ENERGY EFFICIENT IMPROVEMENTS IN COMMERCIAL BUILDINGS

ECBC COMPLIANCE REPORT

Govt. Girls College, Dadupur, Karnal

(Institutional Building, Composite Climate)

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

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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.

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1. EXECUTIVE SUMMARY

BUILDING NAME	**Standard Girls Govt. Collage**
BUILDING TYPE	Educational Building
LOCATION	Dadupur, Karnal
CLIMATIC ZONE	Composite
AREA, m²	6967.7
CONDITIONED AREA, m²	5532.86
OCCUPANCY TYPE	Day time building
Total Connected Load/ Contract Demand	To be estimated by PWD Department
ECBC compliance achieved	ECBC 2017 through prescriptive approach
EPI (Baseline Case), KWh/m²/year	-
EPI (Proposed Case), KWh/m²/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	6,26,70,495
PAYBACK PERIOD (in years)	-
DETAILS OF CONTACT PERSON	B. B. Mehta, Senior Architect Deptt. Of Architecture, Haryana M. - 9814145461

1.1 PROJECT BRIEF:

- The project Standard Govt. girls collage is an upcoming building designed by Department of Architecture with G+2 with a total built-up area of 6967.7 sqm and conditioned area of 5532 sqm. The architectural plans are placed at Annexure 1.
- The project is located in Dadupur, Karnal, 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

1.1.1. MANDATORY PROVISIONS UNDER ECBC

2.2 ENVELOPE

2.2.1. 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.

2.2.2. 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.

2.2.3. 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.

2.2.4. 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

2.2.5. Building orientation and massing

The longer axis of the project Girls Govt. College, Dadupur, Karnal is East-West. The true North is shown in the below figure.

2.2.6. 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.

Table 1: Wall and Roof Assembly

OPAQUE ASSEMBLY	Construction Layers	Specification
Ext. WALL assembly	Assembly layers: a. Cement Plaster (20mm) b. AAC Block (115mm) c. Air Cavity (20mm) d. AAC Block (230mm) e. Cement Plaster (20mm)	U-value, W/m²K: 0.425 Assembly thickness, mm: 397
Wall insulation	Type: NA	R-value, K m²/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/m²K: 0.33 Assembly thickness, mm: 275
Roof insulation	Type: XPS (Slab/Foam)	R-value, W/m²K: 2.5 Thickness, mm: 75 mm

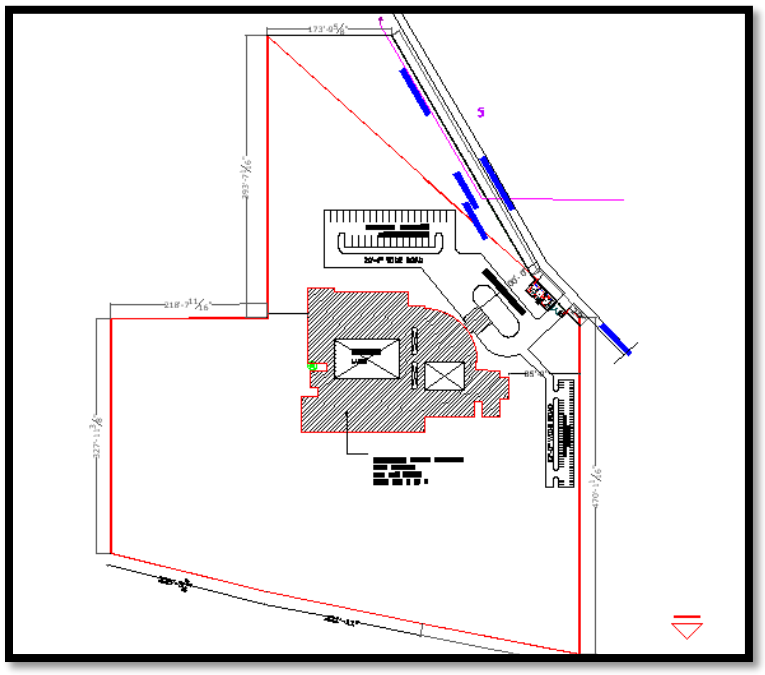

Figure 1: Layout Plan

2.2.7. Window wall ratio

In Prescriptive Method, maximum allowable Window Wall Ratio (WWR) is 40%.

Following is the WWR calculation which confirms that the Overall Window to Wall Ratio is around 19%.

Table 2: Window wall ratio

FACADE	Window+ Wall, ft²	Glazed area, ft²	WWR
East	6969.9	913.8	13%
West	6037.5	512.3	8%
North	12845	3163.3	25%
South	10453	2149.3	21%
Total	36305.4	6739.2	19%

2.2.8. Solar shading analysis

In Prescriptive Method, maximum allowable Solar Heat Gain Co-efficient (SHGC) for Vertical Fenestration is:

- 0.27: For Non-North Façade
- 0.50: For North Façade

In this project, there are overhangs which is the permanent shade for fenestration. As most of the windows have not big overhangs, the effect of shading is less. The maximum allowable SHGC value shall be increased due to shading effect. Here, the maximum allowable SHGC is

calculated by multiplying the prescriptive SHGC requirement with the SEF. The detailed calculations are placed at Annexure-2.

Table 3: SHGC calculation

Façade Orientation	Window Type	ECBC Recommended SHGC	Equivalent SHGC
NORTH	G1	.50	0.55
NON- NORTH	G2	.27	0.35

**Detailed Calculations placed at Annexure-2*

2.2.9. Daylight analysis

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylight time in a year. For the ECBC Building compliance as per ECBC 2017, minimum 40% of above grade floor area shall meet the UDI requirement for this project.

The Glass with the VLT of more than 30% shall be proposed to be used in this project. Accordingly, the detailed calculation has been performed:

Table 4:Above Grade Area calculation

Total above grade floor area, m²		**5732.9.**
Total daylight area per floor meeting UDI requirement during 90% of the year, m²	**TOTAL**	**2865.7**
% of above grade floor area meeting UDI requirements		**50 %**

The Above Grade Floor area has been calculated excluding toilet area.

According to the calculation the total % of Daylight Area Meeting the UDI Requirement for 90% of the Time in a Year come up to be around 50%, which meets the ECBC Building Mandatory requirement. Following are Couple of screenshots of architectural plans with marked daylight area:

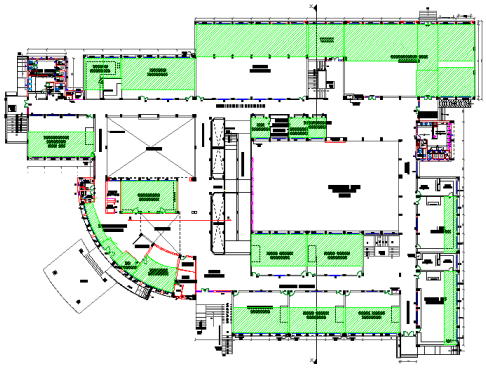

Figure 3: GROUND FLOOR

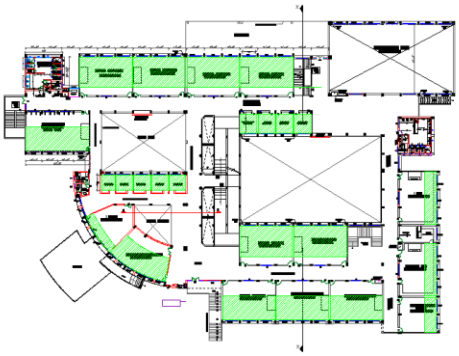

Figure 2: FIRST FLOOR

2.2.10. Glazing Recommendation

Table 5: Glazing recommendation

GLAZING ASSEMBLY	Specification	Incremental cost (compared to BAU)
North	Assembly layers: a. Toughened Glass (6mm) b. Air Cavity (12mm) c. Toughened Glass (6mm) U-value, W/m²K: 1.87 SHGC: 0.55 VLT: 23%	Rs 5660508
Non- North	Assembly layers: a. Single Glaze Glass U-value, W/m²K: 5.4 SHGC: 0.35 VLT: 38%	Rs 24,25,932

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			
			%	%	%	%		W/m²K
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 4: Glass Recommendation – North

Ecosense Enhance (Solar Control Glass) - 6 mm								
Product Name	Shade	Code	Visible Light			SF	SC	U-Value
			Transmission	Reflection				
				External	Internal			
			%	%	%	%		W/m²K
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 5: Glass Recommendation – Non- North

2.2.11. Summary of recommendations for envelope

- The prescriptive requirement for maximum U-factor (W/m2.K) for Opaque External Wall Assembly for this project is 0.40 W/m2.K.
- The Overall SHGC for North façade is 0.55 and Non- North façade is 0.35

- Total daylight area per floor meeting UDI requirement during 90% of the year is 2865.7 m2 (50%) which satisfies the ECBC 2017 requirements.

2.3 COMFORT SYSTEMS AND CONTROLS

2.3.1 Mandatory ECBC requirements

2.3.2 Natural Ventilation

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

2.3.2.1 Minimum equipment efficiencies

The project will meet all the minimum equipment efficiency norms under ECBC 2017 for, unitary AC systems, ceiling fans etc.

2.3.2.2 Controls

The project has given all the necessary controls required for heating and cooling equipment's. The dead band between the heating and cooling temperature shall be maintained at 3^0 C.

2.3.3 Building HVAC design and systems

The project is installing BEE 3 star rated Split AC (Packaged terminal AC) Systems.

2.3.4 Equipment and total system efficiency

Table 6: Equipment Efficiency

Equipment type	ECBC recommended efficiency	System efficiency
Equipment 1 (split)	BEE 3 star rating	BEE 3 star rating

2.3.5 Piping and ductwork

The piping for less than 60^0 C temperature insulation will have R value of 0.35 Sq. m. K/W or higher. For more than 60^0 C temperature insulation R value will be 0.74 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	0.38	13mm

2.3.6 Condensers

The outdoor units of the split ACs 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.

2.3.7 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.

2.4 LIGHTING

2.4.1. Mandatory requirement

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

2.4.2. Lighting power density

The project has adopted Space Function method. The calculations are as follows. Detailed LPD calculations are placed at Annexure-3.

Table 8: Interior lighting power density

Building Type	Area, m2	LPD (W/m^2) Baseline	LPD (W/m^2) Proposed	Wattage Baseline	Wattage Proposed	Equipment Wattage (W)	No of fixtures
Classrooms	1690.71	13.7	12	23162.7	20288.52	18	1127
Faculty room	102.1	10	8	1021.0	816.80	35	23
Assembly Areas	1483.9	10	8	14839.8	11871.84	48	247
Toilets	346.9	7.7	6	2671.6	2081.76	15	139
Laboratory	618.4	15.1	12	9337.8	7420.80	35	212
Common Areas	2725.5	7.7	6	20986.9	16353.48	21	779

2.4.3. 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.

2.4.4. Exterior lighting detail

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

2.4.5. Summary of recommendations for lighting:

- LPD of the building will be done as per the calculations.
- 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.

2.5 SERVICE WATER HEATING

The project is an educational type building hence the hot water requirement is not needed.

2.6 RENEWABLE ENERGY

The project has not installed any renewable energy systems, however the project has provided vacant space in the terrace for any future installation of Renewable Energy systems.

2.7 ELECTRICAL

2.6.1. 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.

2.6.2. 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.

2.6.3. 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.

2.6.4. 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.

2.6.5. 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.

2.6.6. Power distribution system

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

3. 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. 16,23,56,467 for the building systems coming under the scope of ECBC. As for the proposed building it is Rs. 22,44,06,462. The incremental cost of investment in energy efficient systems is Rs 6,20,49,995 which is 38.2 % of BAU.

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 ft^2. This gives a requirement of approximately 397 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 9: Cost Analysis

S.No	Category	Conventional Case	Proposed Case	Cost
1	**Wall**	230 mm thick brick wall	20mm Plaster + 115 mm AAC Block + 20 mm air cavity + 230 mm AAC Block + 20 mm Plaster	
	Wall Area	36304.4	36304.4	
	Cost Per Sqm	1220	1920	
	Total Cost	**44291368**	**69704448**	**25413080**

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	17784	17784	
	Cost Per Sqm	3346	4500	
	Total Cost	59505264	80028000	20522736
3	**Fenestration**	Single Clear 6 mm thick glass	Double Glazed Unit(6 mm Glass + 12 mm Airgap + 6 mm Glass)	
	Window Area	6738.7	6738.7	0
	Cost Per Sqm	6700	7900	1200
	Total Cost	45149290	53235730	8086440
				0
5	**HVAC**	Split AC	Split AC/Fan Coil Units	
	Quantity Tonnes (TR)	397	397	
	Cost Per Tonne (TR)	32990	37000	
	Total Cost	13097030	14689000	1591970
	Envelope			
	Air Leakage (Gasketing/Air Blower test for Swinging Doors and Revolving Doors and Fenestration)			
	Quantity (Running Metre)	-	5616	
	Cost Per Running Metre	-	100	

	Total Cost	-	561600	561600
	Envelope Sealing (Weather Sealing, Gasketing and Caulking)			
	Quantity (Running Metre)	-	35568	
	Cost Per Running Metre	-	100	
	Total Cost	-	3556800	3556800
	HVAC			
	Timer Based Control	-	150000	150000
	Variable Speed Drive for Fans	-	150000	150000
	System/Air Balancing and Commissioning	-	-	-
	Solar Water Heating			
	Solar Water Heating system as per ECBC (20% of Hot Water Requirement)	-	-	-
	Lightings			
	Light Fixtures	313515	1996384	313515
	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
	Service Water Pump and Motors	-	80000	80000
	Total Cost	**162356467**	**224406462**	**62049995**

Capital Investment	**6,20,49,995**
Maintenance cost (@1%)	**6,20,500**
Total	**6,26,70,495**

*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. Detailed cost analysis report in excel format is placed at Annexure 5.

4. ECBC COMPLIANCE FORMS

ECBC Compliance Forms are placed at Annexure -4.

5. APPENDIX:

- Annexure 1 : Architectural Drawings
- Annexure 2 : Calculations (SEF, DEF)
- Annexure 3 : LPD Calculations
- Annexure 4 : Compliance forms
- Annexure 5 : Cost analysis report

** End of Report**