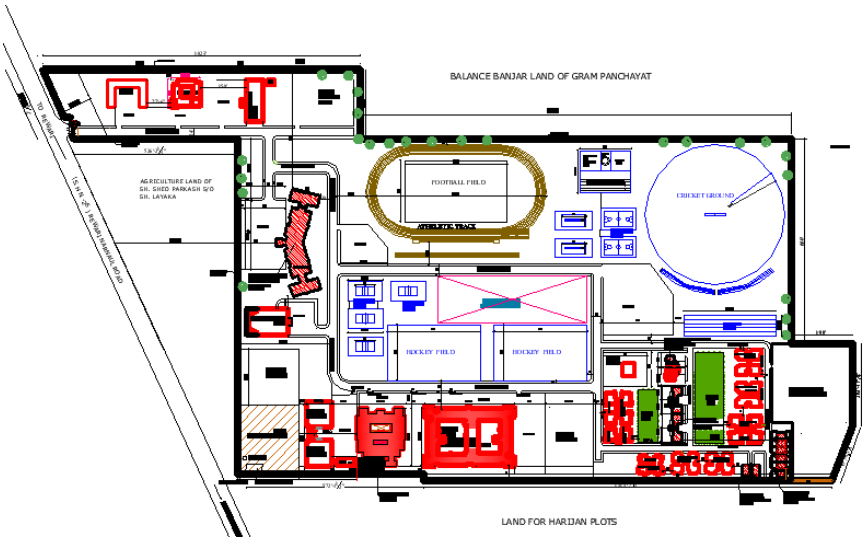
ENERGY EFFICIENT IMPROVEMENTS IN COMMERCIAL BUILDINGS

ECBC COMPLIANCE REPORT



Sainik School (Hostel and Mess Block), Rewari (Haryana)

Hospitality Type, Composite Climate

Project Team

Haryana ECBC Cell,
Haryana Energy Development Agency (HAREDA),
Akshay Urja Bhawan
Plot No. 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

List of Tables

List of Figures

1. EXECUTIVE SUMMARY

BUILDING NAME	**Sainik School (Hostel and Mess Block)**
BUILDING TYPE	Hospitality Building
LOCATION	Gothra Tappa Khori, Rewari
CLIMATIC ZONE	Composite
AREA, m²	9290.7 (2075 m² Mess Block & 7215.7 Hostel Block)
CONDITIONED AREA, m²	2000
OCCUPANCY TYPE	24 Hour Use Building
Total Connected Load/ Contract Demand	To be estimated by PWD Department
ECBC compliance achieved	ECBC 2007 through prescriptive
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_2per year	-
Cost of project, total, incremental cost of interventions, INR	**1,46,53,332**
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 Hostel and Mess Block of Sainik School is an upcoming building designed by Department of Architecture with Hostel Block of G+2 and Ground Floor of Mess Block with a total built-up area of 9290.7 sqm and conditioned area of 2000 sqm.
- The project is located in Gothra Tappa Khori, Rewari , Haryana which lies under Composite region.
- The project is designed by the Department of Architecture, Haryana and the construction work is executed by PWD (B&R).

2. SUMMARY OF ECBC COMPLIANCE

2.1. ENVELOPE

2.2 MANDATORY PROVISIONS UNDER ECBC

2.1.1.1 U-Factors and Solar Heat Gain Coefficient

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

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-m^2. Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m^2.

2.1.1.3 Building Envelope Sealing

The project team will seal, caulk, gasket, or weather-strip the following areas of the enclosed building envelope to minimize air leakage:

a) Joints around fenestration and door frames;
b) Openings between walls and foundations and between walls and roof and wall panels;
c) Openings at penetrations of utility services through, roofs, walls, and floors;
d) Site-built fenestration and doors;
e) Building assemblies used as ducts or plenums; and
f) All other openings in the building envelope

2.1.1.4. Building Orientation and Massing

The longer axis of the building is in north-south direction. The true north is shown in the below site plan.

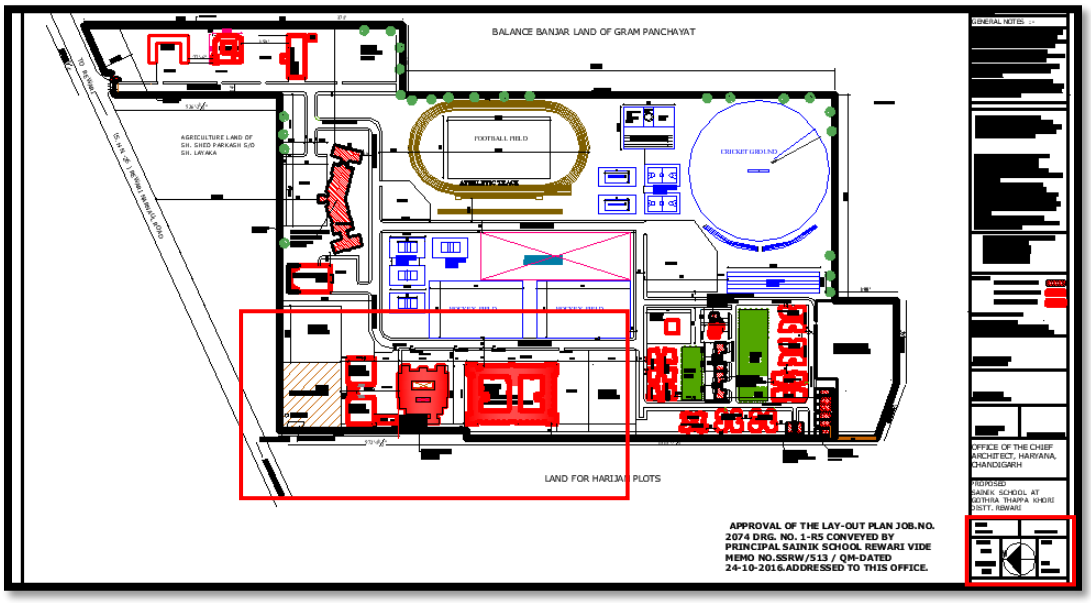


Figure 1: Layout Plan

2.1.2 Building Opaque Envelope

The project will go for double AAC block wall with 20 mm air cavity. The U-Factor of the wall assembly will be maintained at 0.425 W/m² K.

Roof assembly consists of over deck 75 mm PUFF insulation to meet the ECBC requirement of 0.261 W/m² K for 24 hours use buildings. The U-Factor of the roof assembly will be maintained at 0.254 W/m² K.

Table 1: Opaque Envelope Specification

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: 405
Wall insulation	Type: NA	R-value, K m²/W: Thickness, mm:
Roof Assembly	Assembly layers: a. White Tile (8 mm) b. Cement Screed (50mm) c. PUFF Slab Insulation (75mm) d. Mother Slab (150 mm) e. Cement Plaster (12mm)	U-value, W/m²K: 0.254 Assembly thickness, mm: 295
Roof insulation	Type: PUFF (Slab/Foam)	R-value, W/m²K: 3.5 Thickness, mm: 75mm

2.1.3. 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 of Hostel Block is 29.3% and Mess Block is 26.7%. The detailed calculations are placed at Annexure-2.

Table 2: Window Wall Ratio of Hostel Block

FACADE	AREA, m2	Opaque wall area , m2	Glazed area, m2	WWR
North	1181.8	792.9	388.8	32.9%
South	1175.1	785.1	390	33.2%
East	1667.9	1217.1	450.2	27.0%
West	1667.9	1217.1	440.7	26.4%
Total	**5692.7**	**4012.2**	**1680.5**	**29.3%**

Table 3: Window Wall Ratio of Mess Block

FACADE	AREA, m^2	Opaque wall area , m^2	Glazed area, m^2	WWR
North	311	243.1	68.4	22%
South	311	244.1	67.4	21.6%
East	282.9	153.2	129.7	45.8%
West	282.9	228.8	54.1	19.1%
Total	**1187.8**	**870.2**	**317.6**	**26.7%**

2.1.5 Shading Recommendation

The longer axis of the building is in north-south direction, the project was recommended to provide overhangs over all the windows in South and West directions. The project team has decided to provide overhangs in all the directions .

2.1.6 Solar Shading Analysis

The project has used overhangs in all the directions, the M-Factor calculation is shown in following table.

Table 4: SHGC calculation of Hostel Block

Façade Orientation	Window Type	ECBC Recommended SHGC	Projection Factor (PF)	M-Factor	Equivalent SHGC
North	W1	0.25	0.3	0.88	0.28
West	W	0.25	0.9	0.56	0.44
South	W1	0.25	0.3	0.79	0.32
East	W1	0.25	0.8	0.56	0.44

Table 5: SHGC calculation of Mess Block

Façade Orientation	Window Type	ECBC Recommended SHGC	Projection Factor (PF)	M-Factor	Equivalent SHGC
North	W5	0.25	0.33	0.88	0.28
West	W5	0.25	0.33	0.79	0.31
South	W1	0.25	0.33	0.79	0.31
East	W7	0.25	0.42	0.79	0.31

2.1.7 Glazing Recommendation

Since the project has WWR less than 40%, the Project was recommended to use Double Glazed windows in all directions with SHGC less than 0.25. Since the project also has overhangs over windows, the project was assisted in calculation the adjusted SHGC for those windows. Glass of SHGC of 0.28 in North direction and glass of SHGC of 0.32 is used in rest windows with overhangs. Glazing recommendation cut sheet is placed at Annexure 3.

Table 6: Glazing recommendation

GLAZING ASSEMBLY	Specification	Incremental Cost (compared to BAU)
Glazing in Mess	Assembly layers: a. 6mm toughened glass b. 12 mm air gap c. 6mm Clear glass U-value, W/m²K: 1.87 SHGC: 0.28 VLT: 26%	Rs. 1817270 (Compared to conventional clear glass)
Glazing in Hostel	Assembly layers: d. 6 mm Coated glass e. 12 mm air gap f. 6 mm clear glass U-value, W/m²K: 1.88 SHGC: 0.32 VLT: 20%	Rs. 7,78,830 (Compared to conventional clear glass)

2.1.8 Recommendations for Envelope

ECBC Cell has recommended several options in wall and roof sections and glazing also.

i) WWR – Window-Wall ratio of Hostel Block is 29.3% and Mess Block is 26.7%
ii) Roof - RCC with PUFF Slab insulation with overall U-Value of 0.254 W/m²K is recommended.

iii) Wall - Double AAC Block wall with air cavity with U- Value of 0.425 W/m2K is recommended.
iv) Glass – Double Glazed glass of SHGC shall be less than 0.25 and VLT shall be more than 27%.
v) Roof – High SRI tiles shall be used having capability of more than 0.7 SRI value.

2.3. HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

2.3.1. Mandatory ECBC requirements

2.3.1.1 Natural Ventilation

The project team has designed the building following all the necessary provisions of NBC 2005 including the design guidelines for Natural Ventilation. Since the building is a hostel and mess block, the natural ventilation is provided such that the building is comfortable without Air - Conditioning

2.3.1.2 Minimum Equipment Efficiencies

The project will meet all the minimum equipment efficiency norms under ECBC 2007 for Chillers, unitary AC systems, ceiling fans etc. The project is under design stage, the project will take the necessary measures to meet with ECBC 2007 while designing HVAC Systems.

2.3.1.3 Controls

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

2.3.2. Equipment and total system efficiency

Table 7: Equipment Efficiency

Equipment type	ECBC Recommended Efficiency	System Efficiency
Equipment 1 (Split ACs)	BEE 3 Star Rated	BEE 5 Star Rated

2.3.3. 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 8: 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	.38	13 mm

2.3.4. Condensers

The condensers 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.

2.3.5. Summary of Recommendations for HVAC

The project team was recommended to use chiller of COP greater than the COP given in Table 5.1 of ECBC 2007 reference if the building was going to provide central air conditioning system and install minimum BEE 3 Star rated split ACs. The project team was also recommended to integrate automatic controls for Chiller plant that can start and stop the system under different schedules for three different day-types per week, it should be capable of retaining programming in power loss for a period of minimum 10 hours and will have an accessible manual override for 2 hours.

2.3. LIGHTING

2.3.1. Mandatory requirement

The project do not need occupancy sensors in areas like corridors for hostel block as it is a 24 hours use mixed building. The occupancy sensors shall be provided for the office spaces of regularly occupied areas of less than 300m² in the hostel block.

2.3.2. Lighting Power Density

The project has gone for building area method to meet ECBC requirement of ECBC. The project will be using LED lights in all building. LPD of less than 10.8 W/m² will be maintained in the Hostel Block and LPD of less than 15.1 W/m² will be maintained in the Mess Block.

Table 9: Interior lighting power density in Hostel Block

SPACE TYPE	ECBC recommended LPD (W/m²)	LPD as per design (W/m²)
Dormitory/Hostel	10.8	9

Table 10: Interior lighting power density in Mess Block

SPACE TYPE	ECBC recommended LPD (W/m²)	LPD as per design (W/m²)
Mess	15.1	12

2.3.3. Lighting control

The project will be using occupancy sensors only in the common areas of mess block as mess block is usually occupied for only thrice a day during the meal time. The occupancy/motion sensors will be installed in the building which specify the accessibility of the occupant in the specific areas mentioned.

2.3.4. Exterior lighting detail

LED lights with minimum 80 lm/W shall be used for exterior lighting. Astronomical time switch will be used in the exterior lightings.

2.3.5. Exterior lighting control

Astronomical time switch will be provided for automatic control of exterior lighting. The astronomical time switch will provide maximum energy efficiency which will operate according to the time already defined.

2.3.6. Summary of recommendations for lighting:

- LPD of the proposed case in Hostel Block is 9 W/m² and LPD of the proposed case in Mess block is 12 W/m² as per Building Area method.
- Occupancy sensors will be installed in common areas like Toilets and Conference rooms.
- LED lights with min 80 lm/W shall be used in exterior lighting.
- Astronomical timers will be used in exterior lighting.

2.4. SERVICE HOT WATER HEATING

2.4.1. Hot water requirement in the building

The building contains 90 dormitories each consists of sharing of 6 persons. Assuming 6 persons per dormitory, there will be total occupancy of 540. Assuming a person will require 20 Liter of hot water per day, 10800 Liters of hot water will be required per day.

Table 11 : Hot Water Requirement Calculation

Building Type	No. of Dormitories	No. of persons in each dormitory	Total Occupancy	Water Requirement per Person Per Day (as per NBC)	Total Water Requirement
Hostel	90	6	540	20	10,800

The building will install evacuated type solar water heaters with capacity of 3000 Liters per day (27%) to meet the minimum ECBC requirement of 20% hot water through solar water heaters. The brand and model have not been selected yet. The model will be selected such that it has minimum efficiency level mentioned in IS 13129 Part (1&2).

2.5. ELECTRICAL

2.5.1. 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. The cut sheet of the transformer is placed at Annexure-3.

2.5.2. 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.

2.5.3. 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.

2.5.4. 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.

2.5.5. 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 conventional and proposed ECBC complied building. The total investment in the conventional building is Rs. 2,46,78,630.9 for the building systems coming under the scope of ECBC. As for the proposed building it is Rs. 3,91,86,880.75. The incremental cost of investment in energy efficient systems is Rs. 1,45,08,249.88.

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

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. The number of fixtures required in each building is calculated based on their respective LPD i.e 9 W/m^2 for hostel block and 12 W/m^2 for mess block. The detailed calculation of lighting cost is placed at annexure-5 along with cost analysis.

Table 12: Cost Analysis Table

S.No	Catagorey	Conventional Case	Proposed Case	Cost
1	**Wall**	230mm thick brick wall	25mm Plaster + 230mm AAC Block + 5 mm Airgap+115mm AAC Block Brick+12mm Plaster	
	Wall Area Sqm	4882	4882	
	Cost Per Sqm	1220	2841	
	Total Cost	5956040	13869762	7913722
2	**Roof**	Heat reflective paint + 35mm Screed + 85mm EPS board Insulation +150mm BBC +150mm R.C.C + 15mm Plaster	8mm Tiles + Brick Bllast + 85mm PUFF Inulation +150 R.C.C Slab + 12mm Plaster	
	Roof Area Sqm	1324	1324	
	Cost Per Sqm	3346	4700	
	Total Cost	4430104	6222800	1792696
3	**Fenestration**	Single Clear 6 mm thick glass	Double Glazed Unit(6 mm Glass + 13 mm Airgap + 6 mm Glass)	
	Window Area Sqm	1997	1997	
	Cost Per Sqm	6700	8000	
	Total Cost	13379900	15976000	2596100
4	**Lighting**	CFL Lights	LED Fixture	
	Total Cost	492586.875	1184118.75	691531.875
5	**HVAC**	Split AC	Split AC	
	Quantity Tonnes (TR)	14	14	
	Cost Per Tonne (TR)	30000	35000	
	Total Cost	420000	490000	70000
	Envelope			

	Air Leakage (Gasketing/Air Blower test for Swinging Doors and Revolving Doors and Fenestration)			
	Quantity (Running Metre)		3630	
	Cost Per Running Metre		100	
	Total Cost		363000	363000
	Envelope Sealing (Weather Sealing, Gasketing and Caulking)			
	Quantity (Running Metre)		3942	
	Cost Per Running Metre		100	
	Total Cost		394200	394200
	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)			
	Capacity (Liters)		3000	
	Cost (per Liter)		150	
	Total Cost		450000	450000
	Lighting Controls			
	Passive Infrared (PIR) based occupancy sensor with daylight control			
	Quantity (Pcs)		10	
	Cost		4500	
	Total Cost		45000	45000
	Exterior Lighting Controls			

	Astronomical time switch for street light			
	Quantity (Pcs.)		2	0
	Cost (per piece)		6000	0
	Total Cost		12000	12000
	Electrical Systems			
	Energy Metering		80000	80000
	Service Water Pump and Motors		100000	100000
	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	**24678630.9**	**39186880.75**	**14508249.88**

Capital Investment	**1,45,08,250**
Maintenance cost (@1%)	**1,45,082**
Total	**1,46,53,332**

*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.

4. ECBC COMPLIANCE FORMS

ECBC Compliance Forms has been filled and placed at Annexure 4.

5. APPENDIX:

- Annexure 1 : Architectural Drawings
- Annexure 2 : Calculations (SHGC, WWR, Wall & Roof Sections)
- Annexure 3 : Glazing Recommendation
- Annexure 4 : Compliance Forms
- Annexure 5 : Cost Analysis Report

**** End of Report****