 4990-1993, Clause 10.1.6).
2.	Deflection	Allowable Deflection L/360 (Or) 1.5mm Whichever Is Less.	Allowable Deflection L/360 (Or) 1.5mm Whichever Is Less.
3.	Tensile Strength	Minimum Tensile Strength – 250 N/Mm ² (BS 8118-1990)	Parallel To Grain – 32.5 N/Mm ² Perpendicular To Grain – 22.5 N/Mm ²
4.	Density	2710 Kg/M ³ (BS 8118-1990)	Plywood – 780 Kg/M ³ (IS 303-1989)
5.	Life Span Of The Materials	150 Repetitions	Plywood – 7 – 12 Repetitions Steel – 120 Repetitions
6.	Scrap Value	Around 30-40 % Of Purchasing Cost	Nil
7.	Strength Of Concrete	Aluminum Is An Excellent Heat Conductor, This Property Will Accelerate The Heat Of Hydration Of Concrete, Which Enables The Early Strength Of Concrete.	Strength Of Concrete Will Attain Gradually, Since Plywood Is Poor In Heat Conductivity.
8.	Environmental Benefits	100% Recycling Is Possible In Aluminum. Recycling 1 Kg Of Aluminum Will Saves Up to 6kg Of Bauxite, 4kg Of Chemical Products And 14kwh Of Electricity. Reduces Litter & Landfill. No Burning Of Waste Timbers O Construction Site Reduces Haze & Pollution. Every 1mt Of Aluminum Recycles Saves 10mt Co-2 Equivalent. Many Trees Will Be Saved By The Elimination Of Wood & Plywood Framing, Hence Aluminum Formwork Is An More Environment Friendly System.	Recycling Of Plywood & Timber Waste Is Not Possible. No Proper Timber Waste Disposal Is Happening At Construction Projects, Actual Practice Is Landfill & Open Burning. Burning Of Waste Timber Based Products Will Emits Smoke, Fine Particles & Co-2, Which Will Potentially Dangerous To Human Health And The Environment. Almost One Tree Is Required To Cut For The Production Of Ten Nos. Of Plywood; Hence Conventional Formwork Is Not An Environmental Friendly System.

15 Modules Per Floor Floor Plate Area - 12,000 Sq.Ft



1 & 2 BHK MODULE – FLOOR PLAN

5.3 COST COMPARISON BETWEEN CONVENTIONAL & ALUFORMWORK SYSTEM

Table no 5.3 Cost Comparison Between Conventional & Aluformwork System

Si No:	Description	UOM	Conventional Formwork	Alu-Formwork	Remarks
1.	CATERING AREA REQUIRED:				
a.	No Of Towers	Number s	5	5	
b.	No Of Typical Floors	Number s	16	16	
c.	Structure Duration In Months	Sq.M	12	8	
d.	Duration For Mobilization & De-mobilization	Month	2	2	
e.	Total Duration Of Usage	Month	14	10	
f.	Planned Cycle Time	Days	25	10	
g.	Average Number Of Repetitions	Number s	14	16	
h.	Catering Area	Sq.M	11,197	15,390	
i.	Total Shuttering To Be Executed	Sq.M	1,56,758	2,46,240	

5.4 COST COMPARISON BETWEEN CONVENTIONAL & ALUFORMWORK SYSTEM

Table no 5.4 Cost Comparison Between Conventional & Aluformwork System

Si No:	Description	UOM	Conventional Formwork	Alu-Formwork	Remarks
2.	COST OF THE FORMWORK (M+L+P):				
a.	Material Charges (M)	Rs /sq.m	445	244	
	Steel Components	Rs.	2,54,24,388	4,44,20,129	
	H-Beam (Timber)	Rs.	1,30,74,032		
	Plywood	Rs.	1,09,91,138	27,79,517	Accessories costfor Alu-Form
	Timber	Rs.	89,42,466		
	Consumables – Form Oil, NailsEtc.,	Rs.	75,76,158	86,30,970	
	Transportation Charges	Rs.	32,18,921	16,67,300	
	Maintenance Charges	Rs.	13,89,840	26,93,331	
	Total Material Cost	Rs.	6,97,57,310	6,00,82,560	
b.	Labour charges (L)	Rs. / sq.m	221	103	
	Labour cost		3,46,43,518	2,53,62,720	
c.	Plant charges (P)	Rs. / sq. m	43	20	
	Plant cost		67,40,594	49,24,800	
3.	Formwork (Material + Labour +Plant) Amount	Rs.	<u>11,11,41,422</u>	<u>9,03,70,080</u>	
	Formwork (Material + Labour +Plant) Cost per sq.m	Rs. / sq. m	<u>709</u>	<u>367</u>	

From the above analysis, it is been observed that, while using Alu-formwork system, around 45% of cost savings can be done over conventional formwork system.

5.5 COST OF THE CONVENTIONAL FORMWORK :

Catering Area : Table no 5.5 Cost Of The Conventional Formwork

SI No :	RC Element Description	Type Of Formwork System	Scope Of Formwork In Sq.m	Structure Duration In Months	Number Of Working Days In Month	Planned Cycle Time In Days	Number Of Repetition – 'E'	Catering Area In Sq.M – 'F'
			(A)	(B)	(C)	(D)	(E)=(B)*(C)/(D)	(F)=(A)/(E)
1.	COLUMN	COLUMN FORMWORK	36,350	12	25	12	26	1,398
2.	BEAM & SLAB	FLEX SYSTEM	1,20,408	12	25	25	12	10,034
		TOTAL	1,56,758					11,432

Materials Required:

SI No :	RC Element Description	Catering Area Required	Repetition	Items	UOM	Quantity Required Per Sq.m For Making	Material Productivity In Terms Of Repetition	Total Required
1.	Column	1,398	26	Steel Components	Mt	134 kg	120	188
				H – Beams	M	6.5m	100	9097

5.5.1 Cost Of Individual Components:

Table no 5.5.1 Cost Of Individual Components

Steel Components:

SI No:	Description	UOM	Quantity
1.	Required Quantity	Mt	726
2.	Hire Charges Per Month / MT	Rs.	2500
3.	Duration Of Usage (Including Mobilization & Demobilization)	Months	14
4.	Amount	Rs.	2,54,10,000

Plywood :

SI No:	Description	UOM	Quantity
1.	Required Quantity	Mt	14288
2.	Rate Of Plywood (12mm Thick)	Number	2290
3.	Rate Of Plywood (12mm Thick) Per Sq.M	Sq.m	769
4.	Amount	Rs.	1,09,87,472

H - Beam:

SI No:	Description	UOM	Quantity
1.	Required Quantity	m	60045
2.	Value Of H – Beam Per Rmt	Rs.	425
3.	Depreciation Charges Per Month	%	5%
4.	Duration Of Usage (Including Mobilization & Demobilization)	Months	14
5.	Total Percentage Depreciation To Site	%	51%
6.	Amount	Rs.	1,25,04,371

Timber :

SI No:	Description	UOM	Quantity
1.	Required Quantity	cft	15,314
2.	Rate Of Timber	cft	585
3.	Amount	Rs.	89,58,690

5.5.2 Labour Requirement Calculation:

Table no 5.5.2 Labour Requirement Calculation

SI No:	Description	UOM	Making Works		Fixing & Removal		Total Requirement
			Column	Slab	Column	Slab	
1.	Scope Of Work	Sq.m	1,398	10,034	36,350	1,20,408	
2.	No. Of Times	Sq.m	2.5	2			
3.	Total Scope Of Work	Sq.m	3,496	20,068	36,350	1,20,408	
4.	Labour Productivity	Sq.m / man-day	2.5	2	2.75	1.1	
5.	Labour Requirement	Numbers	1,398	10,034	13,218	1,09,461	
Skill Wise Requirement:							
6.	Carpenter	Numbers	698	3250	4411	37050	45,409
7.	Helper	Numbers	700	6,784	8807	72,411	88,702

Labour Cost :

SI No:	Skill	Requirement	Wages per Day	Amount in Rs.
1.	Carpenter	45,409	800	3,63,27,200
2.	helper	88,702	700	6,20,91,400
TOTAL COST				9,84,18,600

5.5.3 Plant & Machinery Charges :

Table no: 5.5.3 Plant & Machinery Charges

SI No:	Description of item with specification	Requirement in numbers	Duration (machine hours)	Hire charges		formwork	
				Charges / month	Total hiring charges	Pro-rata percentage	Amount (Rs.)
1.	WOOD WORK EQUIPMENTS :						
1 a.	Circular saw machine	2	14	2000	28,000	100%	28,000
1 b.	Surface planer	2	14	1000	14,000	100%	14,000
2.	MATERIAL HANDLING EQUIPMENTS :						
2 a.	Tower crane	3	12	3,75,000	45,00,000	40%	18,00,000
2 b.	Passenger cum material hoist	5	12	1,10,000	13,20,000	40%	5,28,000
2 c.	Tractor	2	14	30,000	4,20,000	100%	4,20,000
2 d.	Truck	1	14	30,000	4,90,000	100%	4,90,000
3.	POWER						
3 a.	Power generator – 250 KvA	1	12	40,000	4,80,000	70%	3,36,000
3 b.	Fuel charges	1	12	7,30,800	87,69,600	100%	87,69,600
TOTAL AMOUNT (Rs)							1,23,85,600

5.5.4 Fuel Cost Calculation For Power Generator (250 Kva)

SI No:	Description	Calculation	UOM	Quantity
a.	Number Of DG Set		Numbers	1
b.	Running Hours Per Day		Hours	12
c.	Working Days Per Month	Assumed	Days	25
d.	Total Running Hours Per Month	$D = A \times B \times C$	Hours	300
e.	Fuel Consumption Per Hour	Data	Litre	24
f.	Total Fuel Consumption Per Month	$F = D \times E$	Litre	7200
g.	Fuel Rate (Diesel)	Data	Rs.	101.5
h.	Total Fuel Cost Per Month	$H = F \times G$	Rs.	7,30,800

5.6 ALU-FORMWORK COSTING: CATERING AREA

SL No:	Description	UOM	Area Per Block
1.	Formwork Quantity Per Floor		
1 a.	Wall	Sq.m	2250
1 b.	Slab	Sq.m	650
	Total	Sq.m	2900
2.	No. Of Floors		16
3.	No. Of Blocks		5
	<u>Sub Total</u>		<u>2,32,000</u>

5.6.1 Alu-Formwork Investment Costing Per Sq.M :

Table no 5.6.1Alu-form Investment Costing per sq.m

SL No:	Description	UOM	Percentage	Import Quality	Local Manufacturing Quality
1.	Basic materials cost	Rs.		6,500	6,000
2.	Custom duty & clearance charges	Rs.	33%	2,145	-
3.	Excise duty charges	Rs.	14%	-	840
A	Basic cost of the material / sq.m	Rs.		8,645	6,840
4.	Design fee charges	Rs.	30%	2,593	2,052
5.	Service tax	Rs.	12.5%	324	256
B	Cost for design fees / sq.m	Rs.		2,917	2,308
C	Material landing cost per sq.m	Rs.	D= A+B	11,562	9,148

5.6.2 Materials Cost To The Project :

Table no 5.6.2 Material Cost to the Project

By Depreciation Basis :

SI No:	Description	UOM	Quantity
1.	Investment cost per sq.m	Rs.	11,562*
2.	Expected repetition	Numbers	150
3.	Formwork required quantity	Sq.m	14,500*
4.	Cost of formwork	Rs.	16,76,49,000
5.	Depreciation charges per month – based on their value		3%
6.	Duration of usage (including mobilization & de-mobilization)	Months	10
7.	Total percentage of depreciation to the site		26%
8.	Cost to the project	Rs.	4,40,20,582

By Repetition Basis :

SI No:	Description	UOM	Quantity
1.	Investment cost per sq.m	Rs.	11,562/
2.	Expected repetition	Numbers	150
3.	Formwork required quantity	Sq.m	14,500*
4.	Cost per sq.m per repetition	Rs.	77*
5.	Number of repetition planned	Numbers	16*
6.	Duration of usage (including mobilization & de-mobilization)	Months	1,78,64,000

Maintenance Cost :

SI No:	items	UOM	Rate per unit	Quantity	Amount in Rs.
1.	Aluminium panels	Rs.	200	14,500	29,00,000

5.6.3 Additional Accessories Cost :

Table no 5.6.3 Additional Accessories Cost

SI No:	Accessories Description	Unit	Required Per Sq.M	Total Required	Cost / Unit In Rs.	Cost In Rs.
1.	Stub pin 50mm	Nos	0.15	34,800	25	8,70,000
2.	Pin standard wedge (WG)	Nos	0.250	58,000	5	2,90,000
3.	Wall tie (TI)	Nos	0.040	9,280	39	3,61,920
4.	Dywidag tie-rod	Nos	0.025	5,800	120	6,96,000
5.	Dywidag wing nut	Nos	0.025	5,800	140	8,12,000
TOTAL						30,29,920

5.6.4 Labour Cost Calculation:

Labour Requirement :

Table no 5.6.4 Labour Cost Calculation

SI No:	Description	UOM	Quantity
1.	Scope of work	Sq.m	2,32,000
2.	Labour productivity	Sq.m / Manday	2.5
3.	Labour requirement	Numbers	92,800
4.	Skill wise requirement :		
4 a.	Carpenter	Numbers	32,500
4 b.	Helper	Numbers	60,300

Labour Charges :

SI No:	Skill	Requirement	Wages per day	Amount in Rs.
1.	Carpenter	32,500	800	2,60,00,000
2.	Helper	60,300	700	4,22,10,000
TOTAL			6,82,10,000	

5.7. STRUCTURE COST COMPARISON BETWEEN FRAMED AND BOX TYPE STRUCTURE

5.7.1 Framed Structure :

Table no 5.7.1 Cost of Framed Structure

SI No:	Item Description	UOM	Quantity	Unit Rate				Amount (Rs.)
				Labour	Materials	Plant	Total Rate	
1.	REINFORCED CEMENT CONCRETE							
1 a.	M40 Grade For Columns	Cu. m	4500	550	4500	800	5850	2,63,25,000
1 b.	M30 Grade For Beams & Columns	Cu. m	13000	900	3500	600	5000	6,50,00,000
2.	REINFORCEMENT WORKS							
	Reinforcement works	Mt	2250	12000	45000	300	57300	12,89,25,000
3.	FORMWORK							
3 a.	Column	Sq. m	32000	200	300	50	550	1,76,00,000
3 b.	Beam & slab	Sq. m	120000	300	400	50	750	9,00,00,000
4.	BLOCKWORK							
4 a.	200 mm thick	Sq. m	37000	350	800	50	1200	4,44,00,000
4 b.	100 mm thick	Sq. m	24000	375	600	50	1025	2,46,00,000
5.	PLASTERING WORKS							
5 a.	Ceiling plastering	Sq. m	77500	200	150	40	390	3,02,25,000
5 b.	Internal plastering	Sq. m	46750	150	125	35	310	1,44,92,500
5 c.	External plastering	Sq. m	27000	200	200	225	625	1,68,75,000
STRUCTURE COST FOR THE TYPICAL FLOORS								45,84,42,500
Built-up area in sq.ft								7,20,000
Construction cost per sq.ft								Rs.638-640

5.7.2. Box Type Structure :

Table no 5.7.2 Cost of Box Type Structure

SI No:	Item Description	UOM	Quantity	Unit Rate				Amount (Rs.)
				Labour	Materials	Plant	Total Rate	
1.	REINFORCED CEMENT CONCRETE							
1 a.	M30 Grade (Self Compaction Concrete)	Cu.m	22650	500	4500	700	5,700	12,91,05,000
2.	REINFORCEMENT WORKS							
	Reinforcement Works	Mt	1750	10200	45000	2000	57,200	10,01,00,000
3.	FORMWORK							
3 a.	Wall	Sq.m	191000	200	250	20	470	8,97,70,000
3 b.	Slab	Sq.m	56000					2,63,20,000
STRUCTURE COST FOR THE TYPICAL FLOORS								34,52,95,000
Built-up area in sq.ft								6,25,000
Construction cost per sq.ft								Rs.552-555

Inference From The Above Tables:

The Above Two Table Shows The Cost Comparison Between Framed And Box Type Structure. In Typical Floor Construction, Around 15% Of Cost Saving Is Possible In Box Type Over Framed Structure.

Cost Per Unit For Framed Structures

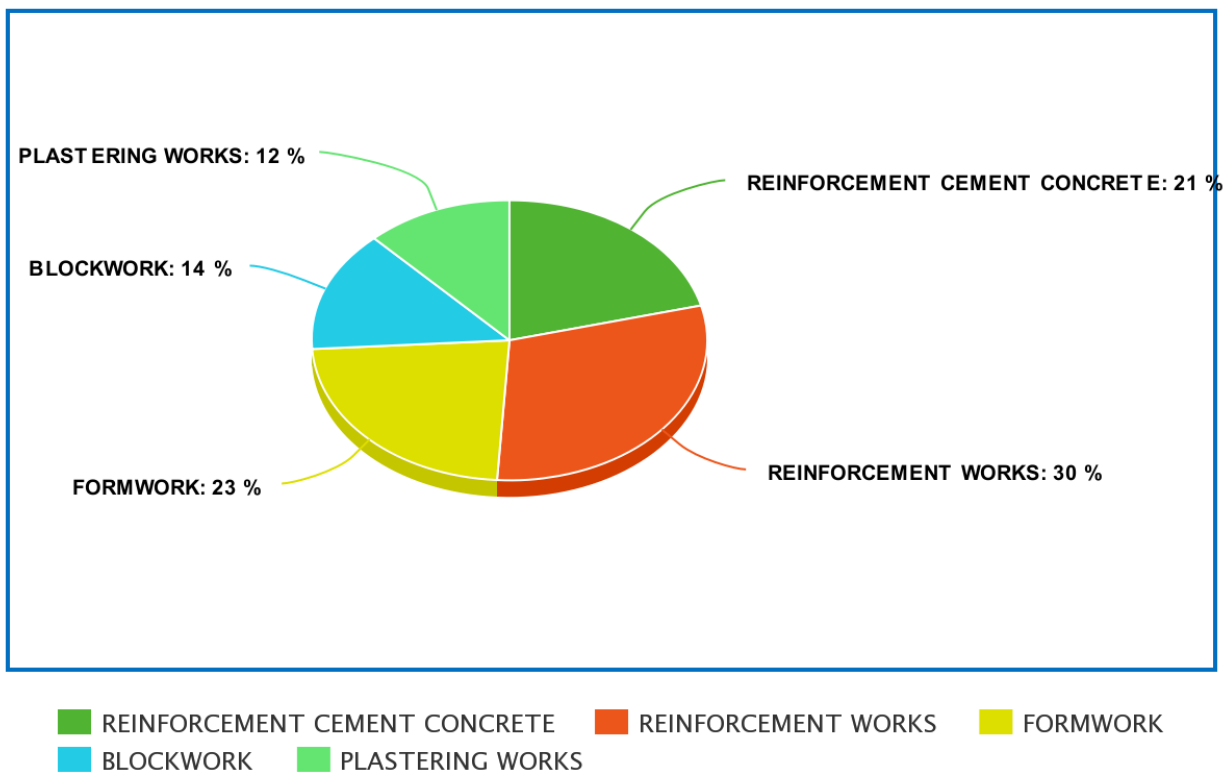


Fig. 5.7.2.1- Cost Per Unit for Framed Structures

meta-chart.com

Cost Per Unit For Box Type Structures

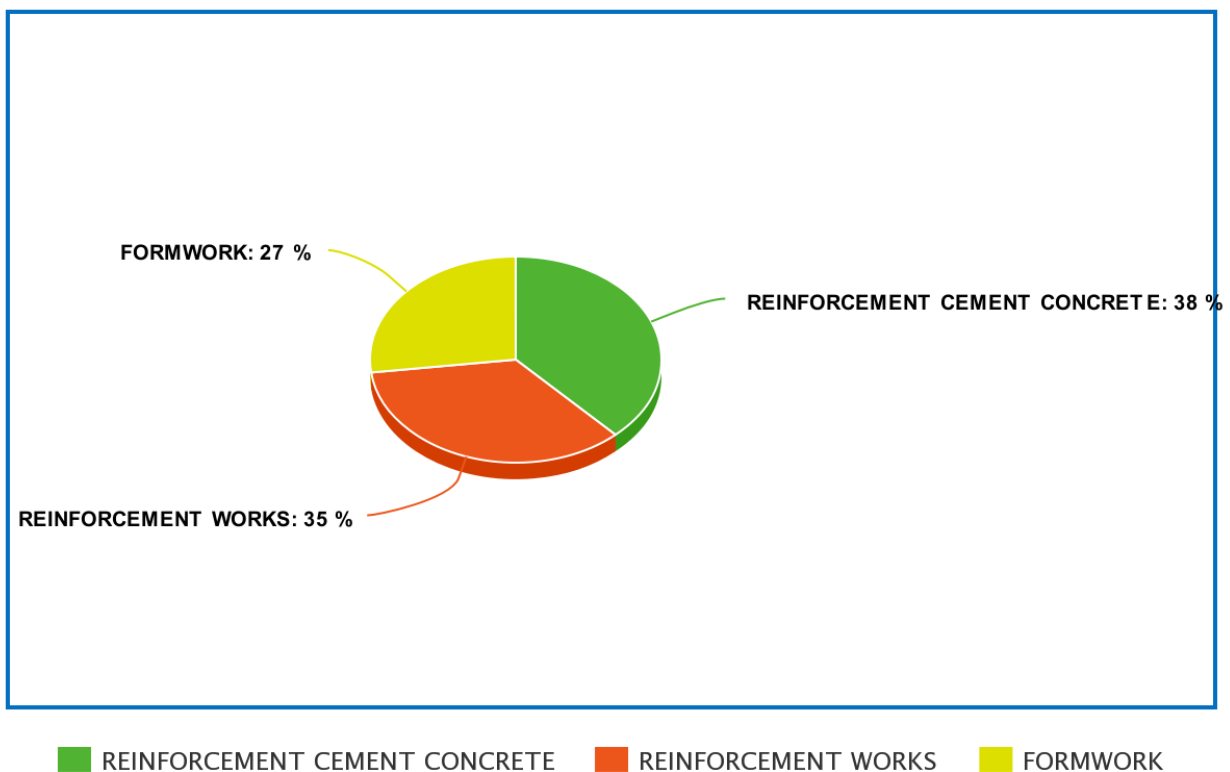


Fig. 5.7.2.2- Cost Per Unit for Box Type Structures

meta-chart.com

5.7.3 Duration Comparison Between Framed & Box Type Construction

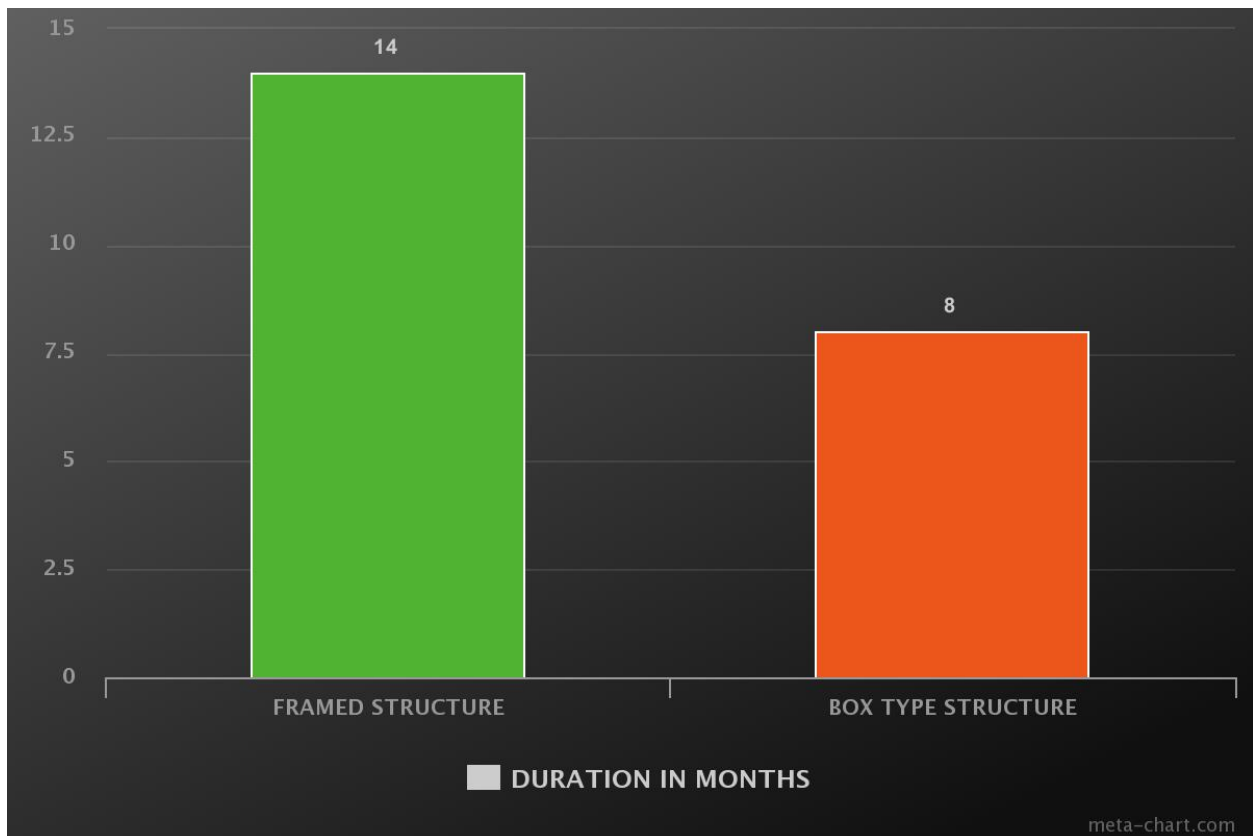


Fig. 5.7.3- Duration Comparison Between Framed & Box Type Construction

5.7.4 Benefits On Reducing The Project Duration:

Construction cost escalation,

Labour rates increases every year at the percentage of 3-5%.

Cement and steel prices increases every year at the percentage of 10-15%.

Around 5-8% of savings in project cost is possible on reducing overheads by early completion of projects,

High and rapid return on investment is possible.

CHAPTER 6

CONCLUSION

The Task Of Housing Due To The Rising Population Of The Country Is Becoming Increasingly Monumental.

In Terms Of Technical Capabilities To Face The Challenge, The Potential Is Enormous. It Only Needs To Be Judiciously Exploited.

Traditionally, Construction Firms All Over The World Have Been Slow To Adopt The Innovation And Changes.

Contractors Are A Conservative Lot. It Is The Need Of Time To Analyze The Depth Of The Problem And Find Effective Solutions.

Aluminum Formwork Serves As A Cost Effective And Efficient Tool To Solve The Problems Of Mass Housing Project All Over The World.

Aluminum Formwork Aims To Maximize The Use Of Modern Construction Technique And Equipment On Its Entire Project.

From The Results Obtained, We Can Come To A Conclusion That When The Aluminum Formwork Is Used In The Construction Project, **The Total Project Cost And The Duration Of The Project Is Lesser Than The Conventional Formwork System.**

Floor Cycle Will Be 7 – 10 Days When The Aluminum Formwork Is Used In Typical Floors, And Hence The **Structure Duration Will Be Reduced By 35 – 40%** Over The Conventional Period Of Construction.

At The Same Time, There Will Not Be Any Additional Activities Such As Blockwork And Plastering, Which **Further Reduces The Overall Project Duration In The Tune Of 5 – 6 Months.**

The Aluminum Formwork System Can Achieve Not Only Faster Rate Of Construction But Can Also **Bring Down The Structural Cost By 20 – 25% Over The Conventional Method** With Lesser Labor Inputs.

Not Only The Direct Benefits, There Are Many Indirect Benefits Of Using Aluminum Formwork System In The Mass Housing Construction Projects.

For Example, Aluminum Is The 100% Recyclable Materials, Which Saves Our Environments From Extraction Of Natural Resources Such As Mining Of Bauxite & Reduces The Cutting Down Of Trees.

REFERENCES

- Ketan Shah, (2005) "Modular formwork for faster, economical and quality Construction", Indian Concrete Journal, Vol-79, pg. 6-23.
- C.S.Poon, Robin C.P. YIP, (2005) "Comparison of conventional and low waste formwork in Hong Kong" World Sustainable Building Conference, Tokyo, 27-29 September 2005, pg. 42-48.
- Ashok Mandal, (2006) "Scaffolding & Formwork- Maintenance & Safety", CE &CR, August 2006, Vol.11, Pg. 46-5.
- <https://timesofindia.indiatimes.com/city/chennai/chennai-buildings-need-overhaul-to-withstand-tremors/articleshow/85613425.cms>
- Nuzul Azam Haron, Ir. Salihuddin Hassim, Mohd. Razali Abd. Kadir and Mohd Saleh Jaafar, (2005)
- "Building Cost Comparison Between Conventional and Formwork System: A Case Study of Four-storey School Buildings in Malaysia", American Journal of Applied Sciences, pg 819-823.
- D.M.Wijesekara "Cost Effective and Speedy Construction for High-Rise Buildings in Sri Lanka by using Aluminum Panel System Formworks", ACEPS – 2012.
- Nagi Reddy Sattigari, Ashwin Mahalingam, George Thomas, 24th International Symposium On
- Automation And Robotics In Construction (ISARC 2007), Construction Automation Group, IIT Madras.
- David Arditi and H Murat Gunaydin, "Total quality management in the construction process", International Journal of Project Management, Vol.15, Issue4, PP: 235-243 (1997).
- Teena Joy (2014), "A Study on Factors Influencing Quality of Construction Projects", International Journal of Innovative Research & Development, Vol.3, Issue 5, PP: 384-387 (2014).
- D.Ashok Kumar, "Study of Quality Management in Construction Industry", International Journal of Innovative Research in Science, Engineering and Technology, Vol.3, Issue 1, PP: 36-43 (2014).
- Stasiowski, F.A. and Brustein, D. "Total Quality Project Management for the Design Firm", Wiley: New York, (1994).