Analysis of Sustainable Development of a Conventional Educational Campus: A Case Study

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Abstract –*Sustainable development is the development that meets the needs of the present without compromising the resources of future generations to meet their own needs. The necessity of using Sustainable technologies and methods into our everyday work environment, that is currently depending on conventional sources, has become so depleting that the future of the people as well as the planet depends on it. Focusing on the major sustainability related issues of a large Educational Institution, taking SaintGits College of Engineering, Kottayam (Kerala, India) as our study area, High Electric-Energy Consumption & Civil Lab Concrete Waste Management are observed and analysed. Using Integrative process of reducing economic & environmental impacts through material & resource management (Deploying recyclable construction materials unit), on site renewable energy (providing clean energy through Solar PVs), these sustainability issues can be handled. Installation of PV Panels (Solar PV through capture of sunlight), considering the tropical climate of the site, provides renewable energy source for the institution to meet more than 50% of its conventional current needs. The production of Recycled Aggregate Concrete from the Civil Laboratory-Concrete Waste is an efficient method to minimize waste production and recycle them to more usable products for various applications such as curb casting, internal partition walls and other construction works. We use the crushed aggregate of the civil lab- waste concrete instead of natural aggregate with suitable mix proportion to cast it and compare the compressive strength, to study about its use for future construction works in our college itself thus, leading to a 3R waste concept. With the estimations and comparisons made with the previous datas collected from the conventional method, we analyse the difference it makes and calculate the amount of energy and resources and their carbon foot print are also studied. We can thus, conserve and make the institution more Sustainable and Energy Efficient.*

Key Words: Sustainable, PV (Photo Voltaics), Recycled Aggregate Concrete, $C0_2$, Carbon Footprint ,Conventional Resources, Compressive Strength,

1. INTRODUCTION

Sustainable Development on conventional institutions is a demand made on the institution to shift from its conventional nature of existence to be more independent and more green. It delivers a long-term growth to enhance the structure more socially, economically and environmentally. A Sustainable Campus is an institution where eco-friendly practices and education combine to promote sustainable and energy efficient healthy space For the Campus individuals. The green campus concept offers an institution, the opportunity to take the lead in redefining its environmental culture and developing new paradigms by creating sustainable solutions to environmental, social and economic needs of the mankind. The Campus taken for Study and Analysis, SAINTGITS COLLEGE OF ENGINEERING, Kottayam(Kerala, India), established in 2002, (located: Pathamuttom, Kottayam 9°30′35″N 76°32′55″E)

Fig 1.Arial view of SaintGits College of Engineering

Based on the sustainability based problems related to the campus taken for study, the paper discusses about 2 phases, PHASE1:High Energy Consumption and PHASE 2:Civil Lab Waste Accumulation. This paper deals with study and analysis of these problems and adding a sustainable and efficient technique to shift its conventional reliability.

1.1 PHASE 1: CONSERVATION OF ELECTRIC-ENERGY (PV SOLAR PANELS)

SaintGits is a large institution that pays high amount of electricity, this paper will discuss about a proposal design for installing solar panels and whether the model has dealt with its energy-requirements using PV - Panels. Including the determination of rooftop area, estimation of the number & energy obtained from the panels and its comparison to the energy consumption by conventional method (Electricity from government sources). Installation of PV Panels (solar PV through capture of sunlight and piezo electricity), considering the tropical climate determining the sunlight hours and position for the locality.

Photovoltaics (PV) is the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry[5]. They are truly a sustainable and environmentally friendly method of producing energy. PV produces no atmospheric emissions or radioactive waste during use. PV electrical production also discharges no greenhouse gases, such as $CO2$, so it will help offset emissions that contribute to global warming. Photovoltaic technology is obviously an enormous environmental benefit. It represents a sustainable solution to our current energy requirements because the active material making up the majority of PV cells is silicon, which is readily available in sand. Also, the abundant energy a single PV generates over its lifetime could be used to produce more PV identical to it. Thus PV is a true breeding technology – it can reproduce itself sustainably over time while providing for society's energy needs. PV panels are made using this technology to conserve solar energy and convert it into electricity and they can be used to replace a huge amount of electricity produced by conventional means and since sun is a renewable and reliable source of energy, PV panels are an efficient source of electricity.

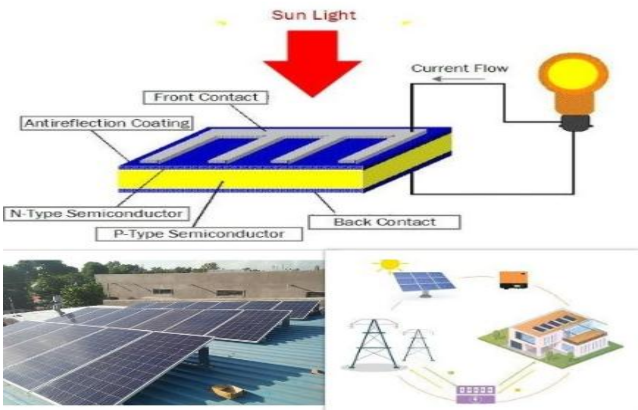

Fig 2 Solar PV Panels

1.2PHASE2:CIVIL-LAB WASTE MANAGEMENT (RECYCLED AGGREGATE CONCRETE)

Concrete cubes in SaintGits Civil laboratory accumulate each year and occupy a large amount of space in the labs before it is thrown out for disposal . Recycled Aggregate Concrete (RAC) is produced from the Civil Lab Waste, where crushed aggregate from the Civil lab Waste Concrete is used to make concrete products instead of natural aggregate, with suitable mix proportion and casting it and then compare their Compressive Strength with that of Natural aggregate and conduct a study on the use of this for future construction works in our college like curb casting, partition walls in staff rooms and other construction works inside SaintGits itself. This method proposes reduction, recycling and reusing of the Concrete lab wastes and converting them to a usable form of construction material for SaintGits Constructions.

Fig 3 curb casting & partition walls

1.3 CARBON FOOTPRINT - $C0_2$ BALANCE

The carbon footprint the amount of Greenhouse Gases (GHGs) associated with a product or service throughout its life cycle. Then, a product's carbon footprint consists of the LCA(Life Cycle Assessment) limited to the emissions that have an impact on global climate change. The property often mentioned as carbon footprint is that the weight, in kilograms or tons, of GHG emissions per person, product, or activity, that an emissions inventory is-required[2]. Variety of various tools exist for calculating the carbon footprints for individuals, businesses, and other organizations. Individuals and corporations can take variety of steps to scale back their carbon footprints and thus contribute to global climate mitigation. They can purchase carbon offsets to catch up on a part or all of their carbon footprint. If they purchase enough to offset their carbon footprint, they become effectively carbon neutral.

The research, published in Nature Energy, measures the complete lifecycle greenhouse gas emissions of a variety of sources of electricity out to 2050.

It shows that the carbon footprint of solar power is in many times lower than coal or gas with carbon capture and storage (CCS). This remains true after accounting for emissions during manufacture, construction and fuel supply.

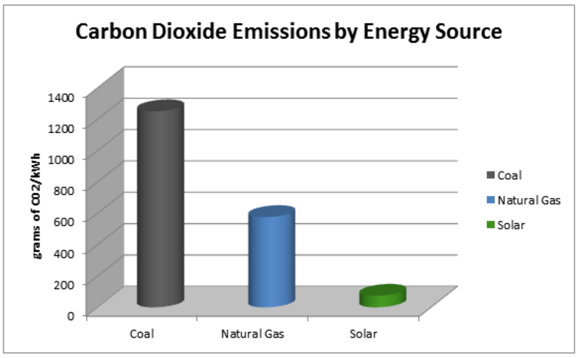

Fig 4. CO_2 Emissions by Energy Sour

Also studies after doing experiments on RAC suggests that CO_2-e emissions decrease slightly by increasing the percentage of recycled coarse aggregates in the concrete mixtures. The emissions due to factories producing natural aggregate, transportation, and the benefits being carbon-less demolished aggregate will be lesser than natural aggregate.

2. LITERATURE REVIEW

- Photovoltaics A Path to Sustainable Futures

Pearce et al. (2002) discusses[5] new trends for making an all-weather photovoltaic (PV) panel which can generate electricity from both sunlight and raindrops and can be applied in industries, buildings and for household purposes. The journal describes about hybrid devices that can harvest kinetic energy from water droplets without affecting the output of the solar cell during sunny times. In this paper the two devices of hybrid sunlight and raindrops, namely the Triboelectric Nano Generator (TENG) and Pseudo Capacitor Graphene Layer (PCGL) are reviewed, their advantages and disadvantages are also discussed . These devices continues to be developed as they need to be more compact and efficient to harvest sunlight during dry seasons and rainfall during wet seasons both for days and nights.

- Different Trends of Hybrid Solar And Raindrops Energies to Generate Photovoltaic

Suryati et al. (2019) states that[1] modern society is approaching physical limits to its continued fossil fuel consumption as both population and energy use per capita increase. The use of carbon based energy sources must be limited in order to attain sustainability in the near future. The problem of global energy expenditure can be partially solved by the application of photovoltaic panels. This shift in energy source, i.e. the application of photovoltaic technologies in both off-grid and on-grid has both benefits and limitations which are discussed in the paper. It is shown that photovoltaic electrical production is a sustainable, technologically feasible and environmentally benign solution to society's future energy requirements.

- Renewable energy technologies for sustainable development of energy efficient building

Chen et al.(2017) proposed that[2] sustainability assessment of buildings is becoming essential for sustainable development especially in the building sector all over the world. Even if the initial cost is expensive it seems to be in compliance with European and international commitments because the technology is very friendly one in environmental terms for buildings and urban applications. Also it helps in the growth of economy in most countries.

- Recycled Concrete as Aggregate for Structural Concrete Production

Malesev et al.(2010) studied[3] comparative analysis of the experimental results of the properties of fresh and hardened concrete with different replacement ratios of natural with recycled coarse aggregate is presented in the paper. Recycled aggregate was made by crushing the waste concrete of laboratory test cubes and precast concrete columns. Regardless of the replacement ratio, recycled aggregate concrete (RAC) had a satisfactory performance, which did not differ significantly from the performance of control concrete in this experimental research.

- Renewable energy technologies for sustainable development of energy efficient building

Kaushik et al.(2018) mentions about[4] a new office building which offers different way to reduce the building consumption. The paper studies regarding the relationship between CO_2 equivalent emissions from embodied energy from building materials and CO_2 equivalent emissions from energy use, also how they should be treated. The result showed decrease in the emission of both primary energy use and co2 equivalent emission. Especially reducing the electricity consumption by replacing with fossil fuels results high decrease in the emission of both primary energy use and CO_2 emissions. The lowest CO_2 equivalent emissions were achieved when bio-based, renewable energies or

nuclear power was used to supply energy for the office building.. The lowest primary energy was achieved when bio-based local heating or renewable energies, in addition to district cooling, were used. The highest primary energy was for the nuclear power option.

- Carbon Footprint of Recycled Aggregate Concrete

Jim´enez et al.(2018)In this paper[6], carbon footprint was used to compare the environmental performance in the production phase of a concrete made with both recycled and crushed virgin limestone aggregates, using a life cycle analysis methodological approach. Research outcomes revealed, as expected, that carbon dioxide equivalent emissions decreased slightly as the use of recycled aggregates increased.

3. METHODOLOGY

3.1 PHASE1: CONSERVATION OF ELECTRIC ENERGY (PV SOLAR PANELS)

3.1.1 SCENARIO OF SOLAR RENEWABLE ENERGY ON SITE INSTALLATION

Installing a rooftop solar system requires solar panels which are an assembly of photovoltaic cells (solar cells), an inverter, AC/DC switches and electrical conduit. Rooftop solar panels can be easily mounted on the roof of buildings to harness solar energy. Rooftop solar panels are installed on the roof and come with a service life of 20-25 years.

Here, choosing site Saintgits College of Engineering (India, Kerala),with an average of 4-6 Lakh Rupees for Electricity Bill , the monthly average electricity billing records an energy consumption (kwh) of 50,000-60,000 units , an average Maximum Demand of 200 kVA units is recorded (2019) ,average power factor(pf) for the utility is 0.98 .

Fig 5. Roof top view (saintgits campus)

Based on the Design Analysis conducted using PVSYST V6.86 ,The following methodology is a design proposal for the installation of a Roof-top Solar plant , analyzing the generation potential ,energy production estimates and sustainability impact assessment (carbon footprint).The Design is based on the following parameters :

- **SATELLITE BASED MAPPING OF ROOFTOP SPACES**

Before installation, the condition of the rooftop is made sure is safe and suitable for the solar panels to fit in. Furthermore, roof has enough space to support the installation. It should also be shade-less so that maximum sunlight can be trapped during the daytime with no shadings. So Here, we have chosen the suitable roof area for the installation as shown in fig.6

- **Slope of the roof**

The slope is necessary to facilitate the drainage of water during the rainy season. Ideally, a north facing roof is preferable as rooftop solar panels installed in such a roof will generate the maximum amount of electricity. Additionally, the inclination of the roof should be in the range of 10 to 30 degrees to allow proper drainage of rainwater and removal of debris. -Here, Plane is oriented using a tilt of 30° ,Azimuth 0°

- **Load profile / Energy assessment of buildings of the institution**

Towers of the institution have varying needs based on the load profile and machineries (Laboratory, Workshops, lathe etc). The Load Calculations for the buildings are estimated through survey(energy consumption of lighting and fans)

- **Estimation of Required Number of Panels**

The required number of panels required to suffice the energy needs of a building is based on the available rooftop area ,spacing factors, shadings if any. There are two types of rooftop solar panels popular in India - monocrystalline and polycrystalline solar panels. A monocrystalline solar panel is made of a single crystal of silicon while a polycrystalline solar panel is made of multiple crystals of silicon. Both of these have their advantages and disadvantages. For the Design , we are using SI-polycrystalline solar panels .

Fig 6. Top view of roof areas to install panels (google maps)

3.1.2 CARBON FOOT PRINT OF SOLAR PANELS

The reasoning behind the Carbon Balance Tool is, that the electricity produced by the PV installation will replace the same amount of electricity in the existing grid. If the carbon footprint of the PV installation per kWh is smaller than the one for the grid electricity production, there will be a net saving of Carbon Dioxide emissions. Thus, the total carbon balance for a PV installation is the difference between produced and saved CO2 Emissions. Even at this top end, however, solar's footprint is very low compared to other sources.

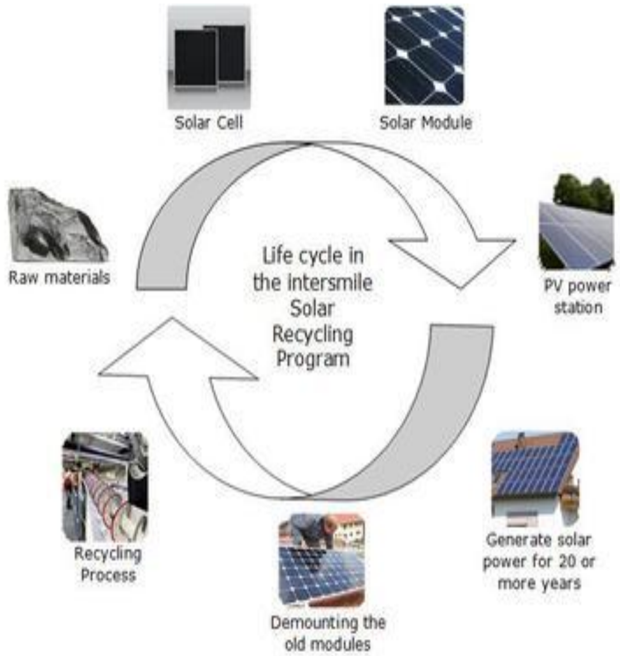

Fig 7. LC Of Solar Panels-1

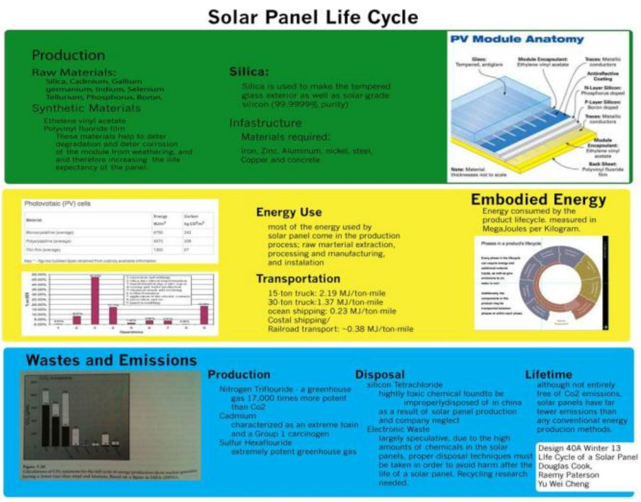

Fig 8. LC Of Solar Panels-2

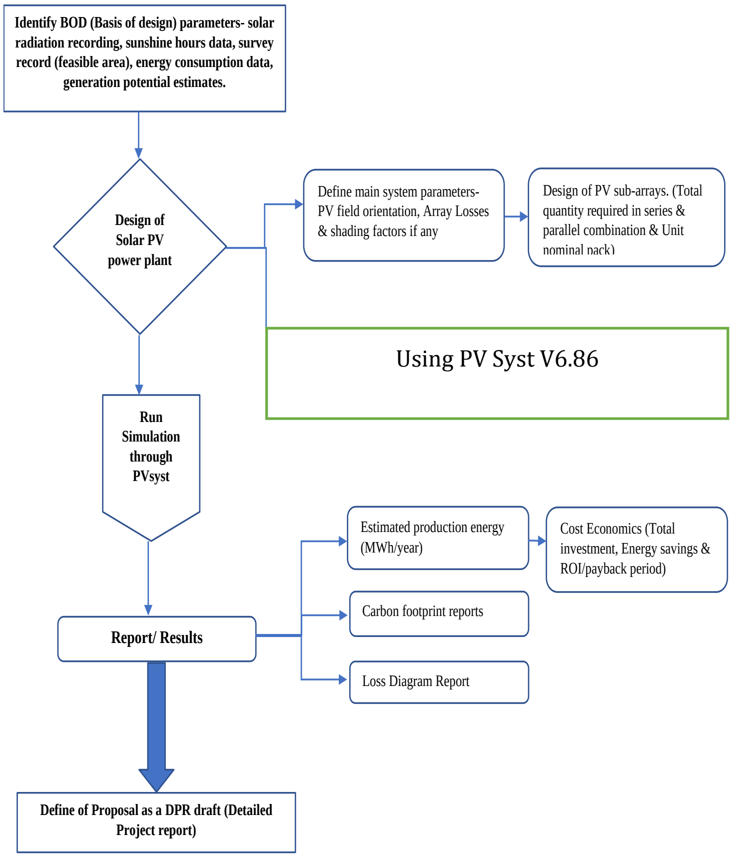

Fig 9. Flow Diagram of the Renewable Energy Design.

3.2. PHASE 2: CIVIL LAB WASTE MANAGEMENT

The major waste produced from labs are concrete wastes. There are various methods for recycling and reusing these wastes. The concrete wastes such as the concrete cubes, cylinders and beams cast for different experiments in the labs can be recycled and used to produce Recycled Aggregate Concrete (RAC). This method replaces natural aggregate with recycled aggregate produced from concrete waste. RAC shows satisfactory performance compared to ordinary concrete in most characteristic properties.

In the last decades, a reduction of natural resources consumption within the production of aggregates through concrete debris recycling has been sought, in order that new aggregates are obtained which replace the usual aggregates coming from the crushing of virgin limestone, which even offers economic advantages, because when comparing costs of recycled aggregates with normal aggregates, savings of almost 4USD (26%) per m3 of aggregate and almost 6USD (9%) per m3 of concrete are often obtained.

Fig 10. Concrete lab waste

3.2.1 AN OVERVIEW OF AGGREGATE PROCESSING

The first stage of aggregate processing involves quarrying, where a large deposit of desirable aggregate is identified and extracted from the ground. Hardened substances are either blasted or cut into smaller manageable sized rubble and transported by truck or conveyor belts to the processing area. The advent of recent blasting methods brought an increase in the number of quarries, which are now used throughout the world, wherever competent bedrock deposits of aggregate quality exist. In many places, good limestone, granite, marble or other quality stone bedrock deposits don't exist. In these areas, natural gravel are mined to be used as aggregate. Where neither stone nor gravel, are available, construction demand usually satisfied by shipping in aggregate by rail, barge or truck. All these methods increases the cost of aggregate, and this is where recycled aggregate plays a vital role. Trucking aggregate more than 40 km is typically uneconomical.

Fig 11. Initial stage of before crushing the waste aggregate.

At the processing site, the aggregates are fed through a crusher. In most cases, a plant will have a primary crusher, which reduce the size of the quarried rubble to about six inches in circumference. The product from the primary crusher is then screened for larger usable products. The remaining material is transported by a conveyor belt for secondary crushing and screening which separates the aggregate into more usable products. Finally after tertiary crushing, the aggregate screen with- single, double, and triple deck configurations – allow for quick identification and separation of variously sized aggregate for use in concrete. These are capital intensive operations, utilizing large earth- moving equipment, belt conveyors, and machines specifically designed for crushing and separating various sizes of aggregate, to make distinct product stockpiles.

All these uneconomical and unsustainable practices of extraction and transpotation of aggregate, can all be avoided in case of recycled aggregate and the only place where we need an investment is for a specially designed crusher.

3.2.2. PROCEDURE FOR MAKING RAC (M20 GRADE) FROM SAINTGITS CIVIL LAB WASTE.

- Recycled aggregate is made by crushing the waste concrete of laboratory test cubes.
- It is generally produced by two-stage crushing of demolished concrete
- The cubes are crushed into sizes in required limit.
- Then this is sieved and 20mm crushed aggregates are separated.
  - This aggregate replaces natural aggregate (100% replacement) and is used to produce recycled aggregate concrete.
  - For casting 3 cubes of M20 grade (1:1.5:3)
    - ➢ Total volume of 3 cubes considering the 10% loss = 0. 01113m3
    - ➢ Total mass = volume/ density of concrete =0.01113/2400 = 26.73kg
    - ➢ Wt. of cement = 4.86kg
    - ➢ Wt. of fine aggregate = 7.29kg
    - ➢ Wt. of coarse aggregate = 14.58kg
    - ➢ For 0.4 water cement ratio, water required = 1.94litres.
  - Three cubes using crushed aggregate and three cubes using natural aggregates are casted.
  - All these samples were cured for 28 days.
  - Then the compressive strength tests of these six samples are carried out.
  - The test results are compared and it shows satisfactory performance.

3.2.3. QUANTITY ESTIMATION OF LAB WASTE PRODUCED IN THE LAB PER YEAR

Table 3.2: Lab waste estimations

Mould	No.	Dimension (mm)	Volume (m3)
Cube	3	150x150x 150	0.0101
Cylinder	3	150x300	0.0424
Beam	2	150x150x 700	0.0315

Total Volume = 0.084m3

No. of groups = 32

Therefore, total volume of concrete = **2.688m3**

3.2.4. CARBON FOOT PRINT OF RECYCLED CONCRETE

Carbon footprint is one among the foremost widely used tools for assessing the environmental impacts of production and utilization of concrete also as of the components derived from it, representing the amount of CO2 and other greenhouse gases related to this product, expressed as CO2 equivalents. Carbon footprint was used to compare the environmental performance within the production phase of a concrete made with both recycled and crushed virgin limestone aggregates, implementing a life cycle analysis methodological approach.

However, in sight of the range and variability of the recycled aggregates' properties, there's a lack of consensus regarding the concrete's behaviour when this type of aggregates is used, so it is necessary to evaluate the feasibility of using them from an environmental perspective, which can be achieved through the application of a lifecycle assessment (LCA) methodological approach.

An important tool to gauge the environmental impacts generated by the concrete production and its components within the LCA methodology is that of carbon footprint. The fact that it not only is a sustainable construction product but also upto 29% CO_2 emissions ,over 29% water absorption is reduced.20% compressive strength and 340% electrical enhancement is improved with better quality of raw materials added to it.

Research outcomes revealed that CO2 equivalent emissions decreased slightly as the use of recycled aggregates increased. It was also corroborated that cement is the material with the greatest influence on greenhouse gas emission generation within the concrete's production phase, no matter the utilization of recycled or virgin aggregates. According to studies on Carbon emissions of Recycled Concrete[6], carbon emissions are reduced for fine aggregate to 19%, for natural coarse 42% and for Recycled coarse 39%.

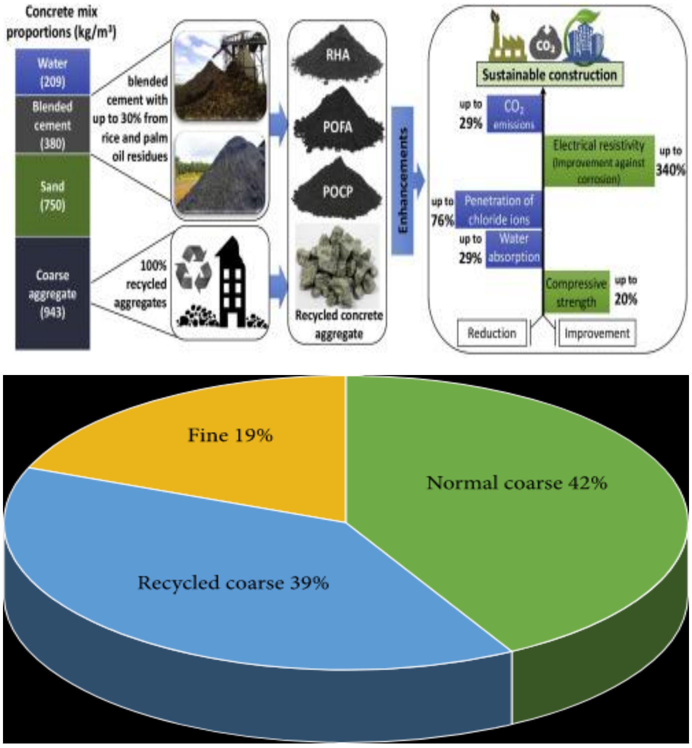

Fig 12. C02 emission system for the concrete production and comparison by recycled aggregate type

From the location of the campus, we can save carbon offsets and also economically, by minimising or deducting from transportation sector, industrial sector and produce the carbon less content for the campus constructions .The greenhouse gas emissions could be reduced by its replacement, by eradicating waste as well as, pollution caused by the waste.

4. RESULTS AND DISCUSSIONS:

4.1 Phase1: Feasibility Analysis for Installation of Rooftop Solar PV at Saintgits

From the Design constructed by PV syst V6.86 , we circulate the values of the design , for the installation of the Rooftop solar PV Panels, for the location of Saintgits College .

The table below shows the result of the estimation and the calculation by the basic design of the required and suitable solar panel model to be installed in the campus, depicts the rooftop area, feasible area, installation capacity, annual energy production, carbon offset generated, total cost of installation and the annual savings.

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Table 4.1: Feasibility Analysis For Installation Of Rooftop Solar Photovoltaics At Saint Gits Institute``

	Building Ref	Total Rooftop Area (m2)	Area Feasible (m2)	Installation capacity (kW)	Annual Energy/production estimated (kWh)	Sustainability/Carbon offset generated (CO2-e in Kg)	Average cost of Installation (in Lakhs- Rs100/w)	Total Cost of Installation (in Cr)	Total Annual savings estimated (Rs 5.50/kwh)
1	CLC 1.0	150.00	112.50	11.25	25458.75	21639.94	1125000	0.11	140023.13
2	CLC 1.1	150.00	112.50	11.25	25458.75	21639.94	1125000	0.11	140023.13
3	RAMANUJAN BLOCK	700.00	525.00	52.50	118807.5	100986.38	5250000	0.53	653441.25
4	VB BLOCK	300.00	225.00	22.50	50917.50	43279.88	2250000	0.23	280046.25
5	WORKSHOP BLOCK	100.00	70.00	7.00	15841.00	13464.85	700000	0.07	87125.50
6	HOSTEL-1	300.00	225.00	22.50	50917.50	43279.88	2250000	0.23	280046.25
7	HOSTEL-2	300.00	225.00	22.50	50917.50	43279.88	2250000	0.23	280046.25
	Sub total	2000	1495	150	338318.5	287570.73	14950000	1.50	0.19

General Estimations

Total Technical Estimations	Unit		Total Financial Estimates	Unit	
Total feasible area of Installation	m2	1495.00	Total Cost of Installation (Rs)	Cr	1.50
Total PV Installaiton capacity feasible	kW	150	Annual average savings estimated in Rs (*Subsidies on the faclility annual billing through grid connected system solar system feeding KSEB & other in house load consumption using renewable energy)*	Cr	0.19
Total annual average energy production	MWh	338.32			
Total number of panels required (*Assuming 250wp Tata power PV model)*	Nos	600	ROI (Return of index)/Payback period	Years	8.03
Annual average carbon sinks/offset generated (*Sustainability accounting, CO2-e*)	Tons	287.57	Cumulative annual net profit (after payback) considering a PV life span of 25 years @ 10% depreciation in Rs	Cr	2.28

References

1 *Average area required for installation of 1Kw solar PV considering sufficient spacing for shading -10m2 (Energy alternatives India, EIA- http://www.eai.in/ref/ae/sol/rooftop/area)*

Average sunshine hours in kerala for annual solar yeild production estimation- 6.2hours (Meteorological data, MNRE, India)

CO2 produced per Kwh of energy from Indian power sector- 0.8Kg/Kwh (Coal based power plants, Natinoal electricity plan-erpc.gov.in › 2018/06 › carbon-emissions-from-power-sector-7062018)

Average cost of PV Installation as a rule of thumb- Rs 70-100/w as per quality requirements.

KSEB electricty rate- Rs3.50-7.50/Kwh (Assuming offseting Rs5.5/kwh using solar PV or contractual based subsidy rate per Kwh of solar energy in lieu with KSEB norms & policy.

1 *The National Renewable Energy Laboratory found in a 2012 study that solar panel output falls by an average of about 0.8 percent annually & depreciates 10% on assets, MNRE, India.*

(provided in the Appendix)

From the analysis, the total cost of installation for 600 Panels at 1495m² is 1.50 Cr ,with savings after grid system it is estimated to be 0.19Cr ,which can be saved in a duration of 8.03 year Payback Period.

4.1.2 Energy data analysis

As mentioned earlier, from an average of 50,000-60,000 (KWH) units monthly(5,50,000 KWH) ,the solar panels according to the design depicts 3,38,320 KWH units, which is 62% of the total annual average energy production.

Let us Assume, this 62% along with its losses are allowed to supply energy for the lighting and power circuits for most of the institution. According to the following table :

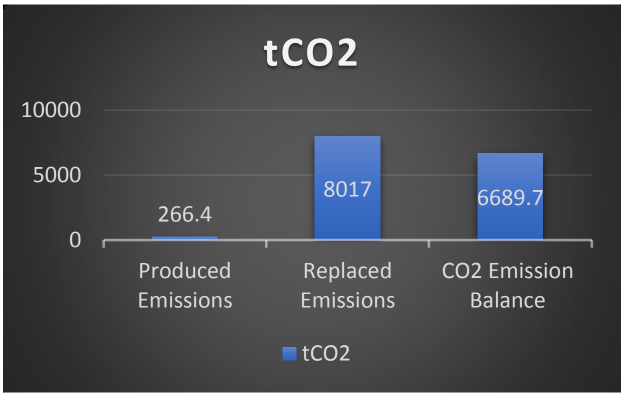
TABLE 4.2: Building Load profile energy consumption estimations-

Sl no	Buliding Ref	Types of connected Load	Qty	Per Unit wattage	Connected load (Kw)	Monthly Units (Kwh)	Annually Units (Kwh)
1	HOSTEL	Fan load circuits	180	75	20.30	3240	33048
		Lighting & power circuits	170	40		1632	16646
2	VB	Fan load circuits	115	75	15.03	2070	21114
		Lighting & power circuits	160	40		1536	15667
3	CLC	Fan load circuits	180	75	20.30	3240	33048
		Lighting & power circuits	170	40		1632	16646
4	RB	Fan load circuits	115	75	15.03	2070	21114
		Lighting & power circuits	160	40		1536	15667
5	WORK SHOP	Fan load circuits	115	75	15.03	2070	21114
		Lighting & power circuits	160	40		1536	15667
Total annual average energy consumption of the connected general distribution load for the institution in Kwh							209732.4
Total annual average energy generation produced by installation of the solar rooftop plants located on each of the building ref as mentioned in Kwh							338318.50
Total average energy that can be offset using renewable energy sources annually in percentile							62%

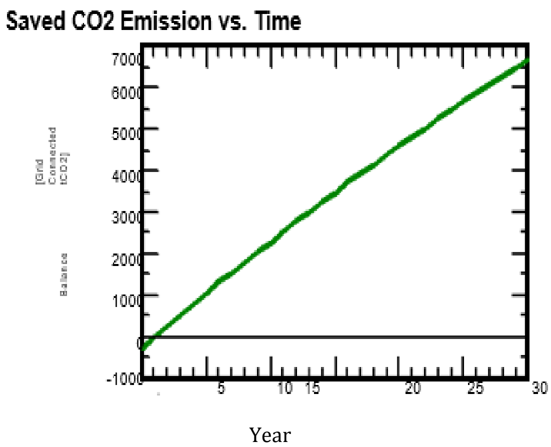
From the above table, the Total annual average energy consumption for the institution is 2,09,732.4 kwh.The renewable energy source has a potential of 3,38,318.50.Hence, it can offset around 62% of the institutions energy demand (building loads) annually. Thus, using the economic and environmental impact .

The annual average Carbon offset generated but the design model is around 288 tons, which is very low and is therefore making the campus sustainable.

Simulation results by PVSYST V6.86 identifies the CO_2 offset in tons-equivalent.



CO_2 Emission Balance : 6689.7 tCO_2



The installation cost is high, but in 8.03 years the loss is regained and the institute is sustainably energy efficient.

Estimations taken from the design, calculated energy consumed in the building, and the overall energy estimated over the peak month, Savings made are estimated and further savings can also be done. As per our roof space, so options for installation and reduced college electricity billing are-

1. Provide all solar generating energy to KSEB and avail subsidy/ deduction in monthly billing.

2. Take a percentage of PV power (say 20-30%) for college needs and send rest to KSEB, ALSO reduces overall billing.

Hence, Phase 1 is successful and can make the campus energy efficient and sustainable in a period of 8.03yrs.

4.2. Phase 2: Compressive test on recycled aggregate concrete.

Compressive Test is conducted on the Recycled Aggregate Concrete sample, and tested using CTM , over 3 samples and their values are noted and compared to that of Natural Aggregate Concrete.

FIG 14. CTM-Compressive test done on the RAC

- The test results shown below gives satisfactory data regarding the strength of the cubes.
- So, we expect the same for higher grades too and hence this recycled concrete can used for all the construction works in the campus.

Table 4.3: Test Results:

	Load at failure (KN)		
	Sample 1	Sample 2	Sample 3
Cubes with natural aggregate	430	500	450
Cubes with recycled aggregate	450	470	450

From the above table, the average load at failure for cubes with natural aggregate is 460KN and that for cubes with recycled aggregate 456.66KN. This shows that recycled aggregate concrete possess sufficient compressive strength.

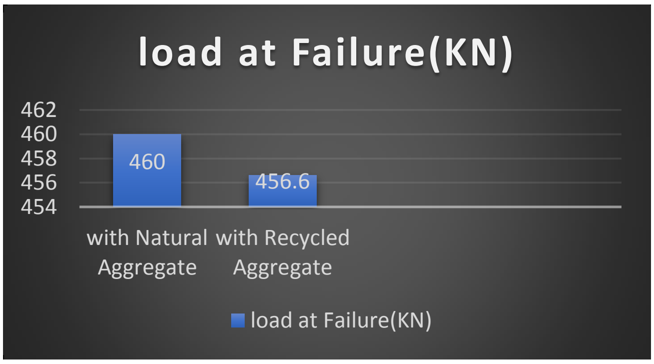


Fig 15. Load at failure

From the table, it is evident that RAC from SaintGits Civil Lab Waste, has proved to be much/equally stronger than Natural Aggregate concrete. Hence, Phase 2 is successfully a sustainable and a Solution to the waste management.

5. CONCLUSIONS

Through this project we have accomplished the following:

- An Eco-Friendly and Energy sustaining institution.
- Reduce, recycle and efficient use of wastes from labs.
- Reserve electricity via inexhaustible energy means.
- Reduce conventional electricity resources.

In the perspective of a future Civil Engineering, it is necessary to bring sustainability in action towards buildings and building materials. The pollution rate is getting high every day due to the industrial action mostly which means if engineering is not based on sustainability, we face serious danger in our living. We need to use more of our technology to lead the energy dependent lives of ours more dependent on renewable sources.

So, in this project, we dealt with two phases where we can put sustainability to become more productive.by using solar panels we have achieved a renewable source of energy which is technically economical and environmentally free. The recycled concrete not only reduces the waste content, but have produced more elements to construction bringing the three R's concept, where we have reused, recycled and reduced the existing wasted concrete to another resourceful concrete.

Further suggestive mode of upgrading the mentioned techniques includes:

Adopting Hybrid panels , which is also a better solution for electric energy Production. These panels can be used to power all the fans and lights in the institution which cuts down the electricity bill to a large extent. In Kerala, especially being a state of Tropical climate, these panels become more beneficial and we can further move to the advanced technology of adopting hybrid panels which can derive energy from sun, rain geothermal etc. So in the future, we can adopt these hybrid panels with much more technology integrated to make our buildings more environment friendly and energy -efficient.

Also the installation cost can be reduced by investing with private sectors or government by grid system, trading off energy consumed that is when the consumption of the host is settled. This way the most important problem that stands in the cost of installation can be dealt, also other sectors can profit the use of renewable energy too.

Building materials, like concrete, are increasingly being questioned for their environmental impact; because construction and demolition waste is a major component of all the waste generated by the construction industry, and to scale back the pressure on the exploitation natural resources, industry has focused on finding greener ways to produce concrete, encouraging the utilization of recycled materials to replace virgin materials.

The results prove that Recycled Aggregate Concrete is the best solution for reducing and reusing concrete lab waste.

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