COMPARATIVE ANALYSIS OF GRIHA CERTIFIED BUILDINGS

NAME	Saarrthi Sovereign	CISF Group Headquarters	Manipal Hospitals –Mangalore	Extension of Hostel 10 building at Indian Institute of Technology, Bombay	Hostel Block – 1 & 2 For Manipal Integrated Services Private Limited at Manipal County.	IIM Udaipur	ENGINEERS INDIA BHAWAN	South Asian University	Coal India Limited Office Building	Gandhi Research Foundation	University of Petroleum and Energy Studies, Dehradun
Location	Phase 2, Hinjewadi, Pune, Maharashtra	: Ahmedabad	Mangalore	Mumbai	Bangalore	Udaipur, Rajasthan	SIPCOT IT Park, Siruseri, Chennai	Maidan Garhi, New Delhi	Chennai	Jain Hills, Jalgaon	Bidoli, Dehradun, Uttarakhand
Site Area	18,030 m2	19360 m2	2,994.78 m2	5964 m2	25494 m2	1214550 sq.m	3944 m2	379122.6 sq.m	32330 SqM	9000 m2	1,08,717 m2
Built up Area	33,235.72 m2	2771.37 m2	15065 m2 including parking	43124 m2	13536 m2	155000 sq.m	10734 m2	344425.1 sq.m	132598 SqM	6,000 m2	33,787.34 m2
Air-conditioned Area	Nil		11642.73 m2	69 m2	6465 m2		5430 m2		132598 SqM	4,600 m2	11792 m2
Non Air- conditioned Area	33,235.72 m2		3422.27 m2	43055 m2	11020 m2		5304 m2		NA	1,400 m2	26476 m2
Typology	Residential			Residential			Commercial/Office				
Energy Consumption Reduction		60.93% over the Benchmark EPI					25.70%	21% below GRIHA LD base case	41.5% reduction from GRIHA benchmark	65% reduction in energy consumption compared to GRIHA benchmark	42.73% from GRIHA benchmark
Waste Reduction								100% Organic waste reduction			
Water Consumption Reduction								56.63% below GRIHA LD base case	50.7% reduction from GRIHA benchmark		33.16% from GRIHA benchmark
Energy Performance Index (EPI)	28.80 kWh/m2 /year	48.28 kwh/m2 /year	223.89 KWh/m2 /year	48.23 kWh/m2 /year	35.66 KWh/m2 /year		104 kWh/m2		186 kWh/SqM/year	41 kWh/m2 /year	35.22 kWh/m2 /year
Renewable Energy installation	None	5 kWp solar PV panel installation	20 kWp Solar PV installation	6 kWp solar PV panel installation	150 KWp Solar PV installation	2917.6 kwp	35 kWp Solar PV Panels	2000 kwp	12600 KWp	Rated capacity of solar PV installed on site is 20.24 kWp	100kWP
GRIHA provisional rating	3 Stars	3 Stars	4 Stars	4 Stars	5 Stars	5 stars	4 Stars	5 stars	5 stars	5 Stars	4 Stars
Year of completion	2016	2015	2015	2016	2015		2014			2013	
Strategies Adopted											
Sustainable Site Planning	• Measures were adopted for soil erosion control, preservation of fertile top soil, protection and preservation of existing mature trees on site. • The services have been planned to cause minimum site disturbance.	• Project is built on a densely vegetated site and priority was to preserve as many trees as possible.	• The only existing tree on site was protected during construction and additional plantation has been done along the site boundary post construction. • Air pollution control measures such as site barricading, coverage of dusty material and appropriate stack height of DG sets were implemented during construction to contain pollution.	• Hard paving has been reduced and landscape is interspersed between the building clusters to reduce the increase in outdoor ambient air temperature. • Sustainable Urban Drainage systems such as bio swales, retention ponds have been integrated to reduce peak run-off quantity.	• The project site is densely vegetated, thus minimizing the cutting of trees was a challenge. • Out of a 53 existing mature trees, 31 mature trees were cut and 22 trees were transplanted. The project has also planted 130 new trees and exceeded 25% than the requisite compensatory plantation requirement of GRIHA. • Sustainable Urban Drainage Strategies (SUDS) have been incorporated on site to manage storm water.	• Hard paving has been reduced and landscape is interspersed between the building clusters to reduce the increase in outdoor ambient air temperature. • Sustainable Urban Drainage systems such as bio swales, retention ponds have been integrated to reduce peak run-off quantity. • The site planning is in synchronization with the lake concept of Udaipur city	• Excavation and Construction activities were completed prior to monsoon season to prevent soil erosion and soil run-off from project site. • More than 73 trees were planted though the site was bereft of trees. • Utilities were planned in such a way that the on-site circulation efficiency was optimized. • Grass pavers are provided to reduce imperviousness of project site.	• Hard paving has been reduced and landscape is interspersed between the building clusters to reduce the increase in outdoor ambient air temperature. • Sustainable Urban Drainage systems such as bio swales, retention ponds will be integrated to reduce peak run-off quantity. • The project will preserve 69% of their existing site features	• Existing trees were preserved and transplanted along the periphery of the site • Excavation and construction started after the monsoon season to prevent soil erosion and soil run off from the site • Top soil was preserved and re-used to raise the ground level along the periphery • Service corridors are planned to cause minimum damage to the site and natural topography • Orientation of the building is east west but zoning of the building has been appropriately done to reduce negative impact of bad orientation	• The building blocks have been designed in accordance to the terrain of the site ensuring that there is minimum site disturbance. • All existing trees have been retained on site and are a part of the building post occupancy. • Minimum impact on environment is ensured by planting native trees, employing efficient storm water management, installation of pervious paving on site for more than 60% of the paved area, use of e-vehicles on site.	• Barricading of the site to prevent air pollution. • Existing trees preserved and native species of trees planted • Top soil preserved and protected for later use • Minimum damage to the existing topography of the site
Water management	• Reduction of 42.34% from the GRIHA base case has been demonstrated in landscape water demand through drip irrigation and planting native/ naturalized species. •100% storm water run-off from roof is being recharged into the ground through recharge pits •Reduction of 57.73% from the GRIHA base case has been demonstrated in building water demand through provision of low-flow plumbing fixtures and use of STP treated water for flushing through dual plumbing system.	1	• Construction water requirement was minimized by adopting curing and ponding techniques. • Potable water demand reduced by reclaiming 37.2% STP treated water for landscaping, flushing and airconditioning make-up water. • Reduction of 51.77% from the GRIHA base case has been demonstrated in building water use by installing water efficient flush systems and flow fixtures.	• The buildings are designed to be about 47% more energy efficient than GRIHA LD base case • Strategies such as ponding for curing of slabs, use of wet hessian cloth for curing of columns and use of curing compounds were adopted during the construction to ensure efficient water use during construction.	• A zero-discharge site has been achieved through managing water efficiently on site by reducing the overall water demand, efficient water reuse and recharge. • Reduction of 53.28% from the GRIHA base case has been demonstrated in landscape water demand through use of efficient landscape methodologies & native plant species. • Reduction of 58% from the GRIHA base case has been demonstrated in building water use by installing water efficient flush and flow fixtures.	• Project shall be utilizing 100% rainwater, which shall be collected in lakes/ and underground tanks, and will be used for various purposes including drinking after required treatments. • DEWATS system will be installed to treat the sewage generated on site. • All fixtures in the project will be low-flow	• High efficient drip irrigation has been utilized for irrigating landscapes which results in reduction of more than 70% of landscape water demand. • Reduction of 67% has been demonstrated on building water Use by installing water efficient flush and flow fixtures. • A 50 KLD capacity of Fluidized Bed Reactor is installed to treat waste water on-site and reuse for flushing, landscaping and cooling tower makeup.	• The project plans to reduce its annual water demand by 56.63% through reuse of treated waste water. • Three Phytorid Sewage Treatment Plants will be installed to treat the sewage generated on site. • All fixtures in the project will be low-flow.	• Reduction in building water consumption by use of low-flow fixtures : 50.7% • Water recycled and reused within the complex : 90% • Reduction in landscape water consumption by planting native species of trees and shrubs and by using efficient irrigation systems : 62.3%	• Native plantation and use of efficient irrigation system • Use of low flow and flush fixtures • Use of non potable water for landscaping	• Reduction in building water consumption by use of low-flow fixtures • 33.16% reduction in landscape water consumption by using native species and efficient irrigation systems • Waste water treated and re-used for landscape water requirement • More than 50% of the paved area topped with lose aggregate to allow penetration of water
Solid Waste Management						All organic kitchen waste shall be converted to Biogas. • All waste from campus will be segregated and sent for recycling through authorized recyclers	• Multi-coloured bins have been provided on floor level to collect and segregate waste at source. • A dedicated place has been provided on site to store segregated waste prior to dispose of. • Sludge from Sewage Treatment Plant is proposed to be used as fertilizer for landscapes	• The project plans to convert all organic kitchen waste into biogas. • All waste from campus will be segregated and sent for recycling through authorized recyclers. • E- waste and medical waste will be disposed of in compliance with the norms.	**Passive architectural design strategies adopted in the building:** • Thick stone and AAC block walls to reduce solar heat gain • Recessed windows to cut direct sun rays and glare inside the building • 99% of living areas are day-lit andwindowtowall ratio restricted to 25% to reduce solar heat gain inside the building		
Transport						• Site planning has been done to improve walkability in the campus through continuous and universally accessible footpaths. • E-rickshaws/Battery operated golf cart will be provided on site for intra-site movement. • Electric charging facilities will be provided for more than 10% of the total car and two wheeler parking slots.		• Site planning has been done to improve walkability of the campus through continuous and universally accessible footpaths. • Vehicular movement has been restricted to only residential and service areas. The core of the campus shall remain vehicle free. • Electric charging facilities will be provided for more than 10% of the total car and two wheeler parking slots.	Building performance as per audit report: **Energy:** • Energy generated through wind energy - 16,788,909 KWh/year. • Final EPI achieved - 71.52 KWh/m2/year. • Reduction inEPIfrompropposedcase–7.78%. • Thermal comfort ismet as perNBC 2005. • Lighting lux levels are met as recommended by NBC 2005. **Water and waste:** • Water test report indicates conformity to IS code 10500. • Total quantity of waste generated - Approx 12 Kg/day. **Noise level:** • Outdoor noise levels are within acceptable limits as per CPCB. • Indoor noise levels are within acceptable limits as per NBC 2005.	Building performance as per audit report: **Energy:** • Energy generated through wind energy - 16,788,909 KWh/year. • Final EPI achieved - 71.52 KWh/m2/year. • Reduction inEPIfrompropposedcase–7.78%. • Thermal comfort ismet as perNBC 2005. • Lighting lux levels are met as recommended by NBC 2005. **Water and waste:** • Water test report indicates conformity to IS code 10500. • Total quantity of waste generated - Approx 12 Kg/day. **Noise level:** • Outdoor noise levels are within acceptable limits as per CPCB. • Indoor noise levels are within acceptable limits as per NBC 2005.	Building performance as per audit report: **Energy** • Energy generated through solar PV - 127814 KWh/year. • Final EPI achieved - 34 KWh/m2 /year. • Reduction in EPI from proposed case - 45%. • Thermal comfort is met as per NBC 2005. **Water and waste** • Portable water test report indicates conformity to IS code • Treated water test report indicates conformity to IS code **Noise level** • Outdoor noise levels are within acceptable limits as per CPCB. • Indoor noise levels are within acceptable limits as per NBC 2005.
Social						• Site planning has been done to improve walkability in the campus through continuous and universally accessible footpaths. • E-rickshaws/Battery operated golf cart will be provided on site for intra-site movement. • Electric charging facilities will be provided for more than 10% of the total car and two wheeler parking slots.		• All construction workers will be provided with proper safety gear and equipment. • All construction workers will have access to clean drinking water, toilets and accommodation. • 20% of the landscape area will be used to grow food.			
Energy Optimization	• The Energy Performance Index of the project has been reduced by 71.20% below the GRIHA base case through envelope optimization, and integrating high performance systems.	• A 5 kWp solar PV plant is installed, which meets 100% indoor lighting requirement	• By adopting the abovementioned strategies, the project achieved a reduction of 50.25% in Energy Performance Index over the GRIHA base case.	• Energy Performance Index has been reduced by 51.77% compared to GRIHA benchmark	• 86% of the habitable spaces are day lit and meet the daylight factors as prescribed by the National Building Code of India. • All operable windows face the vegetated areas on site. • The Energy Performance Index of the project has been reduced by 58.05% below the GRIHA base case through envelope optimization, and integrating high performance systems. • Ambient temperature of 26 ˚ C ±1 ˚ C. is being maintained for 100% of the occupied hours. • The massing of the buildings was designed to enhance cross ventilation.	• The buildings are designed to be about 47% more energy efficient than GRIHA LD base case. • Street lighting is designed to be about 80% more energy efficient than the GRIHA LD base case. • Street lights shall be designed to meet minimum lighting requirements and will be installed with automatic switches.	• High efficacy lamps are installed for exterior lightings which have been operated by timer controller. • Double Glazing Windows with a Solar Heat Gain Coefficient of 0.18 used as Building Envelope. • Reduction of 25.7% from GRIHA established Energy Performance Index for office building has been demonstrated. • Water cooled chiller with high COP of 6.05 has installed for space cooling application. • ECBC mandatory criterions complied lighting, HVAC and electrical power system have been implemented. • 35 kWp Solar PV panels have been installed to reduce use of electricity from fossil fuel. • More than 50% of the living spaces is daylighted and meets the daylight factor as prescribed by National Building Code of India	• The buildings are designed to be about 21% more energy efficient than GRIHA LD base case. • Street lighting is designed to be almost 11% more energy efficient than the GRIHA LD base case. • Street lights will be designed to meet minimum lighting requirements and automatic switches will be installed.	• For achieving visual comfort n Energy efficient artificial lighting design is compliant with ECBC recommendations n Occupancy sensors in rooms to reduce energy consumption n External shading and efficient glazing to reduce solar heat gain and have glare-free daylight have been installed. • For achieving thermal comfort n Building envelope is ECBC compliant, which helps reduce cooling loads in AC spaces and meets thermal comfort levels in non AC spaces. n Centralized air conditioning through variable refrigerant flow technology is installed. Facility of controlling each indoor unit centrally as well as individually based on occupancy censor is provided.	o For achieving visual comfort: • Passive techniques like appropriate orientation of building, highly efficient envelope and mutual shading reduce the external heat gains • Integration of daylight in design reduces the requirement of artificial lighting. An overall of LPD of 0.4 w/sqft has been achieved in the building resulting to 61% savings. • Onsite renewable energy generation contributes to around 8% of total connected load of air conditioning and lighting. • Efficient day lighting design provides thermal and visual comfort levels in the building. • Good quality day lighting and views in classrooms and administration area. • Museum has been designed as per the special lighting requirements. o For achieving thermal comfort: • The building HVAC systems are designed tomaintain thermal comfort conditions based on the design criteria of NBC standards.	• 40% reduction in annual energy consumption as compared to a conventional building • 45% of the total area is day-lighted • External shading and efficient glazing systems to reduce solar heat gain and glare-free day-light • ECBC compliant energy efficient artificial lighting system • ECBC Compliant envelope to reduce space conditioning loads
Visual comfort	• Visual comfort: » Landscaped spaces are provided amidst the buildings to provide visual connectivity and ample daylight in the interior spaces. Adequate day lighting has been ensured inside more than 77.62% habitable spaces.	•Visual comfort: » Strong visual connection has been maintained between all the occupied spaces and public spaces. » 97% of the habitable spaces within the project are day lit. » All the openable windows face the vegetated area with in the project	• Visual comfort: » WWR of 13.11% has been achieved to create a strong visual connection between the building occupants and the outside environment. » 54.4% of the habitable spaces in the building are day lit and meet the daylight factors as prescribed by the National Building Code of India.	• Efficient lighting system has been installed in the building to ensure that the LPD levels are compliant with ECBC standards. • Box windows have been provided in the building which will help in reducing the effective SHGC of the windows & ensuring glare free daylight in the interiors	• Strong visual connection has been maintained between all the occupied spaces and public spaces.						
Thermal comfort	• Terraces, balconies, horizontal shading devices along with appropriate glazing have been provided to reduce 47.11% of direct solar heat gain.1		• Thermal comfort: » Double glazing with SHGC of 0.2 and horizontal shading devices have been integrated in the project to reduce the solar heat ingress. » Water cooled	• AAC blocks have been used for the construction of interior and exterior walls to ensure higher thermal insulation. • Mosaic tiles with high SRI (solar reflective index) have been laid on the terrace of the building to minimize heat gain through roof.							
Renewable energy	• Solar hot water system has been installed to offset 63.23% hot water requirement. Thus, reducing the consumption of energy generated from non-renewable sources.		• A 20 kWp solar PV has been installed which meets 16.24% of interior lighting requirement. • The installed solar hot water system is offsetting 56.17% of annual energy required for water heating.	• 6 kWp rooftop solar photovoltaic system has been installed, which caters to the common area lighting load. • Solar hot water system of 20,000 LPD has been installed on the roof top.	• A 150 kWp solar PV system has been installed for the project which meets 100% interior lighting requirement. • The installed solar hot water system is offsetting 73% of annual energy required for water heating.				• Installed capacity of wind energy : 12600 KWp • Units of electricity generated annually : 27900000 KWh	• Solar PV panels installed at GRF have an installed capacity of 20.24kWp, with an annual generation of 26199kWh. • 100% external lighting demand is catered by installed RE • 60% internal lighting demand is catered by installed RE	
Sustainable building materials	• 18.18% and 32.3% of cement is replaced with fly ash by weight in structural and plaster/masonry work respectively. • Materials such as wooden flush doors, Aluminum window frames and vitrified tiles having recycled content, low-VOC paints, adhesives and sealants have been used in interiors. • Steel having recycled content has been used. • Fly ash bricks have been used for wall construction.	• 30% of OPC has been replaced with fly ash (by weight) in structural and non-structural application. •Indoor air quality is maintained by using 100% interiors finishes with No VOC or Low VOC • All interior materials selected for the project have less carbon footprint. Block board doors and vitrified tiles with recycled content have been used.	• Sustainable materials such as gypsum board, mineral fiber and veneer finish for false ceiling; veneer, gypsum, laminate and MDF for paneling; vitrified tiles and granite for flooring; composite wood and laminate sheets for in-built furniture have been used. • Indoor air quality has been maintained by using 100% interiors finishes with no/low VOC content. • The embodied energy of the non-structural applications has been reduced by 48.6% by use of solid concrete blocks. • 26.3% cement is replaced with fly ash by weight in structural concrete	• AAC blocks have been used for the construction of interior and exterior walls • 42% of OPC has been replaced with fly ash (by weight) in structural concrete. • All wardrobe shelves are made of unpolished Kota stone. • Ceramic tiles with 8% recycled content have been used as flooring in all the habitable areas. • Flush doors with 17% recycled content have been installed in all the rooms. • Glass with 18% recycled content has been installed in all the windows	• 30% cement is replaced with fly ash by weight in both structural and non-structural application i.e. concrete and masonry work. • Materials such as gypsum board for false ceiling, glazed ceramic tiles for ceiling; kota stone, vitrified tiles and granite for flooring and flush doors made of block board and laminates have been used, all of which have low carbon footprint. • Indoor air quality has been maintained by using 100% interiors finishes with no or low VOC content.		• PPC is used for structural and plaster masonry application. • Flyash bricks and Autoclaved Aerated Concrete (AAC) blocks have been used in the project to reduce embodied energy of the building. • Use of low energy flooring, doors and windows		• Use of Plywood and MDF boards manufactured by Uniply, Greenply and Centuryply certified by SGS and recyclable fabric • Use of high density composite wood panels • Use of AAC blocks in the infill wall system	• Natural stone along with on site manufactured sun dried fly ash brick have been used for the block work. • The roof of the museum building is a pre-fabricated structure which has largely reduced the amount of concrete used in the building.	• Use of Portland Pozzolona cement in structural concrete to reduce embodied energy of the building • Use of low energy kota stone in flooring • Energy savings of 54% in structural application and 22% for non-structural applications.