



Bureau of Energy Efficiency



सत्यमेव जयते  
Government of India  
Ministry of Power



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# ANGAN

## Augmenting Nature by Green Affordable New-habitat

A Courtyard for Revolutionary Change in Building Energy Efficiency

An International Conference on Building Energy Efficiency

9<sup>th</sup>-11<sup>th</sup> September, 2019 | Hotel The LaLIT, New Delhi





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THIS PRESENTATION WAS SHARED BY

**Mr. Ripu Daman Singh**

Associate Professor, GZS School of Architecture and Planning, Punjab

FOR THE SESSION:

*“Meeting Two Ends: Heritage and Indigenous Construction Practices”*

DURING ANGAN 2019

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# ANGAN – 2019

Augmenting Nature by Green Affordable New Habitat

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Understanding the key Architectural aspects of an Energy  
Efficient building design

Ripu Daman Singh

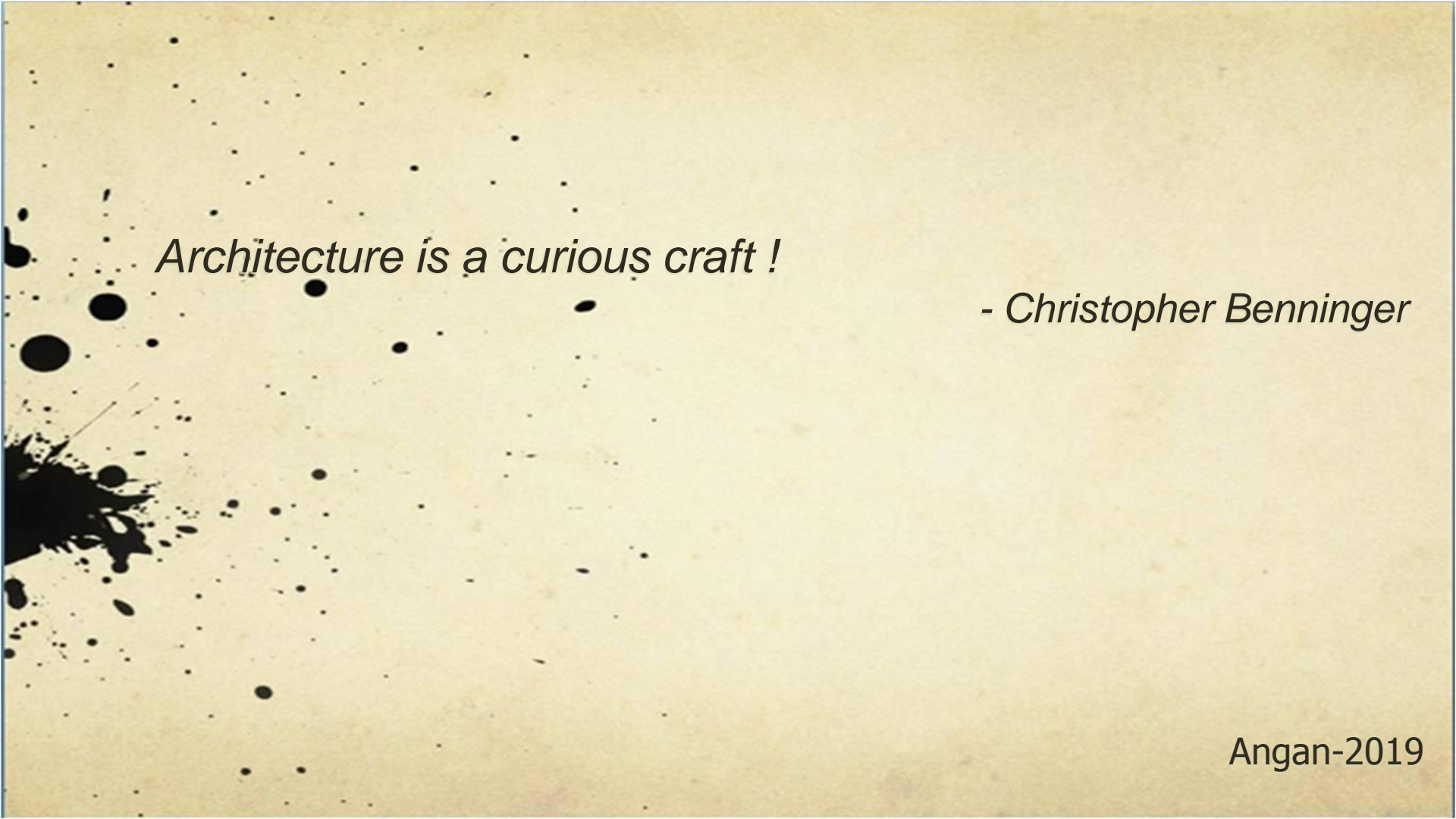
Jatinder Kaur

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The background of the image is a light beige, aged paper with numerous black ink splatters and dots of varying sizes scattered across it. The splatters are most concentrated on the left side, with some larger, more irregular blotches, while the right side is relatively clean.

*Architecture is a curious craft !*

*- Christopher Benninger*

Angan-2019

# A journey in search of design and energy efficiency.

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Buildings as shelters

Maintaining thermal comfort levels

Energy worries

Reality check

Role of architects

Energy efficient building design

# Make a change.

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To our self

To our immediate surroundings

To the society

To the region

To the nation

To the world at large

Better quality of life for ourselves and  
future generations

# Buildings as shelters....

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Buildings as shelters are designed for protection from extremities of climate, and ensuring thermal comfort conditions in the interiors..

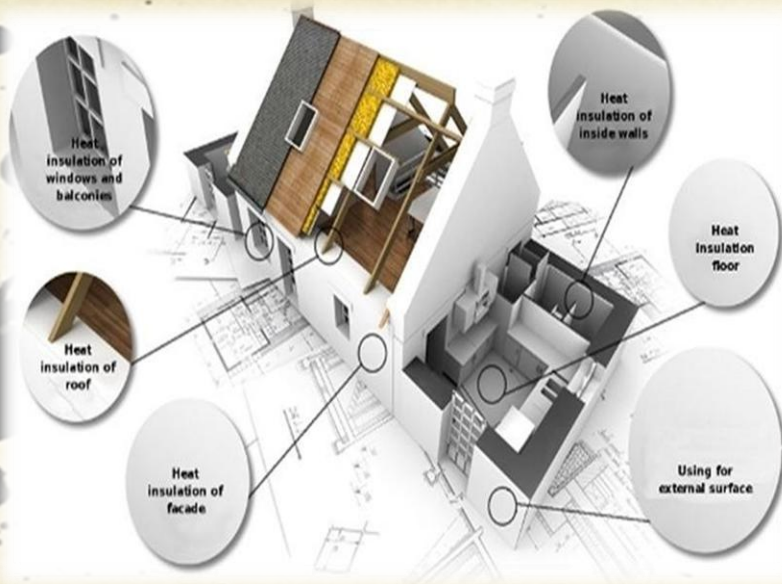
# Major concerns....

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The indoor thermal comfort is mostly maintained by the means of HVAC systems which consume huge amounts of electricity for their operation and have a share of 55 percent in the annual energy demand of a building.

# Buildings....evolutionary changes

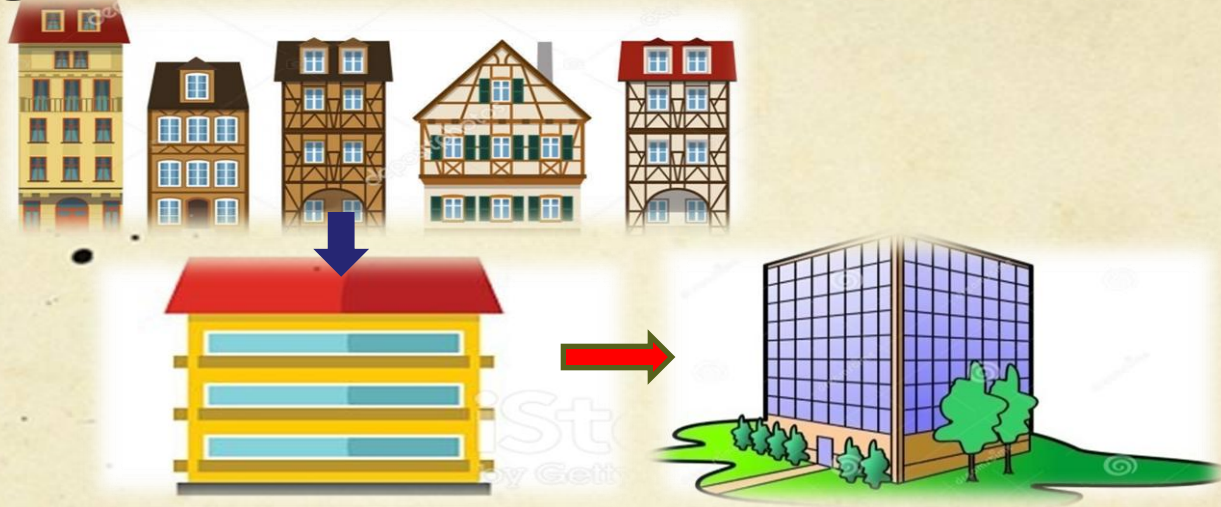


The major evolutionary changes were witnessed since 19th century, when the concepts of building physics were introduced in the building envelope design by the scientists in the year 1828.

The thermal properties of building materials occupied centre stage in design with the advent of terms like thermal conductivity (K-value), also known as U-value.

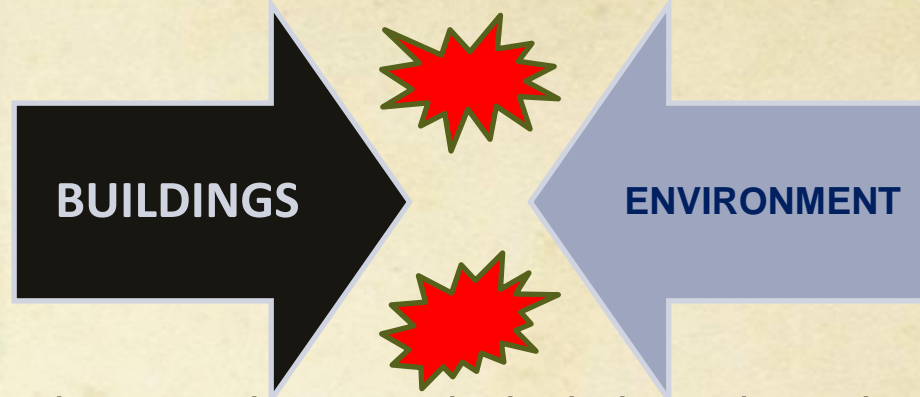
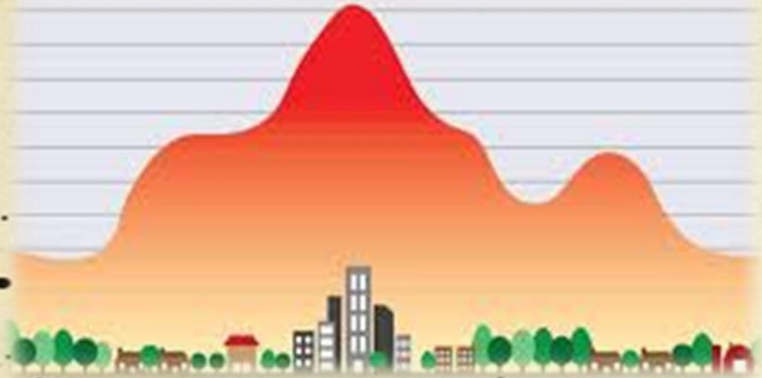
# Buildings.....a shift

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The primary function of a building envelope has not changed over periods of time, but its design has witnessed a gradual shift from being constructed as large thermal masses with small openings in the past to huge glazed unshaded facades in the present.

# Buildings and climate destabilization....



The issue of building energy demand cannot be seen in isolation, since the process of energy production requires the use of coal in India, which is a limited finite natural resource. Moreover, the energy demand of buildings and CO<sub>2</sub> emissions go hand-in-hand, therefore, if the issues related to energy consumption of building sector are not dealt with in the present scenario, then the building sector might be held responsible for climate destabilization.

# Architects and design concerns....

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Form

Energy efficiency

Climate

Materials

Code compliances and Rating systems

Ergonomics

Economics

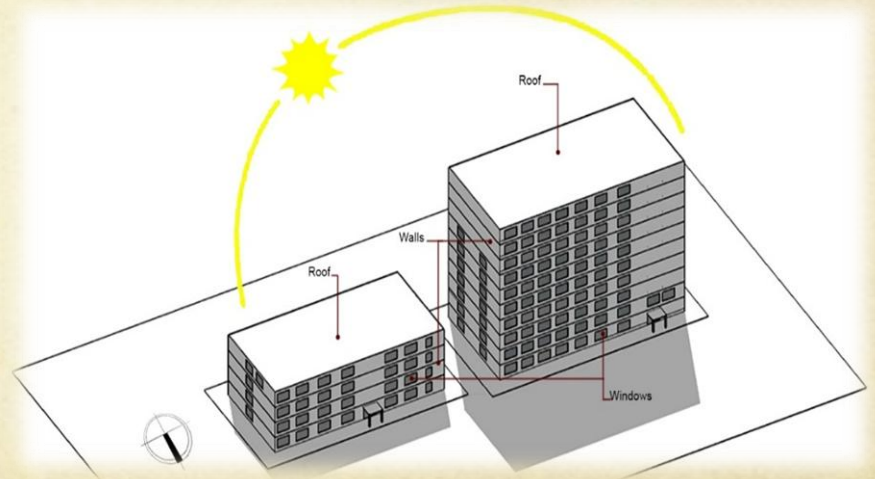
Life cycle

Disposal and more.....

# Building envelope....

The building envelope, being the very first layer of a building that encloses and shields the preferred indoor comfort conditions from harsh outdoor climate, must be looked upon for all possible solutions for energy efficiency measures.

The way forward



# Building envelope....

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## **Opaque components**

- Walls
- Roofs

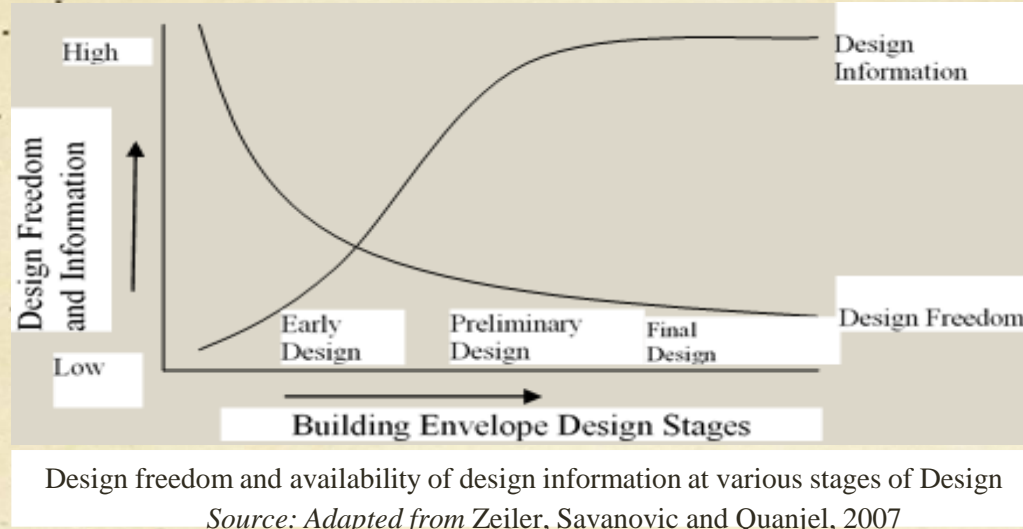
## **Transparent components**

- Windows
- Ventilators
- Skylights

# How to design for energy efficiency?



# Design stages....



Architects have argued that the energy efficiency information related to individual contributions and interactions amongst various design parameters would be beneficial in early stages of design, since majority of them do not prefer to opt for simulation studies due to number of changes taking place during the process.

# Design Principles....

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*Reduce Solar Exposure*

**Envelope form**

**Orientation**

*Reduce incoming Solar Radiation*

**WWR,  
Glazing Proportions**

**Shading**

*Reduce Heat Transfer*

**Insulation**

# Key Architectural aspects of envelope performance

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## *Reduce Solar Exposure*

Envelope form

Orientation

## *Reduce incoming Solar Radiation*

WWR, Glazing Proportions

Shading

## *Reduce Heat Transfer*

Insulation

Building Envelope Form

Building Orientation

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

Window Insulation

Wall Insulation

Roof Insulation

# Composite Climate

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□ The composite climate zone of India poses building design challenges to architects because of extreme hot, cold and humid conditions in different periods of the year

# Impact potential of parameters

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The aim is to understand the role and importance of design parameters in the design process of an energy efficient building envelope

The envelope performance evaluation was done using simulation software DesignBuilder 5.0.3.007

# Impact potential of parameters

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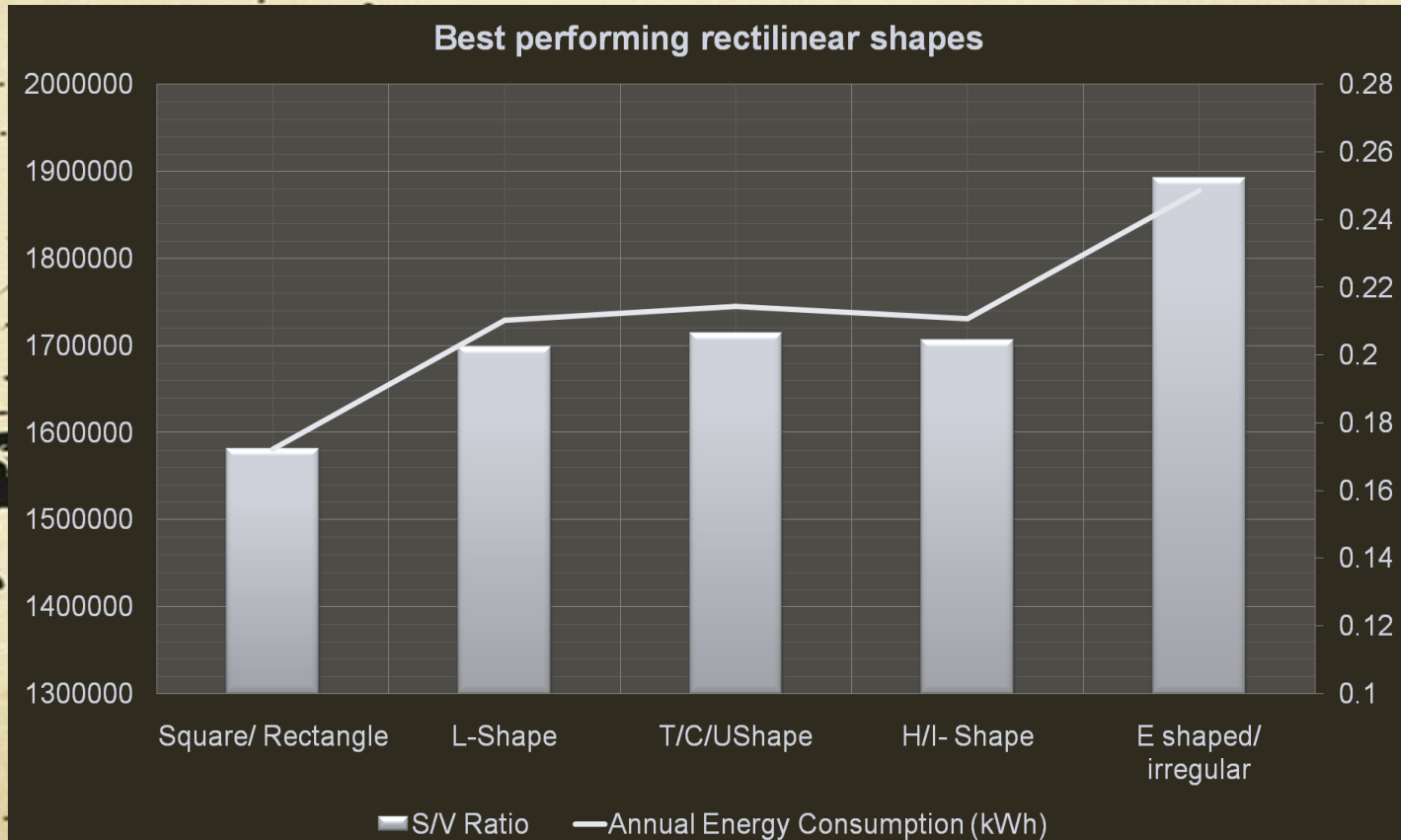
.The input parameters of reference cases (considering day time use fully air conditioned office buildings) for office schedules, zones, geographical location, building systems, internal gains etc. were kept constant for all cases, and simulations were performed for individual and various combinations of envelope parameters to ensure that the true performance of architectural design parameters could be extracted.

# Impact potential of Plan form

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*Initial study* results for evaluation of Rectilinear Plan Shapes w.r.t. S/V ratios and thermal performance expressed as Energy consumption (calculated through simulation), shows that Square/Rectangular forms are most energy efficient due to their low S/V ratio.

# Impact potential of Plan form



# Impact potential of Plan form

## **Building Envelope Form**

Building Orientation

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

Window Insulation

Wall Insulation

Roof Insulation

- Linear / Rectilinear building plans
- Aspect Ratio of 1:2
- Compact built form with low S/V ratio

The Linear/ Rectilinear plan shaped buildings are more impactful in terms of achieving energy efficiency. They have an energy saving potential up to 10% than other shaped buildings due to their low S/V ratio.

# Impact potential of Orientation

Building Envelope Form

**Building Orientation**

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

Window Insulation

Wall Insulation

Roof Insulation

North-South is most suitable

North-South with a tilt of 15-25 degree either ways (NE-SW; NW-SE) have also been found to be efficient in composite climate

Since the solar heat gain through surfaces exposed to North and South direction is lower than that of East and West directions, therefore, North-South orientation shows greater impact potential over other orientations.

# Impact potential of WWR (Window to wall ratio)

Building Envelope Form

Building Orientation

## **WWR & Glazing Proportions**

Window Shading

Wall Shading

Roof Shading

Window Insulation

Wall Insulation

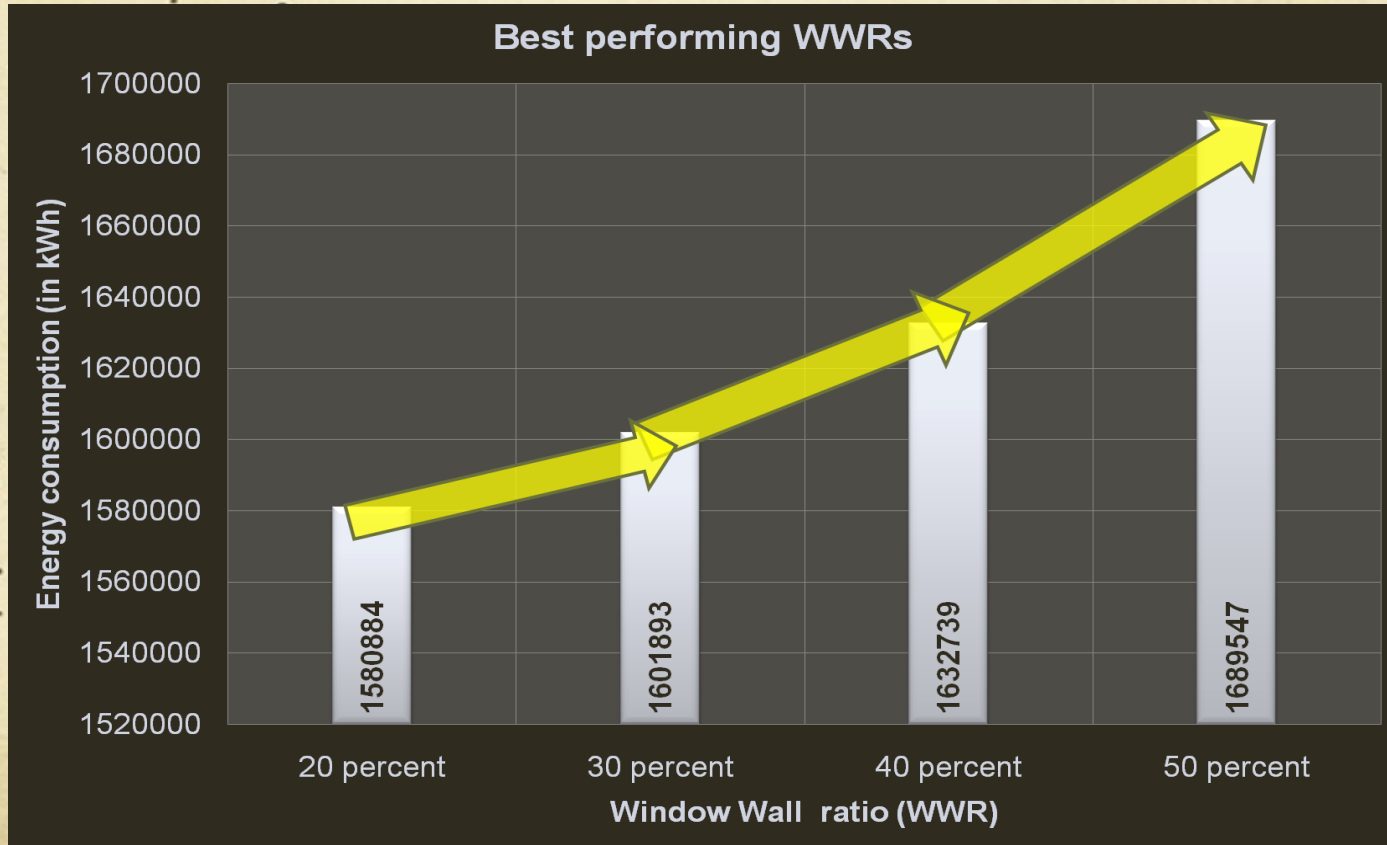
Roof Insulation

Preferred WWR should be between 20 to 40 percent

Maximum glazed area on a particular façade should be limited to 60 percent of that wall area

Rectangular horizontal shaped windows are most suitable

# Impact potential of WWR (Window to wall ratio)



# Glazing proportions options

	Directions	Glazing proportions			
		N NNE, NE, NNW, NW	S SSW, SW, SSE, SE	E ESE, SE, ENE, NE	W WNW, NW, WSW, SW
Building Envelope Form					
Building Orientation					
<b>WWR &amp; Glazing Proportions</b>					
Window Shading	Predominantly North, South directions	50	50	0	0
Wall Shading	Predominantly North, substantial South and marginal glazing in East, West directions	50	30	10	10
Roof Shading					
Window Insulation	Predominantly South, substantially North and marginal glazing in East, West directions	30	50	10	10
Wall Insulation					
Roof Insulation	Predominantly East, West directions	20	20	30	30
	Equal glazing proportions in all directions	25	25	25	25

# Impact potential of Glazing proportions

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- ❑ The glazing proportions with predominant area of exposure in North direction were found to be most energy efficient as compared with predominant East/West exposures.
- ❑ Since the solar heat gain through windows in North direction is the least amongst all other directions, the glazing proportions with predominant North glazing has performed the best in terms of energy efficiency.

# Window shading options

Building Envelope Form

Building Orientation

WWR & Glazing Proportions

**Window Shading**

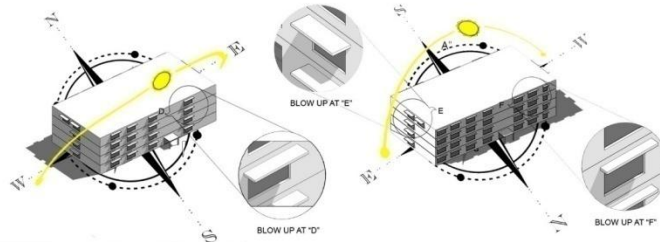
Wall Shading

Roof Shading

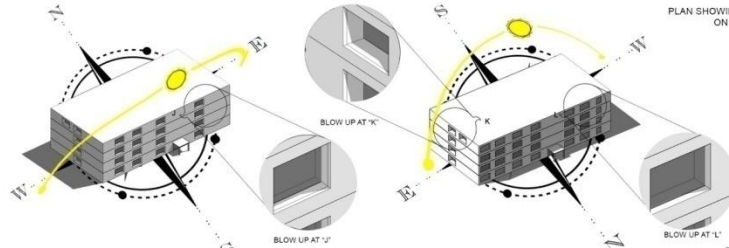
Window Insulation

Wall Insulation

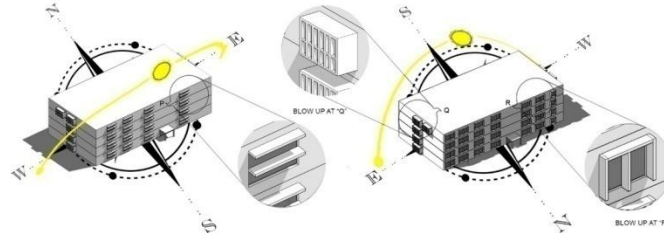
Roof Insulation



WINDOW SHADING OPTION 1

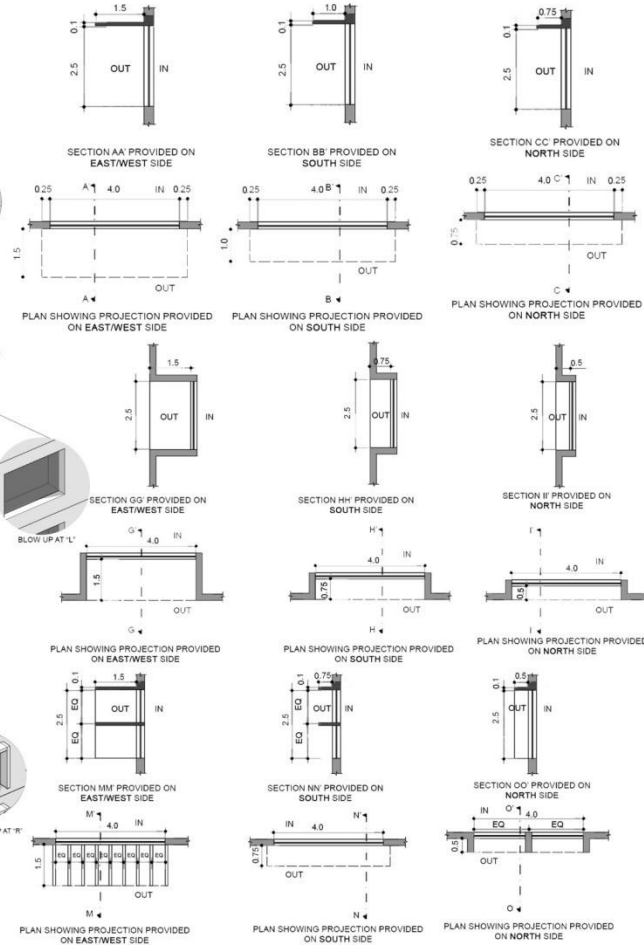


WINDOW SHADING OPTION 2



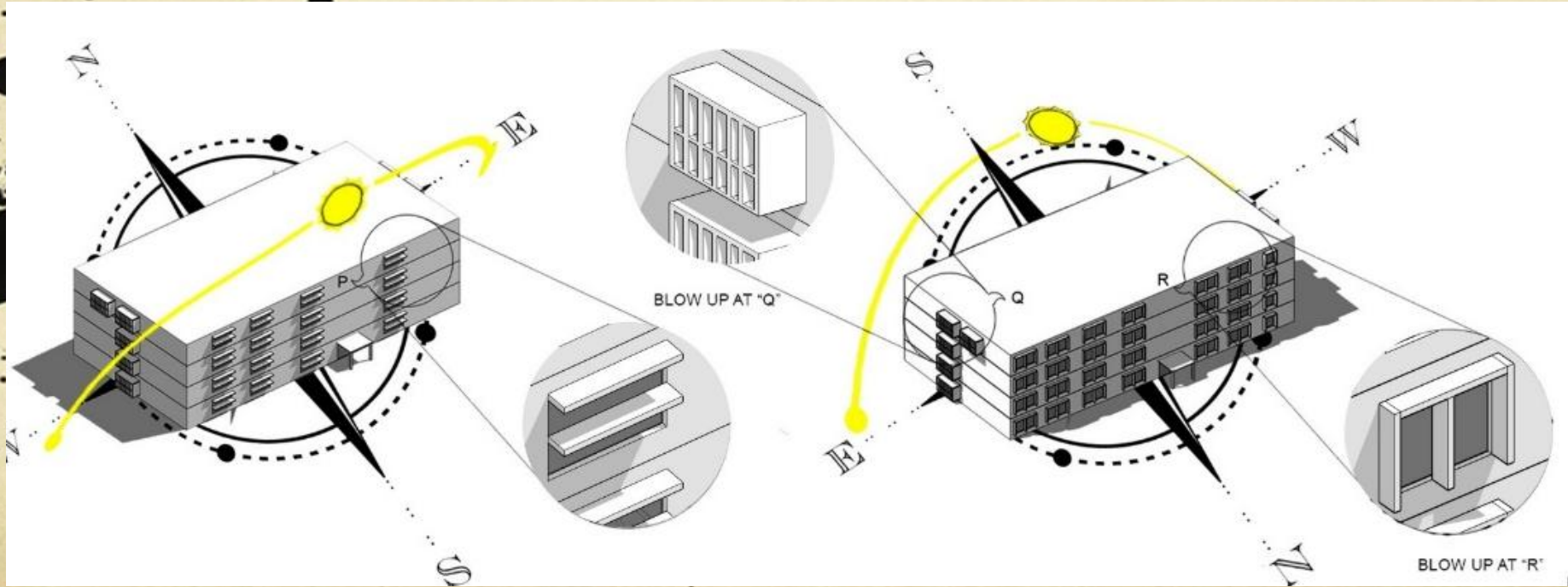
WINDOW SHADING OPTION 3

ALL DIMENSIONS ARE IN METERS

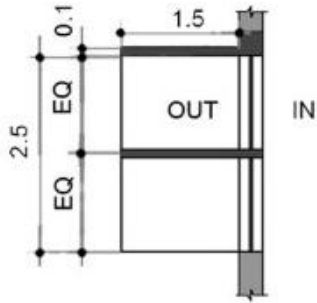


# Impact potential of Window shading

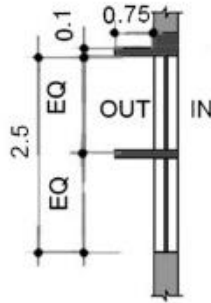
Linear buildings with the displayed combination of window shading were found to be most energy efficient with maximum impact of 7% with 40% WWR and the an impact of 4% shown by 20% WWR.



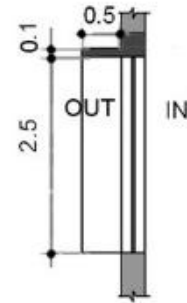
# Impact potential of Window shading



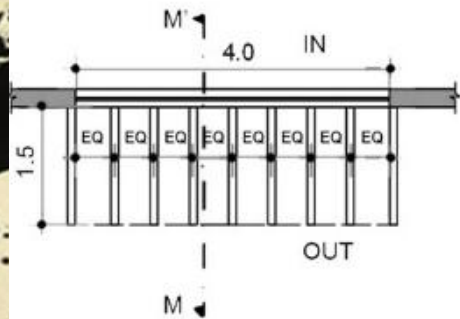
SECTION MM' PROVIDED ON EAST/WEST SIDE



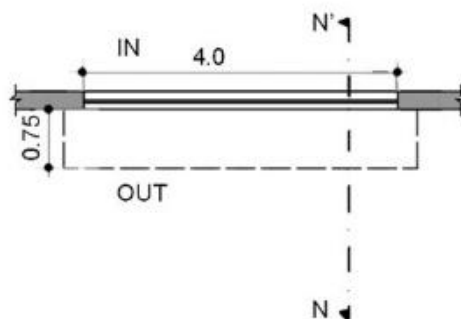
SECTION NN' PROVIDED ON SOUTH SIDE



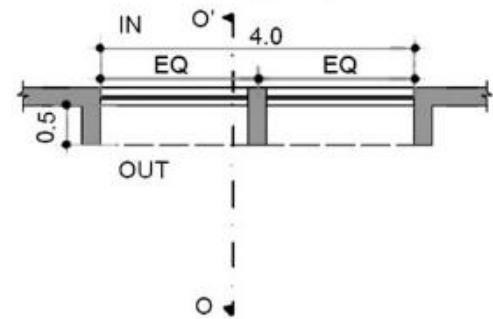
SECTION OO' PROVIDED ON NORTH SIDE



PLAN SHOWING PROJECTION PROVIDED ON EAST/WEST SIDE



PLAN SHOWING PROJECTION PROVIDED ON SOUTH SIDE

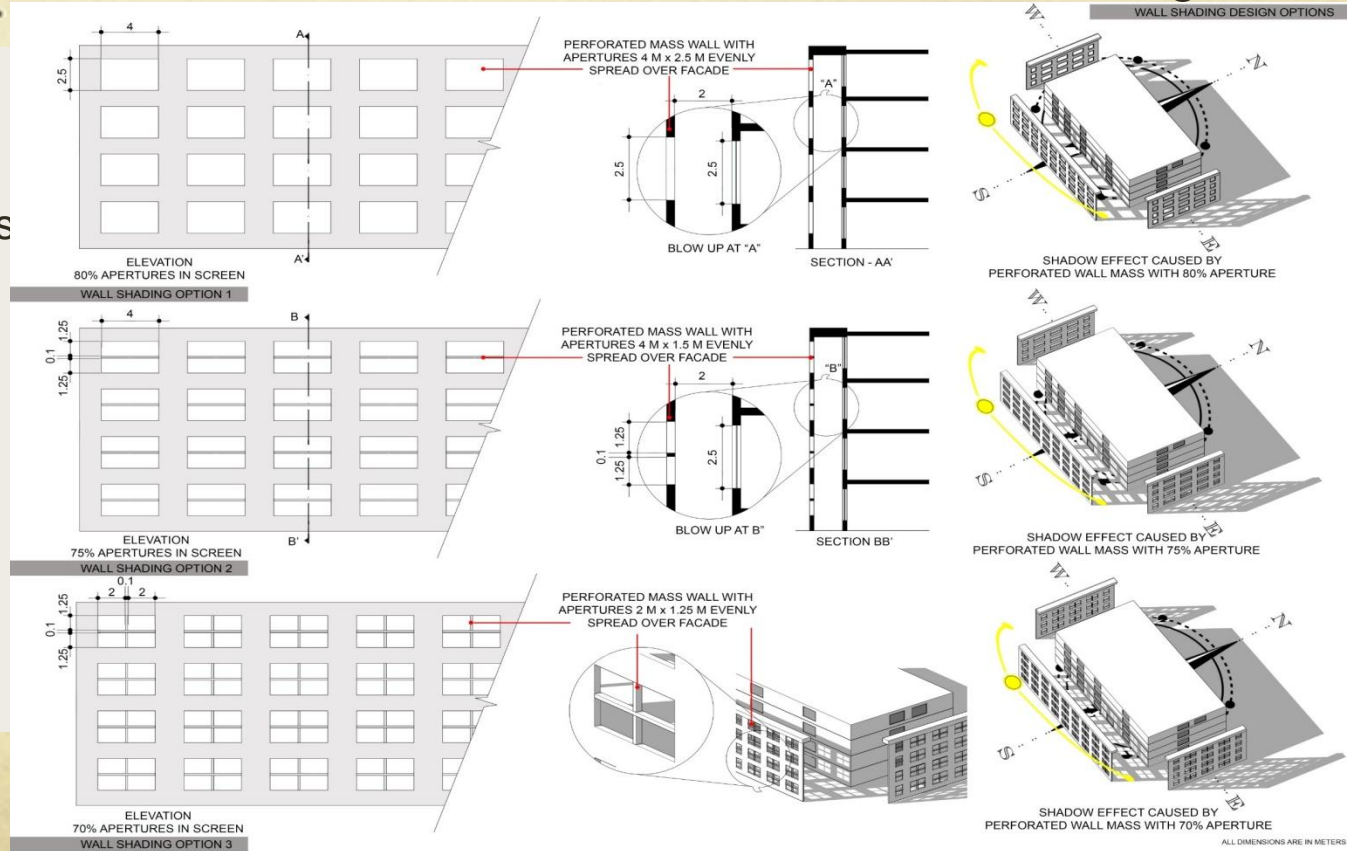


PLAN SHOWING PROJECTION PROVIDED ON NORTH SIDE

Combinations of window shading as per SP41

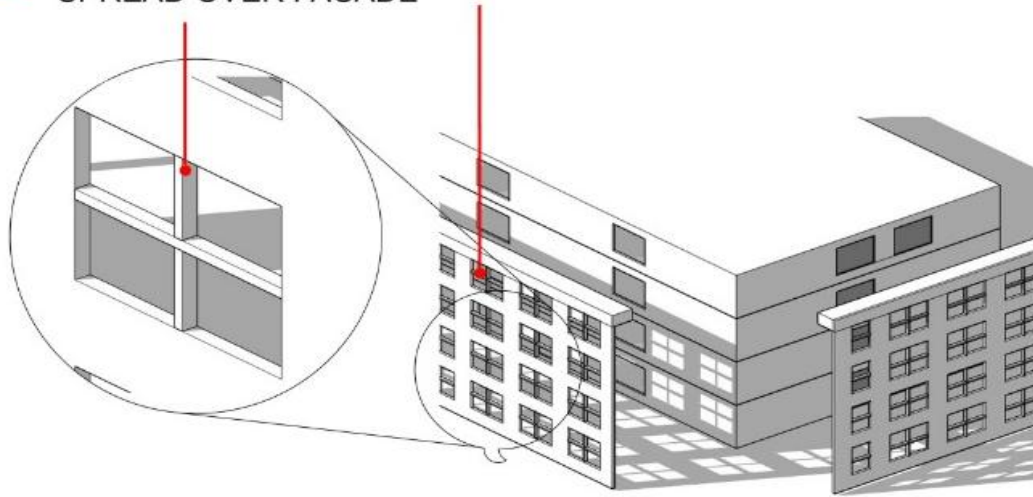
# Wall shading options

- Building Envelope Form
- Building Orientation
- WWR & Glazing Proportions
- Window Shading
- Wall Shading**
- Roof Shading
- Window Insulation
- Wall Insulation
- Roof Insulation

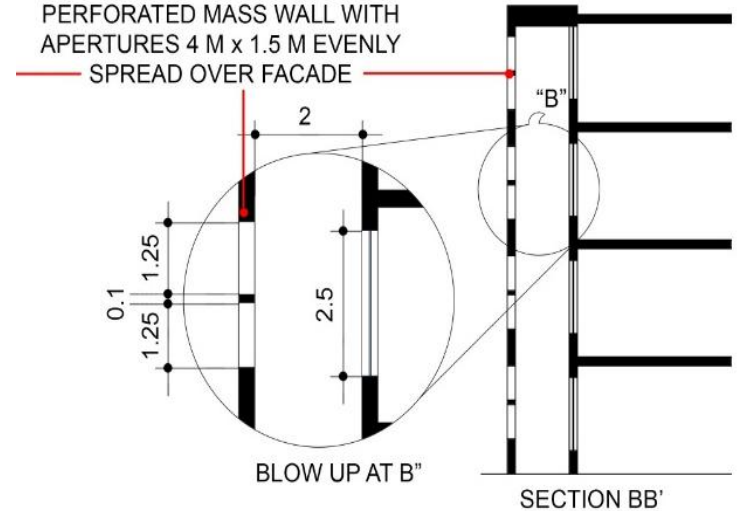


# Impact potential of Wall shading

PERFORATED MASS WALL WITH  
APERTURES 2 M x 1.25 M EVENLY  
SPREAD OVER FACADE



PERFORATED MASS WALL WITH  
APERTURES 4 M x 1.5 M EVENLY  
SPREAD OVER FACADE

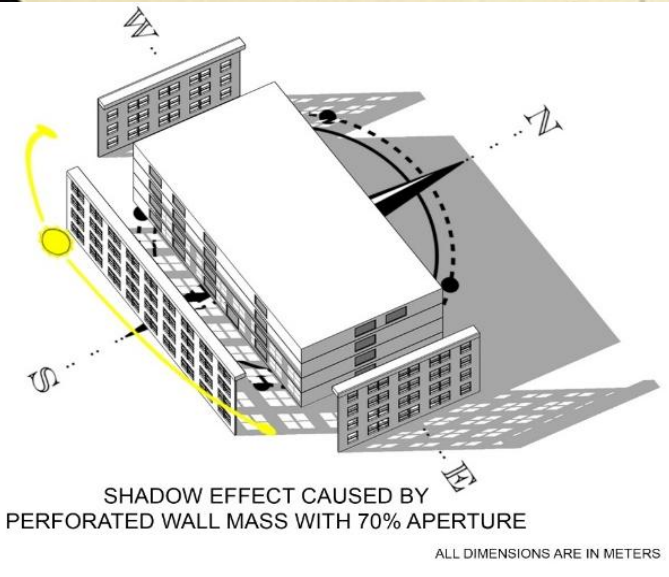


# Impact potential of Wall shading

❑ Wall shading was found to be energy efficient having an impact of 6% with 40% WWR and the minimum impact of 3% with 20% WWR.

❑ The wall shading acted as window shading too as the wall shading elements shaded the window area too

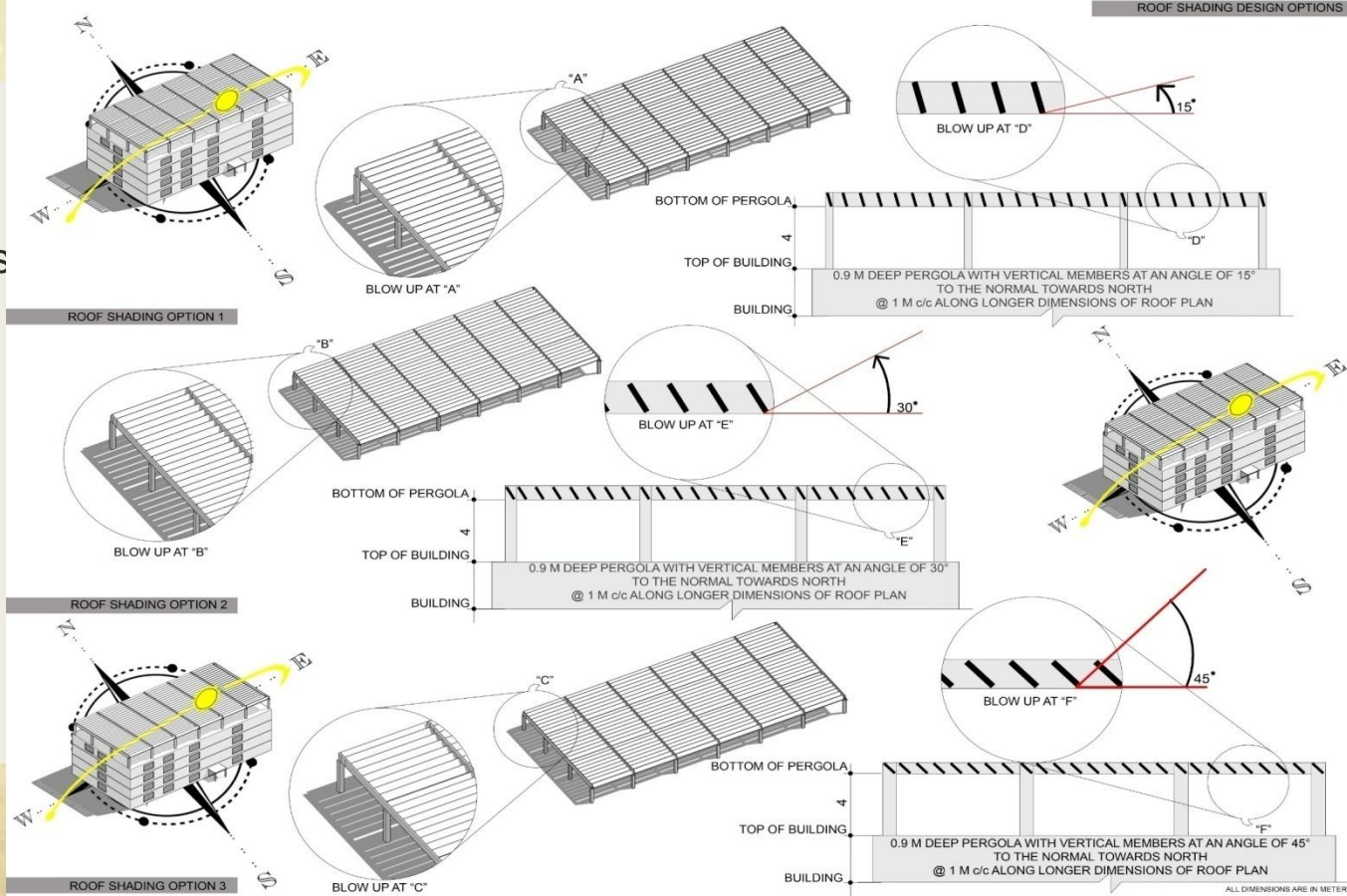
❑ Thus, the effectiveness of wall shading in buildings was found to be present in buildings with higher wall surface area.



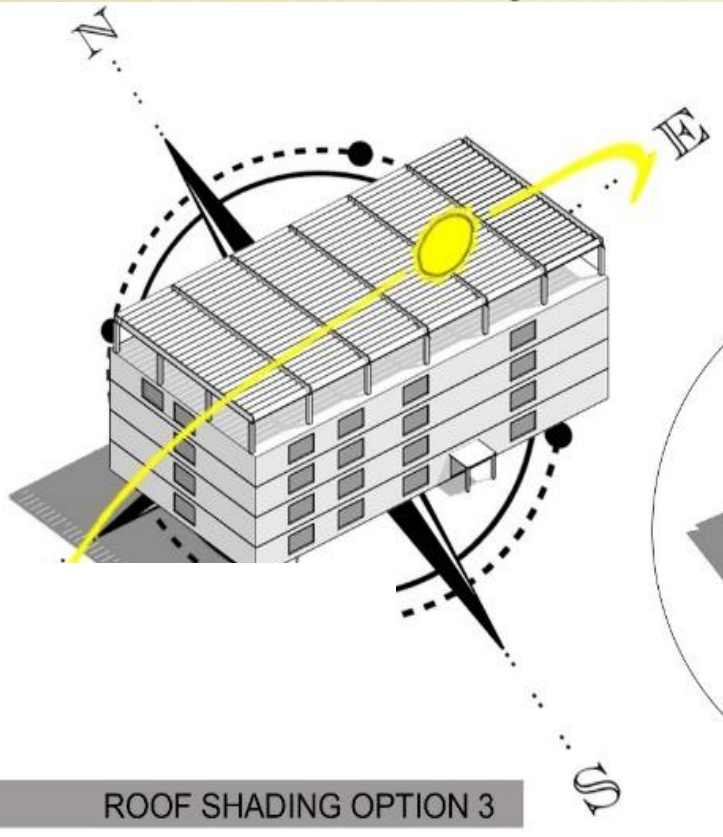
# Roof shading options

ROOF SHADING DESIGN OPTIONS

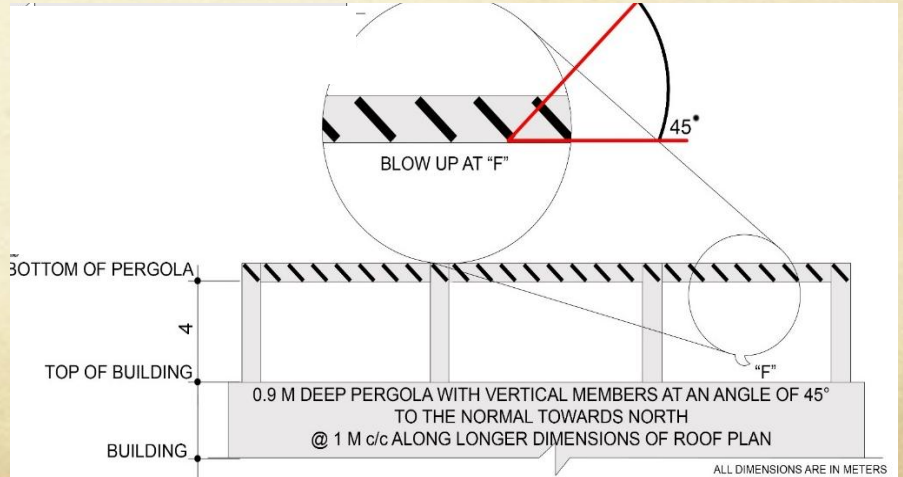
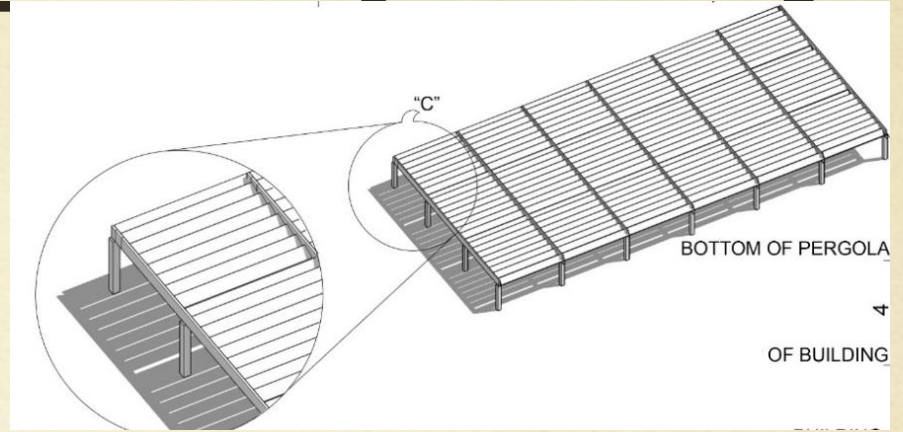
- Building Envelope Form
- Building Orientation
- WWR & Glazing Proportions
- Window Shading
- Wall Shading
- Roof Shading**
- Window Insulation
- Wall Insulation
- Roof Insulation



# Impact potential of Roof shading



ROOF SHADING OPTION 3



# Impact potential of Roof shading

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- ❑ Roof shading has impact of up to 4 % for low rise buildings and the minimum impact of up to 1.5% for high rise buildings.
- ❑ The effectiveness of Roof shading in low rise buildings was found to be more in comparison to high rise buildings due to the difference in exposed roof area.

# Window insulation options

Description of Materials	U-value (W/m <sup>2</sup> K)	SHGC	VLT
<b>Conventional:</b> <u>Single glazed unit with Aluminium frame and 6mm thick clear glass</u>	5.6	0.56	0.73
<b>Option 1 Efficient:</b> <u>Single glazed unit with UPVC frame and 6mm thick tinted/coated glass</u>	4.2	0.4	0.5
<b>Option 2 More efficient:</b> <u>Double glazed unit with UPVC frame and 6mm thick clear glass+12mm air gap+6mm thick clear glass</u>	2.8	0.35	0.54
<b>Option 3 Most efficient:</b> <u>Double glazed unit with UPVC frame and 6mm thick low-e glass+12mm argon gas filling+6mm thick low-e glass</u>	1.7	0.18	0.13

# Impact potential of Window insulation

Building Envelope Form

Building Orientation

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

**Window Insulation**

Wall Insulation

Roof Insulation

□ The maximum impact of window insulation was found to be about 10% with 40% WWR and the minimum impact of about 5% with 20% WWR.

□ Thus, the effectiveness of Window insulation was found to be more in buildings with higher WWR's.

# Wall insulation options

Description of Materials	U-value (W/m <sup>2</sup> K)
<b><i>Conventional:</i></b> <u>Conventional Wall</u> : - 230mm thick brick wall with 12mm plaster on both sides	2.14
<b><i>Option 1 Efficient:</i></b> <u>Cavity Wall System</u> : - 230mm thick outer wall having 50mm air gap and 115mm thick inner wall with 12mm plaster on both sides	1.22
<b><i>Option 2 More efficient:</i></b> <u>AAC Block Wall</u> : - Autoclaved aerated concrete blocks 230mm thick with 12mm plaster on both sides	0.62
<b><i>Option 3 Most efficient:</i></b> <u>Fly ash Wall with Insulation</u> : - Fly ash wall 200mm thick with 10mm polyurethane insulation on outside and 12mm plaster both sides	0.21

# Impact potential of Wall insulation

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Building Envelope Form

Building Orientation

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

Window Insulation

**Wall Insulation**

Roof Insulation

□ The maximum impact of upto 7% for 40% WWR and the impact of upto 3.5% with 20% WWR is shown with wall insulation.

□ The impact of wall shading is pronounced due to the fact that the wall shading also includes the benefits of window shading

# Roof insulation options

Description of Materials	U-value (W/m <sup>2</sup> K)
<b><i>Conventional:</i></b> <u>Conventional Roof:</u> - 150mm thick RCC slab with water proofing, 50mm each of weathering course and screed concrete	2.34
<b><i>Option 1 Efficient:</i></b> <u>Earthen Pot Insulated Roof:</u> - 150mm thick RCC slab with water proofing, 75mm inverted earthen pots laid in lime concrete and finished with 25mm cement mortar	1.6
<b><i>Option 2 More efficient:</i></b> <u>Over deck XPS Insulated Roof:</u> - 150mm thick RCC slab with water proofing, 50mm each of XPS insulation, weathering course and screed concrete	0.46
<b><i>Option 3 Most efficient:</i></b> <u>Over deck Polyurethane Insulated Roof:</u> 150mm thick RCC slab with water proofing, 100mm each of polyurethane insulation finished with 25mm cement mortar	0.2

# Impact potential of Roof insulation

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Building Envelope Form

Building Orientation

WWR & Glazing Proportions

Window Shading

Wall Shading

Roof Shading

Window Insulation

Wall Insulation

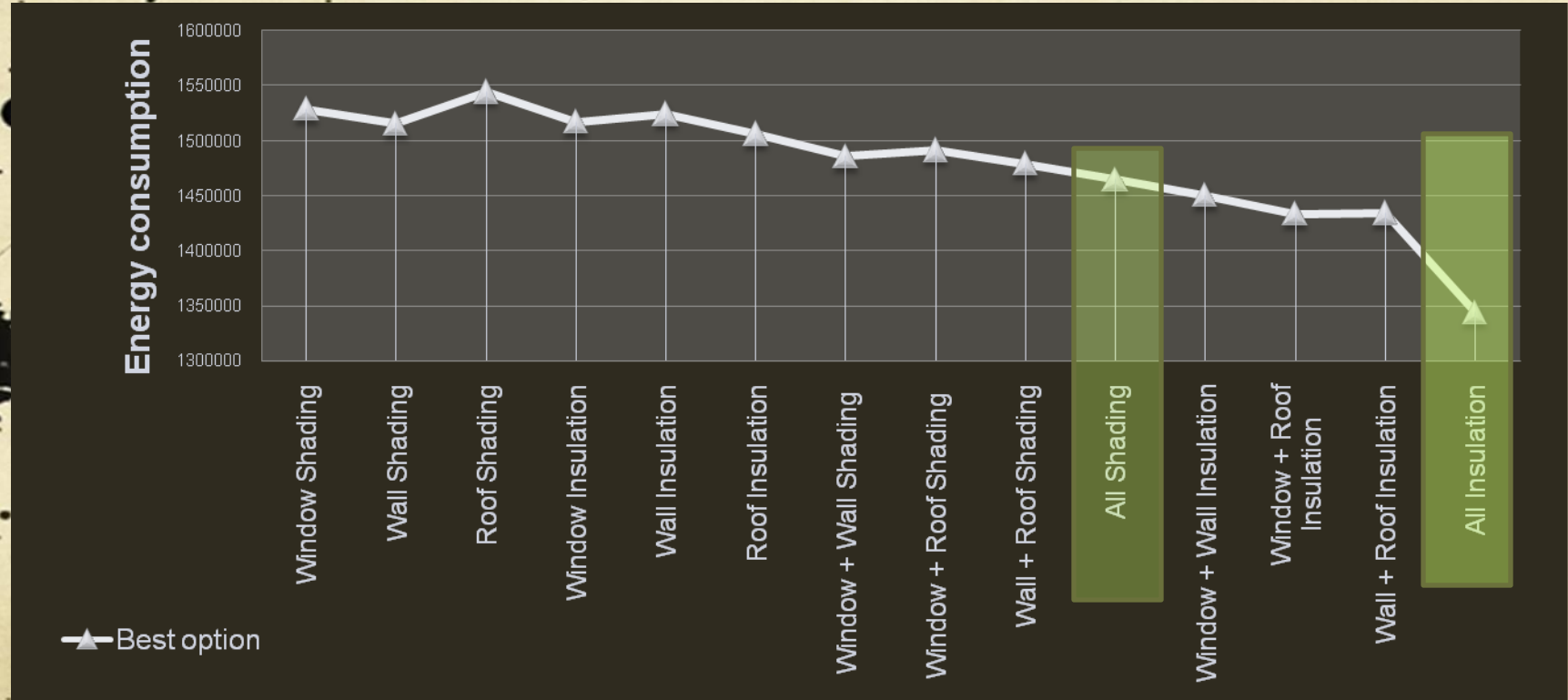
**Roof Insulation**

□ Roof insulation were found to be energy efficient with maximum impact of about 5% in low rise buildings and minimum impact of about 2% in high rise buildings.

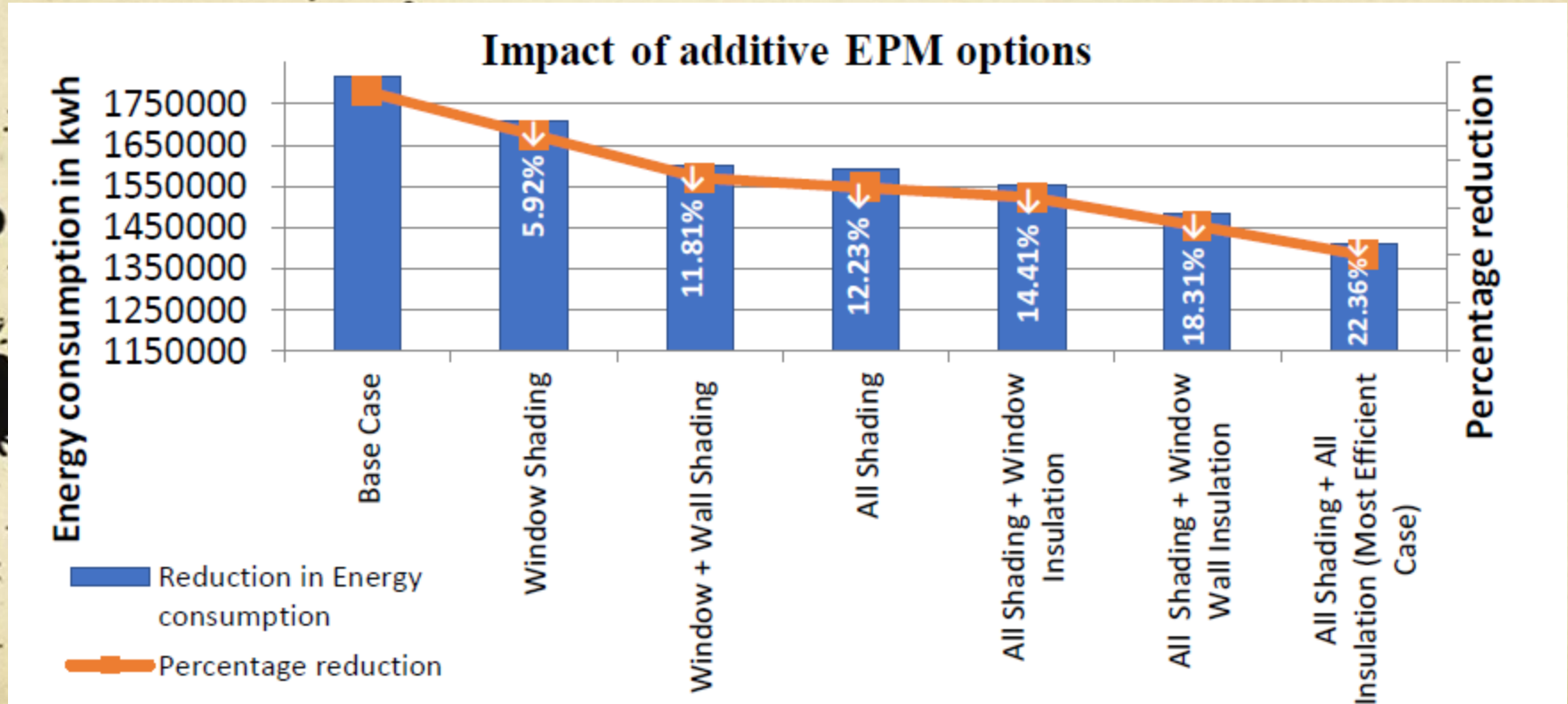
□ The effectiveness of Roof insulation in higher S/V ratio was found to be more in comparison to buildings with lower S/V ratio.

# Impact potential of Shading and Insulation

Individual and combined



# Additive Impact potential of Shading and Insulation



# Summary of research findings

Architectural design parameters	Findings of research
<b>Building Envelope Form</b>	Rectilinear buildings (Low S/V ratio) with an aspect ratio of 1:2 are found to be more energy efficient in comparison to other shape buildings.
<b>Orientation</b>	North-South orientation is more energy efficient in comparison to East-West orientation.
<b>WWR</b>	Buildings with 20% WWR are more energy efficient over buildings with 40% WWR.
<b>Glazing proportions</b>	Buildings with predominant North glazing are more energy efficient over buildings with predominant East-West glazing.

<b>Architectural design parameters</b>	<b>Findings of research</b>
<b>Window Shading</b>	Window shading devices with horizontal overhangs in South, vertical fins in North and combination of both in East/West directions are found to be more energy efficient over Recessed windows, and much more energy efficient over the provision of horizontal overhangs only.
<b>Wall Shading</b>	Wall shading with Perforated mass wall with 70 percent apertures are found to be more energy efficient over that with 75 percent apertures, and much more energy efficient over that with 80 percent apertures.
<b>Roof Shading</b>	Roof shading with 0.9m deep Pergola with vertical members at an angle of 45° are found to be more energy efficient over that having an angle of 30°, and much more over that having an angle of 15°.

<b>Architectural design parameters</b>	<b>Findings of research</b>
<b>Window Insulation</b>	Window insulation with DGU & argon gas filling are found to be more energy efficient over DGU with air gap, and much more energy efficient over SGU with tinted glass.
<b>Wall Insulation</b>	Wall insulation with Fly ash Wall + PU Insulation are found to be more energy efficient over AAC Block Wall, and much more energy efficient over Cavity Wall System.
<b>Roof Insulation</b>	Roof insulation with Over deck PU Insulated Roof are found to be more energy efficient over XPS overdeck Insulated Roof, and much more energy efficient over Earthen Pot Insulated Roof.
<b>Combinations of various Parameters</b>	Specific energy efficiency findings corresponding to various combinations of architectural parameters have been established in the present research, which can widen the scope of design decision-making and lead to enhanced energy efficiency (up to 22.36%) using these combinations.

# The way forward....



Suzlon One Earth, Pune



Kolhapur Institute of Orthopedics



Office hub, Gurugram



Adobe Office, Noida



Zydus Corporate office, Ahmedabad

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Let's open our eyes to the world around us.



India Habitat Centre, N. Delhi



India International Centre, N. Delhi



High Court Chandigarh

Angan-2019

# Let's open our minds to the possibilities around us.



IIM, Bangalore



IRRAD office, Gurugram



Development Alternatives,  
Delhi



Pearl Academy, Jaipur  
Angan-2019

# Let's understand the needs of our clients and the environment.

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Understand.....

Their concerns

Their problems

Their fears

Their needs

Their expectations

Their participation

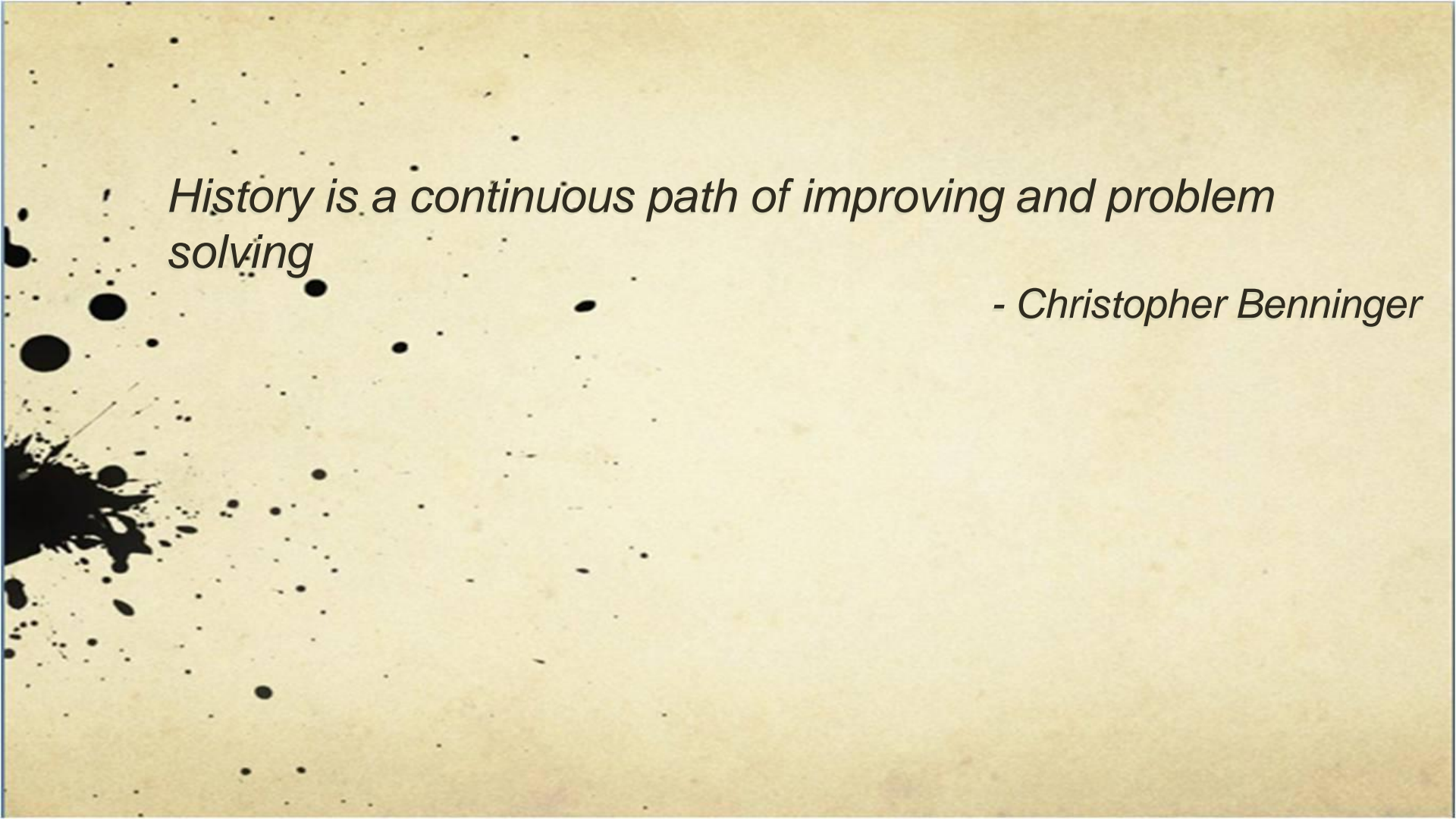
Most importantly.....OUR ACTIONS

Come,  
let's engage  
with the  
world around us

now....

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That's the bottom line.

The background of the image is a light beige, aged paper texture. It is decorated with numerous black ink splatters and dots of varying sizes, scattered across the surface. A larger, more dense splatter is visible on the left side, while smaller, isolated dots are spread throughout the rest of the page.

*History is a continuous path of improving and problem solving*

*- Christopher Benninger*

*Thank  
you*

