



ENERGY EFFICIENT IMPROVEMENTS IN COMMERCIAL BUILDINGS **ECBC COMPLIANCE REPORT**



Government Law College, Nacholi -
Faridabad
(Educational Building, Composite Climate)



©United Nations Development Programme, 2017

Project Team

HAREDA ECBC Cell,
Institutional Plot 1,
Sector -17, Panchkula

Published by

United Nations Development Programme
55, Lodhi Road, New Delhi-110003

Disclaimer

This report has been compiled based on the recommendations and implementation of interventions adopted in the demonstration building to achieve ECBC compliance. The views expressed in this publication, however, do not necessarily reflect those of the United Nations Development Programme and the Bureau of Energy Efficiency, Ministry of Power, Government of India.

CONTENTS

1. EXECUTIVE SUMMARY	5
1.1 PROJECT BRIEF	6
2. SUMMARY OF ECBC COMPLIANCE.....	6
2.1. ENVELOPE	6
2.1.1. MANDATORY REQUIREMENTS	6
2.1.2. Building Orientation and Massing	7
2.1.3. Building Opaque Envelope.....	7
2.1.4. Window Wall Ratio.....	8
2.1.5. Solar Heat Gain Co-efficient Analysis.....	8
2.1.6. Daylight analysis.....	Error! Bookmark not defined.
2.1.7. Glazing Recommendation	9
2.1.8. Summary of Recommendations for Envelope	11
3. HEATING, VENTILATION & AIR-CONDITIONING (HVAC)	11
3.1 Mandatory ECBC requirements.....	11
3.1.1. Natural Ventilation	11
3.1.2. Minimum Equipment Efficiencies	11
3.1.3. Controls	11
3.1.4. Building HVAC Design and Systems.....	11
3.1.5. Equipment and total system efficiency	11
3.1.6. Piping and ductwork.....	11
3.1.7. Condensers.....	12
3.1.8. Summary of recommendations for HVAC.....	12
4. LIGHTING	12
4.1 Mandatory requirement.....	12
4.2 Lighting power density	12
4.3 Lighting control.....	12
4.4 Exterior lighting detail	12
4.5 Summary of recommendations for lighting:	12
5. SERVICE WATER HEATING	13
6. ELECTRICAL.....	13
6.1 Transformer	13



Empowered lives.
Resilient nations.

6.2 Motors (type, efficiency) 13

6.3 Diesel Generator Sets 13

6.4 Check Metering and Monitoring 13

6.5 Power Factor Correction 13

6.6 Power Distribution System 13

7. Cost Analysis: 13

8. ECBC COMPLIANCE FORMS 17

9. APPENDIX: 17

List of Tables

Table 1: Opaque envelope specification.....	7
Table 2: Window wall ratio	8
Table 3: Skylight Roof Ratio	8
Table 4: SHGC calculation	9
Table 5: Glazing recommendation.....	9
Table 6: Equipment Efficiency.....	11
Table 7: Piping and ductwork insulation	12
Table 8: Cost Analysis	14

List of Figures

Figure 1: Site Plan showing Orientation of the Building.....	7
Figure 2: Glass Recommendation – Fenestration	10
Figure 3: Glass Recommendation – Skylight.....	10

1. EXECUTIVE SUMMARY

BUILDING NAME	Government Law College
BUILDING TYPE	Educational Building
LOCATION	Nacholi - Faridabad
CLIMATIC ZONE	Composite
AREA, m ²	8,721.14
CONDITIONED AREA, m ²	5500
OCCUPANCY TYPE	Day time use building
Total Connected Load/ Contract Demand	To be estimated by PWD Department
ECBC compliance achieved	ECBC 2007 through prescriptive
EPI (Baseline Case), KWh/m ² /year	-
EPI (Proposed Case), KWh/m ² /year	-
ENERGY CONSUMPTION BUSINESS AS USUAL, kWh/YEAR	-
ENERGY CONSUMPTION WITH ENERGY EFFICIENCY INTERVENTIONS, kWh/ YEAR	-
ENERGY SAVING ACHIEVED, kWh/ YEAR	-
Expected reduction in annual energy bills, INR % over BAU	-
Estimated GHG reduction, tCO ₂ per year	-
Cost of project, total, incremental cost of interventions, INR	1,52,27,251.59
PAYBACK PERIOD (in years)	-
DETAILS OF CONTACT PERSON	B. B. Mehta, Senior Architect, Deptt. of Architecture Mob. No. 98141-45461

1.1 PROJECT BRIEF

- The project Standard Government Law College is an upcoming building designed by Department of Architecture with G+2 with a total built-up area of 8,721.14 sqm and conditioned area of 5500 sqm.
- The project is located in Nacholi, Faridabad, Haryana which lies under Composite region.
- The project is designed by the Department of Architecture, Haryana and the approved by PWD (B&R).

2. SUMMARY OF ECBC COMPLIANCE

2.1. ENVELOPE

2.1.1. MANDATORY REQUIREMENTS

2.1.1.1. Fenestration U-Factor

U-factors shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

2.1.1.2. Air Leakage

Air blower test will be adopted for determining the air leakage for swinging entrance doors and revolving doors and it will be sealed, caulked, gasket, or weather-stripped in order to minimize air infiltration and leakage and shall not exceed 5.0 l/s-m². Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m².

2.1.1.3. Fenestration Solar Heat Gain Coefficient

SHGC shall be determined for the overall single or multi glazed fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

2.1.1.4. Fenestration Visual Light Transmittance

Visual light transmittance (VLT) shall be determined for the fenestration product in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

2.1.1.5. Opaque Construction

U-factors shall be calculated for the opaque construction in accordance with ISO-6946. Testing shall be done in accordance with approved ISO Standard for respective insulation type by an accredited independent laboratory, and labeled or certified by the manufacturer.

2.1.1.6. Building Envelope Sealing

Following areas of the building envelope, of all except naturally ventilated buildings or spaces, shall be sealed, caulked, gasketed, or weather-stripped:

- Joints around fenestration, skylights, and door frames

- Openings between walls and foundations, and between walls and roof, and wall panels
- Openings at penetrations of utility services through roofs, walls, and floors
- Site-built fenestration and doors
- Building assemblies used as ducts or plenums
- All other openings in the building envelope
- Exhaust fans shall be fitted with a sealing device such as a self-closing damper
- Operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame

2.1.2. Building Orientation and Massing

The longer axis of the project Govt. Law College, Nacholi, Faridabad is East – West oriented. The true north of the building is shown in the following figure. The Architectural drawings are attached in Annexure -1.

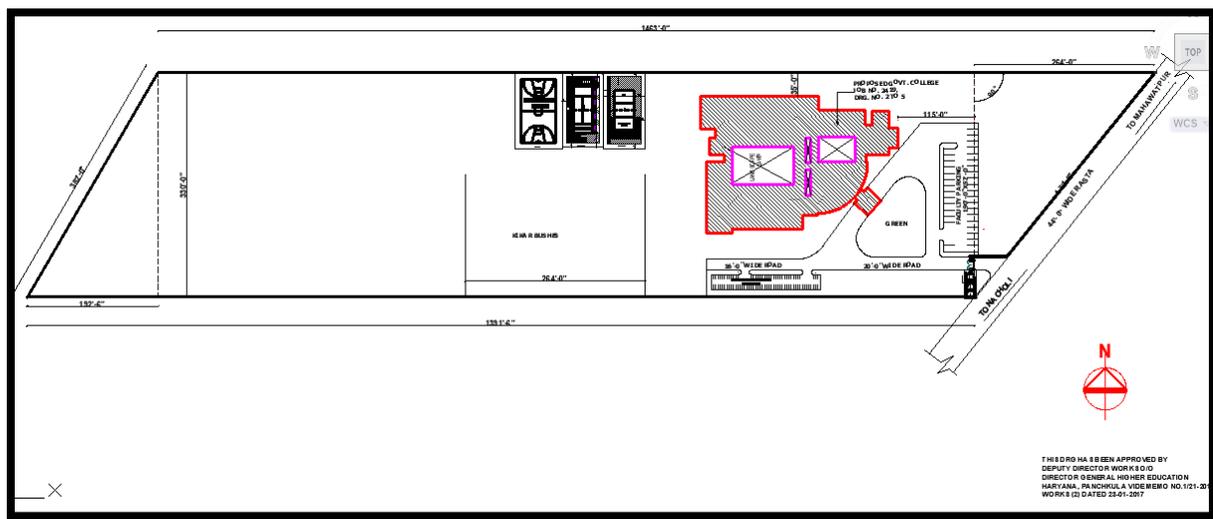


Figure 1: Site Plan showing Orientation of the Building

2.1.3. Building Opaque Envelope

Table 1: Opaque envelope specification

OPAQUE ASSEMBLY	Construction Layers	Specification
Ext. WALL assembly	Assembly layers: a. Cement Plaster (20mm) a. AAC Block (115mm) b. Air Cavity (20mm) c. AAC Block (230mm) d. Cement Plaster (20mm)	U-value, W/m^2K : 0.425 Assembly thickness, mm: 405
Wall insulation	Type: NA	R-value, $K m^2/W$: - Thickness, mm: -

Roof Assembly	Assembly layers: a. White Tile (10mm) b. Cement Screed (20mm) c. XPS Insulation (75mm) d. Cement Screed (20mm) e. Mother Slab (RCC) (150mm)	U-value, W/m ² K: 0.33 Assembly thickness, mm: 275
Roof insulation	Type: XPS (Slab/Foam)	R-value, W/m ² K: 2.679 Thickness, mm: 75mm

2.1.4. Window Wall Ratio

In Prescriptive Method, maximum allowable Window Wall Ratio (WWR) is 60%.

Following is the WWR calculation which confirms that the Overall Window to Wall Ratio is around 15%. The detailed calculation are attached in Annexure-2.

Table 2: Window wall ratio

WWR Calculation Summary			
Elevation	Window + Wall Area (sqft)	Window Area (sqft)	WWR (Window Wall Ratio)
North Side Elevation	19719.3	2592.3	13.2%
West Side Elevation	5071.6	423.6	8.3%
East Side Elevation	5071.6	396.6	7.8%
South Side Elevation	19045.8	3779.8	19.8%
Overall WWR	48908.2	7192.3	14.7%

The College is being constructed with Skylight. As per ECBC, Skylights shall comply with maximum SRR ratio of 5%.

Following is the SRR calculation which confirms that the Overall Skylight to Roof Ratio is around 1.3%.

Table 3: Skylight Roof Ratio

SRR Calculation Summary		
Roof Plan	Area (Skylight + Roof Area) (sqft)	Skylight/Glazing Area (sqft)
TOTAL	40400.0	525.0
Skylight to Roof Ratio		1.3%

2.1.5. Solar Heat Gain Co-efficient Analysis

In Prescriptive Method, maximum allowable Solar Heat Gain Co-efficient (SHGC) for Vertical Fenestration is 0.25. In this project, there are overhangs which is the permanent shade for fenestration. The maximum allowable SHGC value shall be increased due to shading effect. Here, the maximum allowable SHGC is calculated as follows.

Table 4: SHGC calculation

Façade Orientation	Window Type	ECBC Recommended SHGC	Projection Factor (PF)	M-Factor	Equivalent SHGC
North	W1	0.25	0.705	0.8	0.27
West	W	0.25	1.22	0.5	0.5
South	W1	0.25	0.7	0.64	0.39
East	W1	0.25	1.14	0.5	0.5

2.1.6. Glazing Recommendation

Table 5: Glazing Recommendation

GLAZING ASSEMBLY	Specification	Incremental cost (compared to BAU)
Fenestration	Assembly layers: a. Toughened Glass (6mm) b. Air Cavity (12mm) c. Toughened Glass (6mm) U-value, W/m ² K: 1.87 SHGC: 0.27 VLT: 23%	Rs. 5,24,301
Fenestration	Assembly layers: a. Single Glaze Glass U-value, W/m ² K: 5.4 SHGC: 0.48 VLT: 43%	Rs. 1,11,000
Fenestration	Assembly layers: a. Toughened Glass (6mm) Clear shade glass U-value, W/m ² K: 5.4 SHGC: 0.38 VLT: 23%	Rs. 1,71,000
Sky light	Assembly layers: b. Toughened Glass (6mm) Clear shade glass U-value, W/m ² K: 5.4 SHGC: 0.38 VLT: 23%	Rs. 20,320 (As SHGC value is higher, cost is almost similar to BAU)

Ecosense Enhance - 6 mm (Solar Control Glass) - 12 mm (airgap) - 6 mm (Clear Low-E Glass/Clear Essence)								
Product Name	Shade	Code	Visible Light			SF	SC	U-Value
			Transmission	Reflection				
				%	External			Internal
Dawn	Clear	SC 26/33	25	21	33	30	0.34	1.88
Spring	Clear	SC 59/52	55	29	27	51	0.59	1.88
Aura	Clear	SC 48/46	45	27	24	43	0.49	1.88
Snow	Clear	SC 21/28	20	26	34	26	0.3	1.88
Nectar	Clear	SC 32/35	31	23	20	32	0.37	1.87
Ivory	Clear	SC 20/25	19	34	22	21	0.24	1.86
Cove	Blue	SH 18/25	17	12	33	22	0.25	1.88
Marine	Blue	SH 38/37	36	19	29	33	0.38	1.88
Bay	Blue	SH 31/34	30	13	34	29	0.34	1.9
Orchid Blue	Blue	SH 13/23	13	14	34	19	0.22	1.88
Indigo	Blue	SH 22/26	20	12	20	23	0.26	1.87
Bluebell	Blue	SH 13/21	12	17	23	17	0.20	1.86
Pine	Green	SN 22/24	21	16	33	21	0.24	1.66
Meadow	Green	SN 49/38	47	25	28	34	0.39	1.88
Coral	Green	SN 39/35	37	20	24	30	0.34	1.88
Jade	Green	SN 18/24	18	20	34	21	0.24	1.88
Lime	Green	SN 27/26	26	18	20	23	0.26	1.87
Citrus	Green	SN 16/21	15	25	24	17	0.20	1.86

Figure 2: Glass Recommendation – Fenestration

Ecosense Enhance (Solar Control Glass) - 6 mm								
Product Name	Shade	Code	Visible Light			SF	SC	U-Value
			Transmission	Reflection				
				%	External			Internal
Dawn	Clear	SC 26/33	29	18	26	43	0.49	5.4
Spring	Clear	SC 59/52	65	26	26	64	0.73	5.4
Aura	Clear	SC 48/46	53	25	21	58	0.67	5.4
Snow	Clear	SC 21/28	23	26	36	38	0.44	5.4
Nectar	Clear	SC 32/35	37	22	16	45	0.52	4.8
Ivory	Clear	SC 20/25	23	34	19	34	0.39	4.5
Cove	Blue	SH 18/25	20	12	26	36	0.41	5.4
Marine	Blue	SH 38/37	43	17	28	48	0.55	5.4
Bay	Blue	SH 31/34	35	12	22	46	0.53	5.4
Orchid Blue	Blue	SH 13/23	15	14	35	35	0.4	5.4
Indigo	Blue	SH 22/26	24	12	16	38	0.43	4.9
Bluebell	Blue	SH 13/21	14	17	20	32	0.37	4.5
Pine	Green	SN 22/24	25	14	26	35	0.4	5.4
Meadow	Green	SN 49/38	56	22	26	48	0.56	5.4
Coral	Green	SN 39/35	44	19	22	46	0.53	5.4
Jade	Green	SN 18/24	21	20	35	36	0.41	5.4
Lime	Green	SN 27/26	31	17	16	37	0.43	4.8
Citrus	Green	SN 16/21	18	25	21	31	0.36	4.5

Figure 3: Glass Recommendation – Skylight & Fenestration

2.1.7. Summary of Recommendations for Envelope

- The prescriptive requirement for maximum U-factor (W/m².K) for Opaque External Wall Assembly for this project is 0.425 W/m².K and maximum U- factor for roof is 0.33 W/m².K
- WWR – Window-Wall ratio of the project is 14.7%
- SRR – Skylight to Roof ratio of the project is 1.3%
- The SHGC for the fenestration in different directions is 0.27, 0.38 and 0.5.
- Since the SRR of the building is less than 2%, the SHGC of the skylight is 0.38.

3. HEATING, VENTILATION & AIR-CONDITIONING (HVAC)

3.1 Mandatory ECBC requirements

3.1.1. Natural Ventilation

The project team has designed the building following all the necessary provisions of NBC 2005 including the design guidelines for Natural Ventilation.

3.1.2. Minimum Equipment Efficiencies

The project will meet all the minimum equipment efficiency norms under ECBC for unitary AC systems, ceiling fans etc. The project is under design stage, the project will take the necessary measures to meet with ECBC while designing HVAC Systems. The split ACs going to be installed in the offices will be BEE 3-Star Rated.

3.1.3. Controls

The project will give all the necessary controls required for heating and cooling equipment. The dead band between the heating and cooling temperature shall be maintained at 3^o C.

3.1.4. Building HVAC Design and Systems

The project is installing Split AC (Packaged terminal AC) Systems.

3.1.5. Equipment and total system efficiency

Table 6: Equipment Efficiency

Equipment type	ECBC recommended efficiency	System efficiency
Equipment (Split AC)	BEE 3 star rating	BEE 3 star rating

3.1.6. Piping and ductwork

The piping for cold fluid less than 15^o C temperature, the insulation will have R value of 0.35 Sq. m. K/W or higher.

Table 7: Piping and ductwork insulation

System Description (with operating temperature, °C)	Pipe size (mm)	ECBC recommended R value (m ² .K/W)	R value of insulation used (m ² .K/W)	Thickness of insulation used (mm)
Nitrile Rubber	20mm	1.4	0.35	13 mm

3.1.7. Condensers

The outdoor units of the Split ACs installed will be placed at a shaded location such that they are not exposed to direct sunlight. The exhaust of the condensers will be free from obstruction so that proper heat transfer takes place.

3.1.8. Summary of recommendations for HVAC

- The project team was recommended to install minimum BEE 3 Star rated split ACs.
- The project team was also recommended to Nitrile Rubber for insulation of ducting with a size of 13 mm thickness.

4. LIGHTING

4.1 Mandatory requirement

The project will install Occupancy sensors in common areas like offices, staff rooms, classrooms, corridors, toilets, and conference rooms and Astronomical time switch will be provided for exterior lighting.

4.2 Lighting power density

The project has adopted Building Area method. And as per ECBC 2007, the Baseline LPD for educational building is 12.9 W/m². And the proposed LPD for the building is 10 W/m².

4.3 Lighting control

The project will install Occupancy sensors in areas like offices, staff rooms, classrooms, conference rooms and Astronomical time switch will be provided for exterior lighting. The occupancy/motion sensors will be installed in the building which specify the accessibility of the occupant in the specific areas mentioned.

4.4 Exterior lighting detail

LED lights with minimum 80 lm/W shall be used for exterior lighting. Astronomical timers will be used in the exterior lightings. The astronomical time switch will provide maximum energy efficiency which will operate according to the time already defined.

4.5 Summary of recommendations for lighting:

- LPD of the building shall not exceed 10 W/m² as per Building Area method.
- Occupancy sensors will be installed in common areas like Toilets and Assembly areas.
- LED lights with min 80 lm/W shall be used in exterior lighting.

- Astronomical timers will be used in exterior lighting.

5. SERVICE WATER HEATING

The project is an educational type building hence there is no requirement of hot water.

6. ELECTRICAL

6.1 Transformer

11 KV / 433 – 250V 25 KVA Oil core Conventional type Aluminum conductor Distribution Transformers with BEE 5 Star Rating shall be installed in the project to maintain maximum power losses at 50% and full loading capacity.

6.2 Motors (type, efficiency)

The motors better than IS 12615 rated motors will be installed for plumbing purposes. IS Certified recommended motors improves better energy efficiency and consuming less energy as compared to conventional case.

6.3 Diesel Generator Sets

The project shall install Two 320 kVA, 415 V, 50Hz 3 phase water cooled silent type Diesel Generators with 4 Star BEE rating.

6.4 Check Metering and Monitoring

A HT side Incomer Panel, Main LT panel load manager to be provided and at the outgoing feeder MFM to be provided. The meters with MFM shall be done for all common loads like HVAC, plumbing, lighting, lifts, etc. All meters with RS 485 port total data from meters will be transferred to computer with the help of software for energy monitoring. The meters can display V, A, kVA, kWh, PF, current, voltage, THD.

6.5 Power Factor Correction

Automatic Power Factor Corrector with capacitor banks shall be provided for maintaining minimum power factor 0.95 to 1. The capacitor shall be of MPP/APP/MDXL type.

6.6 Power Distribution System

Project will install cables of adequate size to maintain the internal power distribution losses at max 1%.

7. Cost Analysis:

For the increased energy performance of the building, energy efficient materials were used in the building which are not conventionally used. Cost comparison analysis was done for the building systems coming under the scope of ECBC for both the baseline and proposed buildings. The total investment in the conventional building is Rs. 3,56,50,445.28 for the building systems coming under the scope of ECBC. As for the proposed building it is Rs. 5,07,26,932.00. The incremental cost of investment in energy efficient systems is Rs INR INR 1,52,27,251.59 including 1% maintenance cost of the energy efficient materials.

Since the building is in designing stage, cost reference is taken from the most accepted market price that was taken from market research.

The quantity of tonnage refrigeration required in the building is calculated from the thumb rule accepted in the HVAC industry of 1 TR for 150 ft². This gives a requirement of approximately 400 ton refrigeration for the air conditioned area in the building.

The number of fixtures required in the building were estimated based on LPD. Conventional building has 40 W CFL fixtures and proposed case has 20 W LED fixtures.

Table 8: Cost Analysis

S.No	Catagorey	Conventional Case	Proposed Case	Cost Increment
1	Wall	230mm thick brick wall	20mm Plaster + 115 mm AAC Block + 20 mm air cavity + 230 mm AAC Block + 20 mm Plaster	
	Wall Area	3898	3898	
	Cost Per Sqm	1220	1920	
	Total Cost	4755560	7484160	2728600
2	Roof	Heat reflective paint + 35mm Screed + 85mm EPS board Insulation +150mm BBC +150mm R.C.C + 15mm Plaster	20 mm Cement Screed + 150 mm R.C.C Slab + 75 mm XPS insulation + 20 mm Cement Screed + 12 mm Tiles	
	Roof Area	3781.65	3781.65	
	Cost Per Sqm	3346	4500	
	Total Cost	12653400.9	17017425	4364024.1
3	Fenestration	Single Clear 6 mm thick glass	Double Glazed Unit(6 mm Glass + 12 mm Airgap + 6 mm Glass)	
	Window Area	672.18	672.18	

	Cost Per Sqm	6700	7900	
	Total Cost	4503606	5310222	806616
5	HVAC	Split AC	Split AC/Fan Coil Units	
	Quantity Tonnes (TR)	400	400	
	Cost Per Tonne (TR)	32990	37000	
	Total Cost	13196000	14800000	1604000
	Envelope			
	Air Leakage (Gasketing/Air Blower test for Swinging Doors and Revolving Doors and Fenestration)			
	Quantity (Running Metre)		2616	
	Cost Per Running Metre		100	
	Total Cost		261600	261600
	Envelope Sealing (Weather Sealing, Gasketing and Caulking)			
	Quantity (Running Metre)		35568	
	Cost Per Running Metre		100	
	Total Cost		3556800	3556800
	HVAC			
	Timer Based Control			
	Variable Speed Drive for Fans			
	System/Air Balancing and Commissioning			

	Solar Water Heating			
	Solar Water Heating system as per ECBC (20% of Hot Water Requirement)			
	Lightings			
	Light Fixtures	421878.375	1962225	1540347
	Lighting Controls			
	Passive Infrared (PIR) based occupancy sensor with daylight control			
	Quantity (Pcs)		45	
	Cost		4500	
	Total Cost		202500	202500
	Exterior Lighting Controls			
	Astronomical time switch for street light			
	Total Cost		12000	12000
	Electrical Systems			
	Energy Metering	40000	40000	0
	Service Water Pump and Motors	80000	80000	-
	Low Loss Transformers	Needs to be computed based on actual design after finalizing detailed electrical consumption		
	Power Factor Control	Needs to be computed based on actual design after finalizing detailed electrical consumption		
	Total Cost	INR 3,56,50,445.28	INR 5,07,26,932.00	INR 1,50,76,486.73

Capital Investment	INR	1,50,76,486.73
Maintenance cost (@1%)	INR	1,50,764.87
Total	INR	1,52,27,251.59

*Note - The above cost details has been referred from market research assessment with various vendor's (manufacturers/suppliers) as per availability & selection of material/product in the state of Haryana. The excel sheet of Cost Analysis with calculations is placed at Annexure-3.

8. ECBC COMPLIANCE FORMS

ECBC Compliance Forms are placed at Annexure-4.

9. APPENDIX:

- Annexure 1 : Architectural Drawings
- Annexure 2 : Calculations (U-Factor, SHGC, WWR)
- Annexure 3 : Cost analysis report
- Annexure 4 : Compliance forms

** End of Report**