ARCHITECTURE follows the SUN

PROF. DR. ARVIND KRISHAN

Former Dean & Head Dept. of Architecture School of Planning & Architecture New Delhi
Currently: Principal Architect: Center for Architectural Systems Alternatives, New Delhi
arvindkrishan@vsnl.com & arvindkrishan@gmail.com
Web: http//www.arvindkrishan.com

ABSTRACT:

Sun is a regenerative resource that has fed the ecosystem of planet Earth for ever**. In this moment of environmental crisis, when the eco-system and very existence of life is threatened, **Sun provides the only hope. It is perhaps the only source of energy that can meet the needs and aspirations of humanity. Therefore the challenge for contemporary design is to use the regenerative solar spectrum and design a sustainable habitat within the capacity of the finite eco-system that is our Mother Earth., without creating a destructive cycle of the eco-system ?

***KEYWORDS**: Architecture, Sun, Architectural Design*

INTRODUCTION

Therefore can the **building envelope** be **generated in response to perceived motion of the Sun**? It is therefore appropriate to define it as a **SOLAR ENVELOPE. Entire building envelope becomes a receptor, converter, storage and dissipater of solar energy.**

SOLAR ENVELOPE CAN BE DESIGNED WITH COMPONENTS RESPONDING TO

- **Produce direct electrical energy through Photovoltaic panels.**
- **Distribute day-light, within the building, creating a healthy day-lit environment and open spaces.**
- **Create ventilation: through convection created by Solar Chimneys.**
- **To cool or heat the building, when coupled with earth tunnels using the thermal inertia of the earth and 'Trombe' walls,**

Since perceived motion of the Sun is curvilinear (Fig.1.0), one wonders <u>why do buildings get designed as one form of cuboids or another ?</u>

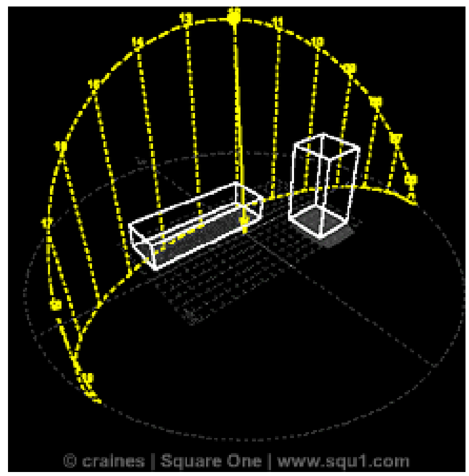

Fig.(1.0) Perceived Solar Geometry: A curvilinear phenomenon

<u>DESIGN CHALLENGE : IN A COMPOSITE CLIMATE, CONTEXT,</u>

For PEDA Office building project at Chandigarh, India,. A three dimensional configuration of the building in response to the perceived motion of Sun. was evolved.

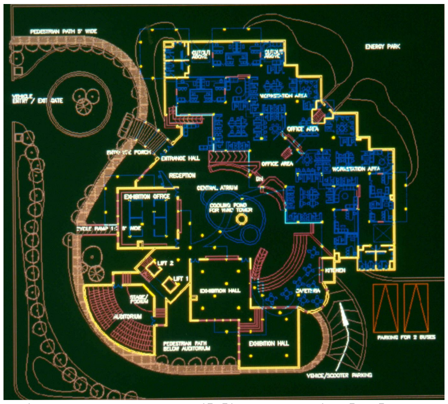

Fig. 2.0 PEDA Building: Typical Plan

With the objective of creating a building that would be sustainable (Fig.2.0), **a new language of design emerged:** a three dimensional configuration of the building enabling: Air movement through large volumes, good day-light distribution and integration of renewable systems – photovoltaic panels.

Building envelope was designed in response to solar geometry as a **Solar Envelope: i.e. solar energy receptor, converter and dissipater.**

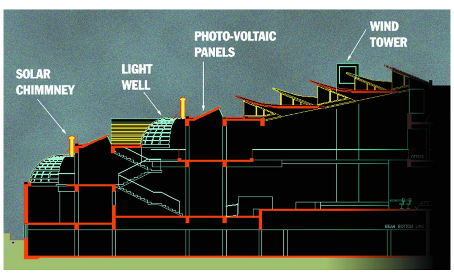

Fig. 3.0Building section: A cascading design

Building envelope (Fig.3.0) – A Solar Envelope: integrating Solar Shells (for day light and to regulate solar penetration), Solar chimney for ventilation (Fig. 4.0), PV panels for power generation, Wind Tower for passive down draft cooling.

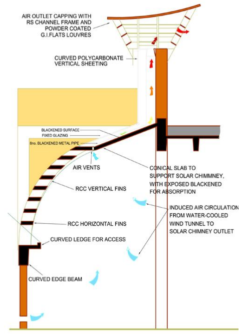

Fig. 4.0 Solar Chimney

SOLAR SHELLS

A unique system for day light distribution that eliminates glare was developed through design of Solar Shells in solar geometry. They allow solar penetration in winter and block it in summer during the over heated period. Fig 5.0

Fig. 5.0 Southern face Solar Shells: In construction and Interior distribution of daylight (winter) when completed.

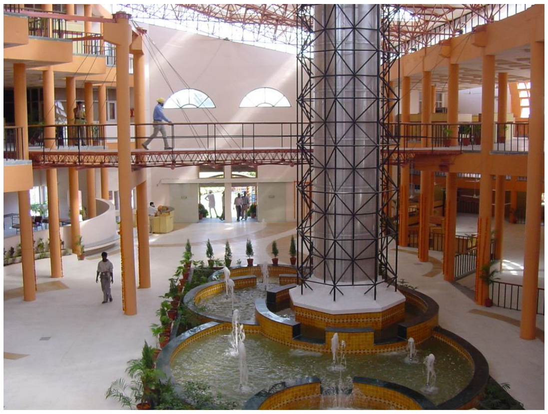

Fig. 6.0 Internal view: day lit environment Integrating various elements and water body

ATRIUM ROOF:

Main atrium roof has been designed as a series of hyperbolic paraboloid shells designed in response to solar geometry, and latitude of the site (Fig.7.0). It allows **winter Sun** to penetrate but eliminates **summer Sun**, thereby overheating in summer is avoided but heating in winter times is achieved. These shells are made of a light weight sand-which section made of two external layers of 3MM of high quality fibre glass and 75 mm of high density EPS insulation.

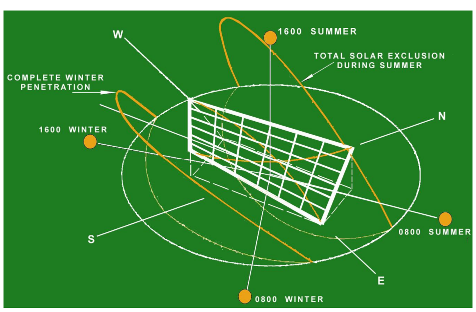

Fig:7.0: Hyperbolic Paraboloid & Solar Geometry

Fig. 8.0 Hyperbolic Paraboloid Shell: 5.0 M x 5.0 M 75 mm th. Light Weight Sand-which panel construction.

INTEGRATION OF RENEWABLE ENERGY SYSTEMS:

Photo-voltaic systems provides 33% of power requirement of the building. PV cells panels were integrated in a unique manner wherein, Glass to Glass sand-which PV cells panels form the roof of the atrium – a major part of the assemblage. **This generates power, becomes the main element of roof and allows good diffuse day light penetration. Fig.9.0 and Fig 10.0.**

Fig. 9.0 Atrium roof BIPV: Integration of PV Systems through Glass to Glass Sand-which panels.

Fig. 10.0 Wind Tower and BIPV

ENERGY PROFILE:
PEDA building has a 83 Kw connected load against a similar building requirement of 300 Kw. It has 27 Kw PV system installed in the building producing 1/3rd. requirement of power.

BUILDING ENERGY EFFICIENCY AWARD Fig.11.0
PEDA building has been awarded '5 Star rating – as the most energy efficient building in the country by BUREAU OF ENERGY EFFICIENCY , Govt. Of India. This is based on actual performance at an EPI (Energy Performance Index) at 14.1 Kwh.sq.m/year.

Fig. 11.0 BEE Award

<u>DESIGN CHALLENGE: CAN WE EVOLVE A NEW LANGUAGE OF ECOLOGICAL ARCHITECTURE FOR AN INNOVATIVE INSTITUTE ?:</u>

SSS – National Institute of Renewable Energy, Ministry of New and Renewable Energy Sources, Government of India.

Author was invited to participate in a limited competition for the above project. **An innovative architectural design evolving a language of ecological architecture presented by the author was selected by the jury for implementation of the project.**

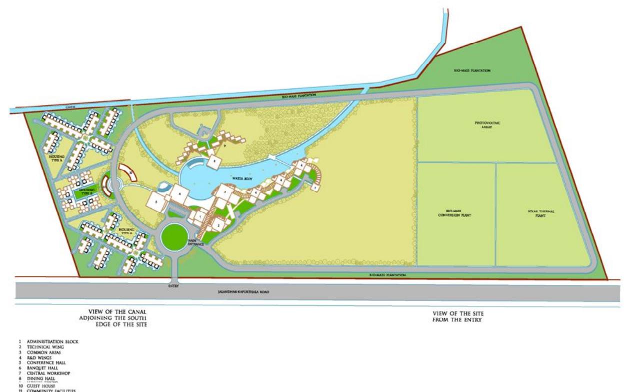

Fig. 12.0 Master Plan

STRATEGIES FOR PLANNING AND DESIGN:

- Control of micro-climate of the site by generating a water-body drawn of the canal and by forestation of the site.
- Entire complex and each building designed as a climate responsive – solar passive building.
- Architectural design: the primary generator / tool for developing a low energy building design.
- Maximize environmental control through naturally conditioned laboratories and spaces.
- Maximize use of day light to minimize electricity consumption in day time.
- Couple evaporative cooling from water-body with building design.

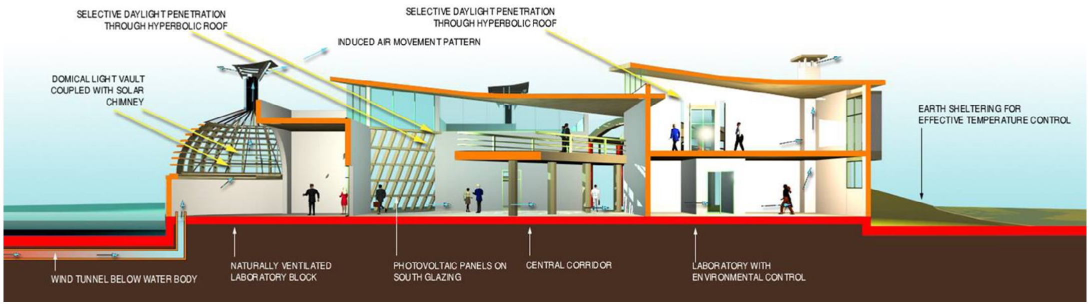

Fig. 13.0: R & D Wing Sectional Perspective:

ECOLOGICAL ARCHITECTURAL DESIGN OF R&D WINGS

- R & D wing has therefore been designed to couple the naturally conditioned laboratories and spaces to the water-body through **Down draft Wind towers coupled with earth-tunnels to the laboratory and building spaces.**
- **Domical Solar Shell** designed for adequate day-light distribution have been integrated with Solar chimney on domical vault. The system is coupled to down draft wind towers for ventilation and complete passive cooling cycle.

ROOF SYSTEM:

- Roof forms the critical element of the building design since it attracts the maximum solar heat gain and can be.
- Hyperbolic paraboloid roof shells form the roof to optimize on structural design since this is the only doubly-curved surface generated by a straight line making it simple to construct and since it generates only direct stresses
- Double curved surface responds naturally to solar geometry i.e. cutting of solar heat gain due to summer sum and allowing penetration of solar heat gain for winters.
- This is an element to generate efficient day-light distribution.

WATER MANAGEMENT:

Equally critical natural resource that is facing acute scarcity is availability of water. For this project spread over 75 acres of land on a highway with no municipal services or facilities.

A complete scheme of water management is planned / designed as illustrated above. This includes direct aquifer recharge, building run-off collection into the lake, re-cycled water from Root Zone system of sewage treatment and surface run-off seepage through ponding.

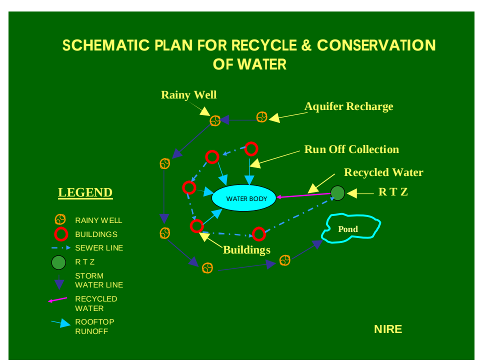

Fig. 14.0 Water management system

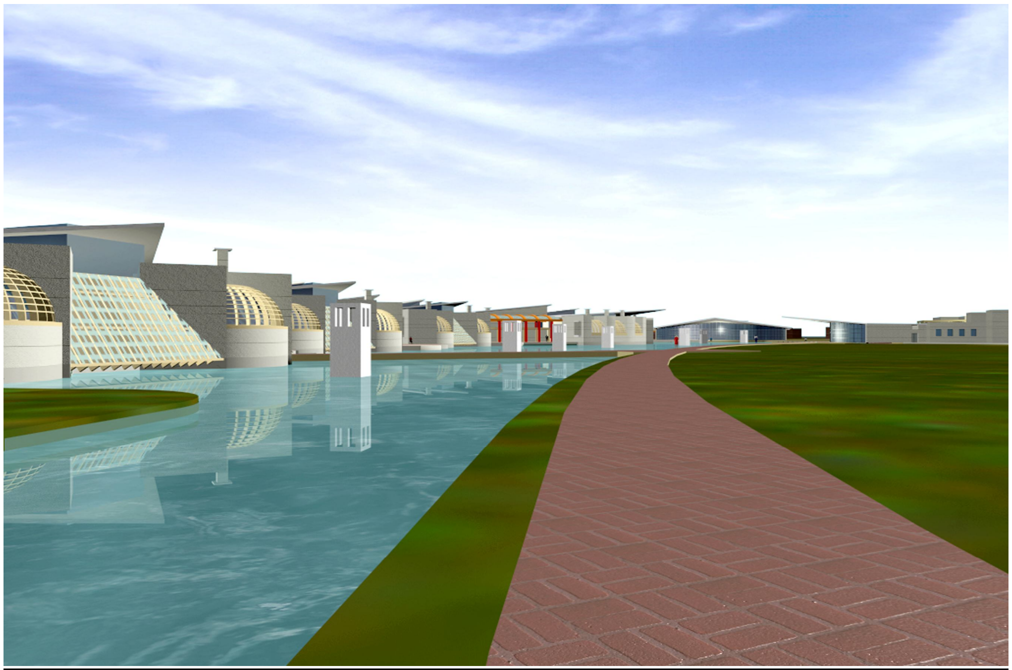

Fig. 15.0 View from the lake Note: Phase I of the Project has been completed and is in operation.

ENERGY PROFILE:

This project has been designed with an indirect evaporative cooling system integrated with passive down draft wind towers coupled with earth tunnels as the cooling systems. It is predicted that the project will consume about 1/5th. Of power as compared to a conventional building.

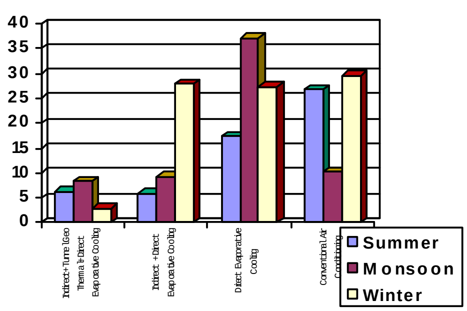

Fig: 16.0 Comparative annual power consumption

CONCLUSION

GOOD MEANINGFUL ARCHITECTURE EVOLVES AT THE MEETING POINT WHERE ART BECOMES SCIENCE AND SCIENCE BECOMES ART.

Helen Castle argument: " Over the last decade or so, there has been a real danger that the widespread adoption of sustainable codes and government policies has become a straitjacket for designers - an imposition rather than a productive force. It has become a matter of ticking off boxes for green building validation, rather than engaging with wider ecological thinking and solutions",
(ECO-REDUX, ARCHITECTURAL DESIGN UK, Nov. – Dec. 2010), is well placed..