

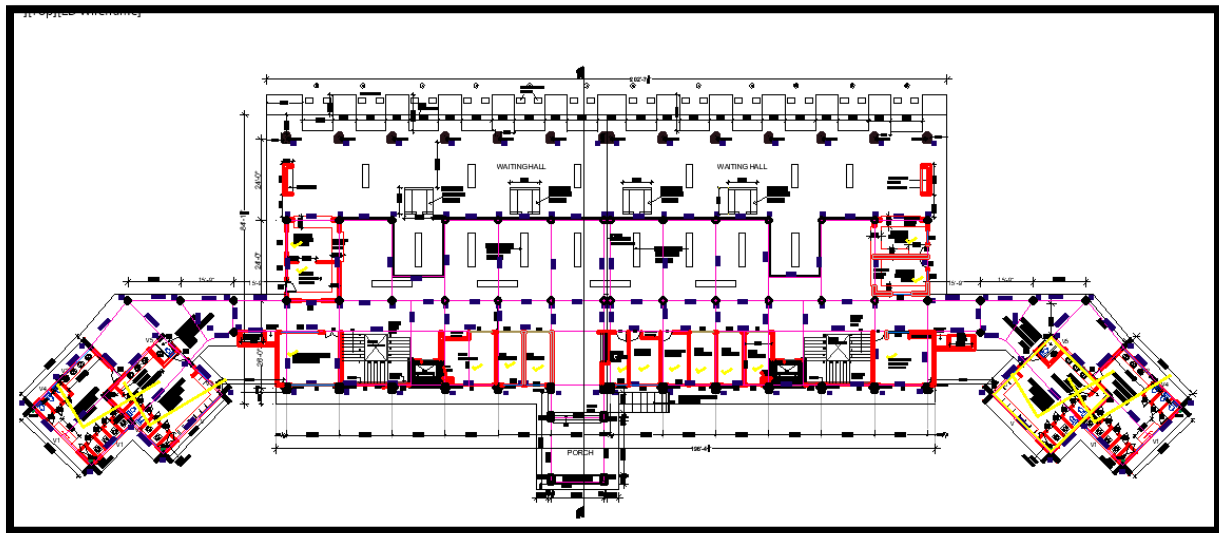


Empowered lives.
Resilient nations.



ENERGY EFFICIENT IMPROVEMENTS IN COMMERCIAL BUILDINGS

ECBC COMPLIANCE REPORT



12 Bays Bus Stand, Fatehabad
(Mixed Use Building, Composite Climate)



©United Nations Development Programme, 2017

Project Team

Haryana ECBC Cell,
Department of New and Renewable Energy (HAREDA),
Akshay Urja Bhawan
Institutional 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

1. EXECUTIVE SUMMARY	4
2. SUMMARY OF ECBC COMPLIANCE.....	5
2.1 ENVELOPE.....	5
2.1.1 MANDATORY PROVISIONS UNDER ECBC.....	5
2.1.1.1 U-Factors and Solar Heat Gain Coefficient	5
2.1.1.2 Air Leakage	5
2.1.1.4. Building orientation and massing.....	5
2.1.2 Building opaque envelope	6
2.1.3 Window wall ratio	7
2.1.4 Shading Recommendation.....	7
2.1.5 Glazing Recommendation	7
2.1.6 Recommendations for envelope.....	8
2.2. COMFORT SYSTEMS AND CONTROLS	8
2.2.1. Mandatory ECBC requirements.....	8
2.2.2. Building HVAC design and systems.....	9
2.2.3. Piping and ductwork.....	9
2.2.4. Condensers.....	9
2.2.5. Summary of recommendations for HVAC.....	9
2.3. LIGHTING	9
2.3.1. Mandatory requirement	9
2.3.2. Lighting power density	9
2.3.3. Lighting control.....	10
2.3.4. Exterior lighting detail.....	10
2.3.5. Exterior lighting control.....	10
2.3.6. Summary of recommendations for lighting.....	10
2.4. SERVICE WATER HEATING	10
2.5. RENEWABLE ENERGY.....	10
2.6. ELECTRICAL.....	11
2.6.1. Transformer	11
2.6.2. Motors (type, efficiency).....	11
2.6.3. Check metering and monitoring.....	11

2.6.4.	Power factor correction.....	11
2.6.5.	Power distribution system	11
3.	COST ANALYSIS AND FEASIBILITY REPORT	11
4.	ECBC COMPLIANCE FORMS	14
5.	APPENDIX.....	14

LIST OF TABLES

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

LIST OF FIGURES:

Figure 1:	Layout Plan.....	6
Figure 2:	Interior lighting power density	10

1. EXECUTIVE SUMMARY

BUILDING NAME	12 Bays Bus Stand
BUILDING TYPE	Bus Stand (Mixed Use)
LOCATION	Fatehabad
CLIMATIC ZONE	Composite
AREA, m ²	7,333.3
CONDITIONED AREA, m ²	5,250
OCCUPANCY TYPE	24 Hrs Use Building
Total Connected Load/ Contract Demand	-
ECBC compliance achieved	ECBC 2007 through prescriptive method
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	81,33,520
PAYBACK PERIOD (in years)	-
DETAILS OF CONTACT PERSON	B. B. Mehta, Senior Architect, Deptt. of Architecture Mob. No. 98141-45461

The 12 Bays Bus Stand, Fatehabad is a proposed 24 hrs use building. The building is being built by Haryana Roadways. The architectural plans of the building have been designed by Department of Architecture, Haryana. The execution work of construction will be done by PWD (B&R), Haryana. The building has G+3 floors which contains waiting hall, shops, offices, dormitories, waiting rooms and other general facilities. The total built up area of the project is around 7,333.30 sq. mts. The architectural plans of the building are placed at Annexure-1.

The project is under design stage and the project is targeting for ECBC during design stage. The project is using XPS insulation in roof, LED lights, occupancy sensors, and energy efficient Split ACs.

2. SUMMARY OF ECBC COMPLIANCE

2.1 ENVELOPE

2.1.1 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-m². Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m².

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 East- West oriented. The true North is shown in the below site plan.

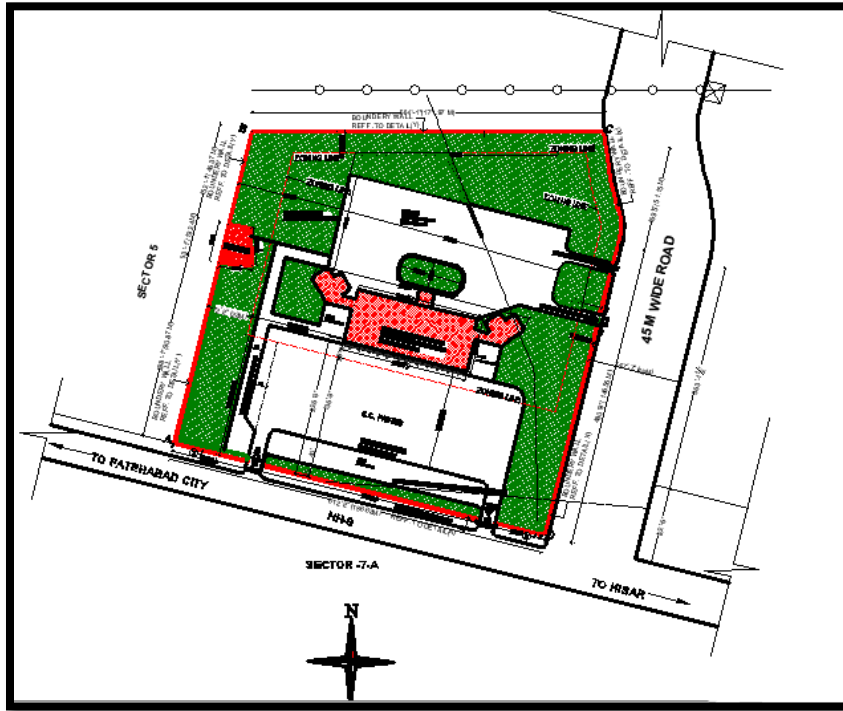


Figure 1: Layout Plan

2.1.2 Building opaque envelope

The project will go for double brick wall with 75 mm rockwool insulation. The U-Factor of the wall assembly will be maintained at 0.399 W/m² K.

Roof assembly consists of over deck 75 mm XPS insulation to meet the ECBC requirement of 0.261 W/m² K for 24 hrs use buildings. The U-Factor of the roof assembly will be maintained at 0.256 W/m² K.

Table 1: Opaque envelope specification

OPAQUE ASSEMBLY	Construction Layers	Specification
Ext. WALL assembly	Assembly layers: Innermost a) Plaster -12 mm b) Bricks - 115 mm c) Rockwool -75mm d) Bricks - 230 mm e) Plaster - 12 mm	U-value, W/m ² K: 0.399 Assembly thickness, mm: 444
Wall insulation	Type: Rockwool	R-value, K m ² /W: 1.875 Thickness, mm:75 mm

Roof Assembly	Assembly layers: Topmost a. White tiles - 8 mm b. Cement Screed - 50 mm c. XPS insulation - 75 mm d. RCC 100mm e. Cement Plaster - 12 mm	U-value, W/m ² K: 0.256 Assembly thickness, mm: 245 mm
Roof insulation	Type: XPS	R-value, K m ² /W: 3.57 Thickness, mm:75 mm

2.1.3 Window wall ratio

The Overall Window Wall Ratio is comes out to be 14.7%. The building has also used overhangs over windows in some directions in some sections of the building. Detailed WWR Calculations is placed at Annexure-2. Following is the brief summary of WWR calculations in four directions.

Table 2: Window wall ratio

FACADE	AREA, m ²	Opaque wall area , m ²	Glazed area, m ²	WWR
North	1831.9	1591.1	240.8	13.6%
South	1769.4	1418.2	351.1	19.2%
East	471.1	434.3	36.8	7.8%
West	471.1	431.8	39.3	8.4%
Total	4543.3	3875.4	667.9	14.7%

2.1.4 Shading Recommendation

The project was recommended to provide overhangs over all the windows in South and West directions. However they provide overhangs in all the directions to maintain uniformity. The projection factor is different in different directions and it ranges from 0.7 to 1.26. The detailed M-Factor Calculation is placed at Annexure-2 for all directions and different window types.

2.1.5 Glazing Recommendation

Since the project has WWR less than 40%. The project also has overhangs over windows. The project was recommended to use windows in all directions except North with SHGC less than 0.25. In North direction, glass of SHGC less than 0.27 shall be used. In other directions, glass of adjusted SHGC 0.5 can be used. The overall effective Solar Heat Gain Co-efficiency does not exceed 0.25. The detailed calculation SHGC sheet is placed at Annexure-2 and the spec sheet of the glass is placed at Annexure-3.

Table 3: Glazing recommendation

GLAZING ASSEMBLY	Specification	Incremental cost (compared to BAU)
Glazing type 1	Assembly layers: a. 6mm toughened glass b. 12 mm air gap c. 6mm Clear glass U-value, W/m ² K: 1.7 SHGC: 0.27 VLT: 38%	5,61,120 (Compared to conventional clear glass)
Glazing type 2	Assembly layers: a. 6 mm Coated glass U-value, W/m ² K: 5.4 SHGC: 0.5 VLT: 29%	2,40,480 (Compared to conventional clear glass)

2.1.6 Recommendations for envelope

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

- i) WWR – Window-Wall ratio is 14.7%
- ii) Roof - RCC with over deck XPS insulation.
- iii) Wall - Double AAC Block wall with Rockwool insulation in cavity to meet ECBC through prescriptive approach.
- iv) Glass – Double Glazed glass of SHGC shall be less than 0.27 for North, 0.5 for Non- North and VLT shall be more than 27%.
- v) Roof – High SRI tiles shall be used having capability of more than 0.7 SRI value.

2.2. COMFORT SYSTEMS AND CONTROLS

2.2.1. Mandatory ECBC requirements

2.2.1.1. Natural Ventilation

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

2.2.1.2 Minimum equipment efficiencies

The project will meet all the minimum equipment efficiency norms under ECBC 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 while designing HVAC Systems.

2.2.1.3 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^o C.

2.2.2. Building HVAC design and systems

The project is installing split AC and will take the necessary measures to meet with ECBC while designing HVAC Systems.

Table 4: Equipment Efficiency

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

2.2.3. Piping and ductwork

The piping for hot fluid less than 60° C temperature and cold fluid less than 15° C temperature, the insulation will have R value of 0.35 Sq. m. K/W or higher.

Table 5: Piping and ductwork insulation

System Description	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	13mm

2.2.4. 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.

2.2.5. Summary of recommendations for HVAC

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

2.3. LIGHTING

2.3.1. Mandatory requirement

2.3.1.1 Automatic Controls

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

2.3.2. Lighting power density

The project has adopted Space Function Method. The maximum LPD is maintained below the maximum allowed in ECBC in respective spaces. The calculations are as follows:

S.No	Building Type	Area, m ²	LPD (W/sqm) Baseline	LPD (W/sqm) Proposed	Wattage Baseline	Wattage Proposed	Equipment Wattage (W)	No of fixtures	Price / fixture (Rs)	Total Cost (Rs)
1	Toilets	856	9.7	8	8303.20	6848.00	18	380	50	19022
2	Shop/Clock Room	111	18.3	16	2031.30	1776.00	10	178	139	24686
3	Waiting Hall	512.5	5.4	4	2767.50	2050.00	10	205	100	20500
4	Office 1	41.8	11.8	10	493.24	418.00	15	28	174	4849
5	Office 2	1025.6	11.8	10	12102.08	10256.00	15	684	174	118970
6	Dormitories	64	11.8	10	755.20	640.00	18	36	110	3911
7	Officer's Room	97.5	11.8	10	1150.50	975.00	15	65	174	11310
8	Ticket Counter	23.6	16.1	14	379.96	330.40	10	33	98	3238
Total Amount										206486

Figure 2: Interior lighting power density

2.3.3. Lighting control

The project will install Occupancy sensors in areas like offices, conference rooms, toilets, corridors 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.

2.3.4. 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.

2.3.5. Exterior lighting control

Astronomical time switch will be provided for automatic control of exterior lighting.

2.3.6. Summary of recommendations for lighting

1. LPD of the building will be done as per the calculations.
2. LED lights with minimum 80 lm/W shall be used for exterior lighting.

2.4. SERVICE WATER HEATING

Since the building is an office building of a proposed Bus Stand, there is no requirement of hot water in the building.

2.5. RENEWABLE ENERGY

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

2.6. ELECTRICAL

2.6.1. Transformer

BEE 5 star 250 KVA Transformer has been selected for the proposed Building. The Transformer shall be selected with ECBC norms and the Energy Efficiency Level of the Transformer shall be selected based on IS-1180 with following Losses:-

Transformer Losses shall be as per IS-1180, Energy Efficiency Level-II (6.15KW / 18.5KW at 50%/100% loading respectively).

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. Check metering and monitoring

The project shall install smart meters that can display kVA, kWh, PF, current, voltage, THD. For Transformer Incomer Feeder & DG Incomer Feeder:- Schneider Make EM6400NG Series / Equivalent model.

For Outgoing Feeders: - L&T, make VEGA model-A / equivalent model.

2.6.4. Power factor correction

Automatic Power Factor Controller Relay shall be programmable microprocessor based to maintain the power factor between 0.95 and 1. Capacitor Bank: - Capacitor Bank shall be 525V with detuned reactors for control the harmonics in the system.

2.6.5. Power distribution system

ALL LT Power Cables shall be 1.1KV Grade, XLPE insulated, PVC sheathed, Armored cables (A2XFY). The size of the cables selected shall be decided as per the Load requirement duly consideration that the cable losses (heat losses) shall not exceed 1%.

3. COST ANALYSIS AND FEASIBILITY REPORT

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. 18687280.58 for the building systems coming under the scope of ECBC. As for the proposed building it is Rs. 26740271. The incremental cost of investment in energy efficient systems is Rs. 81,33,520 including maintenance cost @1%.

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 by space function method. Conventional building has 40 W CFL fixtures and proposed case has 20 W LED fixtures. The detailed calculation of number of calculation is placed at annexure-4 along with cost analysis.

Table 6: Cost Analysis

S.No	Catagorey	Conventional Case	Proposed Case	Cost
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	4543.5	4543.5	
	Cost Per Sqm	1220	1920	
	Total Cost	5543070	8723520	3180450
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	2066.4	2066.4	
	Cost Per Sqm	3346	4500	
	Total Cost	6914174.4	9298800	2384625.6
3	Fenestration	Single Clear 6 mm thick glass	Double Glazed Unit(6 mm Glass + 12 mm Airgap + 6 mm Glass)	
	Window Area	668	668	
	Cost Per Sqm	6700	7900	
	Total Cost	4475600	5277200	801600

5	HVAC	Split AC	Split AC/Fan Coil Units	
	Quantity Tonnes (TR)	50	50	
	Cost Per Tonne (TR)	32990	45000	
	Total Cost	1649500	2250000	600500
	Envelope Sealing (Weather Sealing, Gasketing and Caulking)			
	Quantity (Running Metre)		3942	
	Cost Per Running Metre		100	0
	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)			
	Lightings			
	Light Fixtures	104936	262051	157115
	Lighting Controls			
	Passive Infrared (PIR) based occupancy sensor with daylight control			
	Quantity (Pcs)		25	
	Cost		4500	

	Total Cost		112500	112500
	Exterior Lighting Controls			
	Astronomical time switch for street light			
	Total Cost		12000	0
	Electrical Systems			
	Energy Metering		250000	250000
	Service Water Pump and Motors		160000	160000
	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	18687280.58	26740271	80,52,990

Capital Investment	80,52,990
Maintenance cost (@1%)	80,530
Total	81,33,520

*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

The Compliance Forms are placed at Annexure-4.

5. APPENDIX

- Annexure 1 : Architectural Drawings
- Annexure 2 : Calculations (SHGC, WWR)
- Annexure 3 : Cut Sheets
- Annexure 4 : Compliance form
- Annexure 5 : Cost Analysis

End of the Report