# Planning and design of greenhouse

**Planning of green house facility –**

**site selection, orientation,**

**Structural design and covering materials.**

- A **GREENHOUSE**, is basically the purpose of providing and maintaining a growing environment that will result in optimum production at maximum yield.

- They are the semi-permanent structures and the service life is of 10-25 years.

- It is supposed to withstand the loads like own weight, wind, snow, hanging basket etc.

# Site selection and orientation

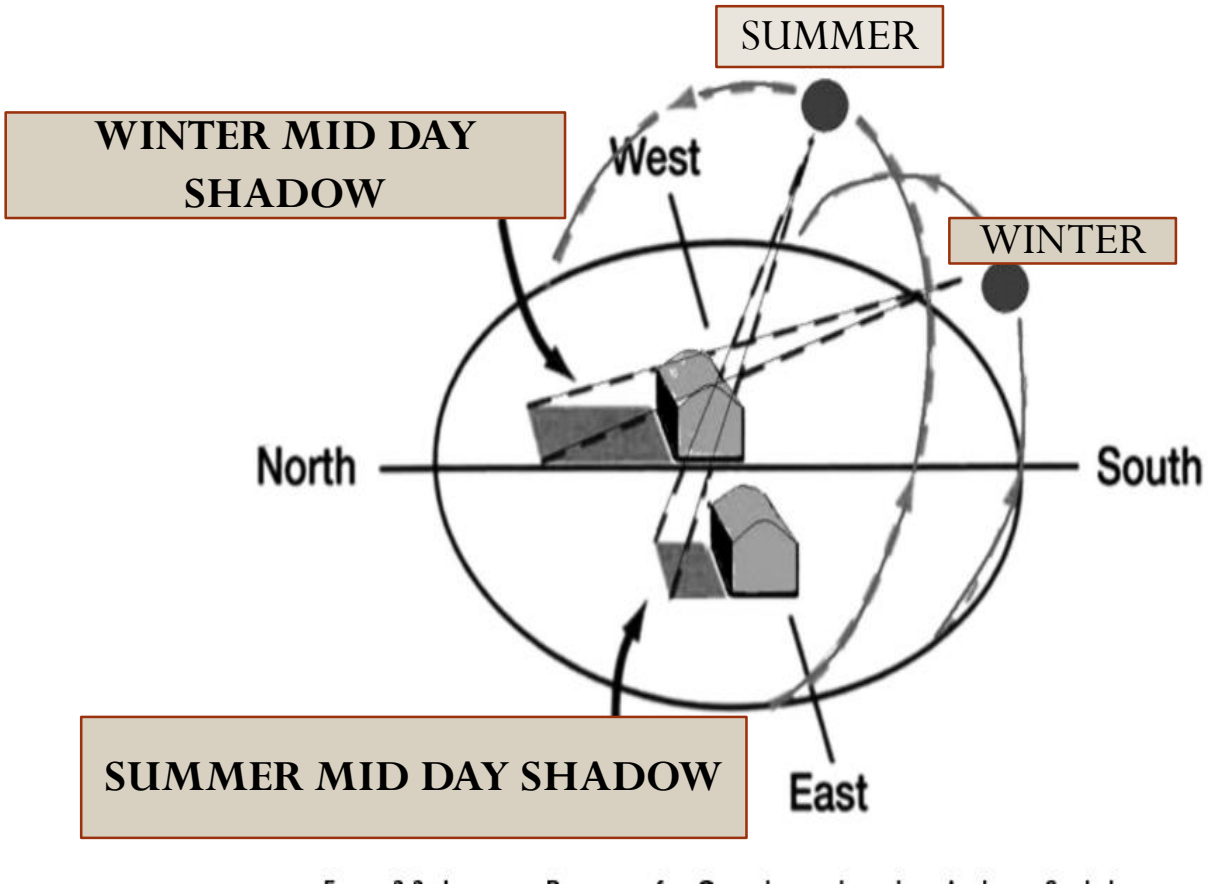
A greenhouse is designed to:

- It should withstand local wind, snow and crop loads.
- The building site should be on levelled ground.
- Site should be well aerated with good solar radiation.
- Good drainage system.
- Site should be with a natural windbreak.
- Irrigation water should be of pH 5.5-7 and EC between 0.1-0.3 mmhos/cm.

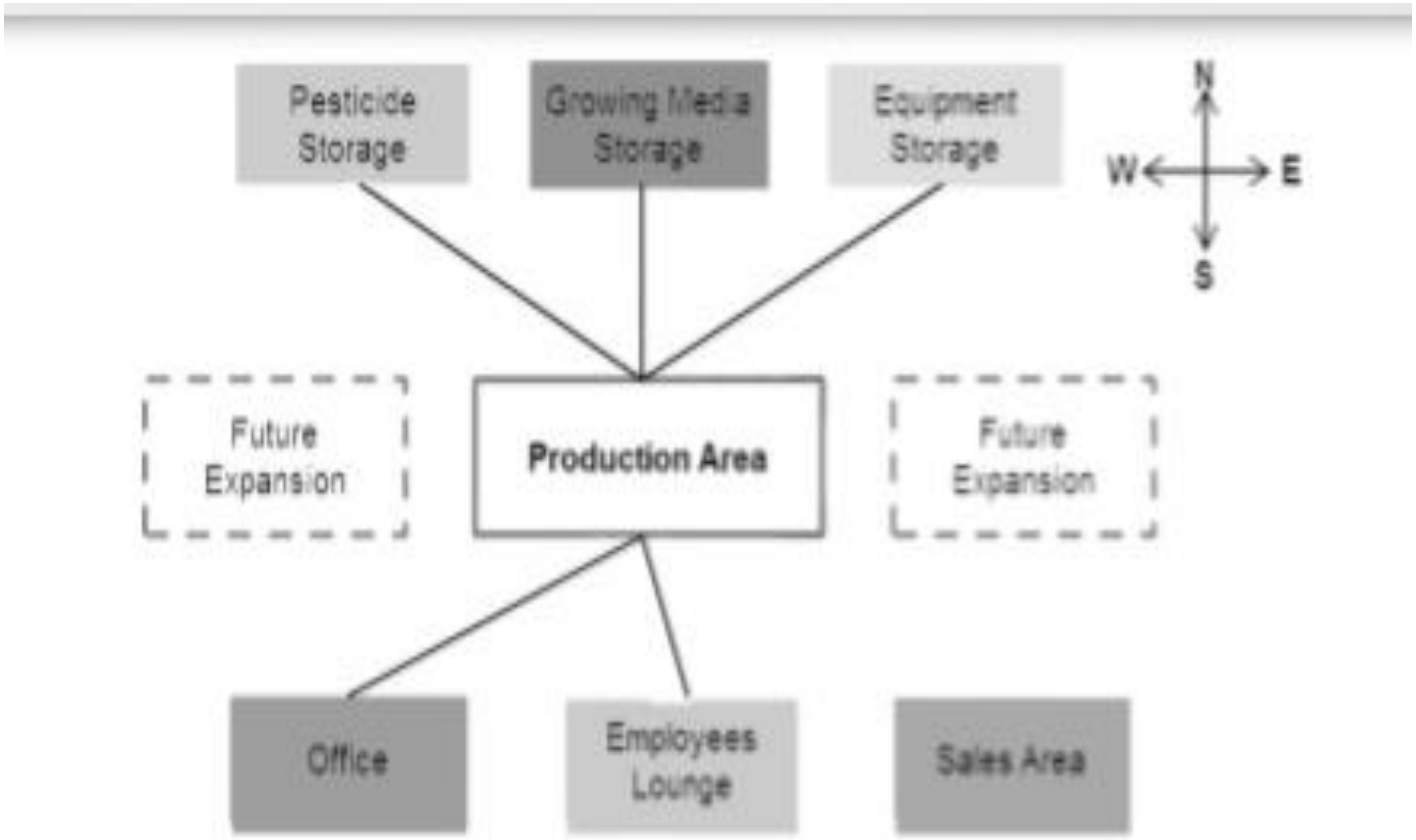
# Orientation

- Adequate solar intensity.
- Sufficient wind for efficient ventilation.
- Single span GH
- In cooler region must be designed with the ridge running East to West so that low-angle light of the winter sun can enter along a side rather than from an end where it would be blocked by the frame trusses.
- In warmer region it can be north-south direction since the angle of the sun is much higher.
- Naturally ventilated orientation- east-west
- It works better by wind ventilator.

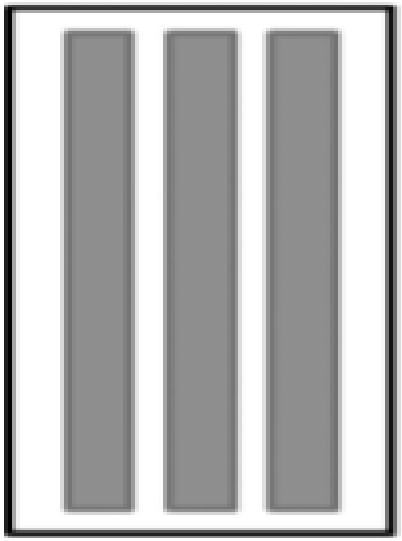
- Wind direction(summer) should be in south direction and in winter season in north direction.
- The wind breaks should be at least 30m away from the north and west of the greenhouse structure.


SUMMER
WINTER MID DAY SHADOW
West
WINTER
North
South
SUMMER MID DAY SHADOW
East

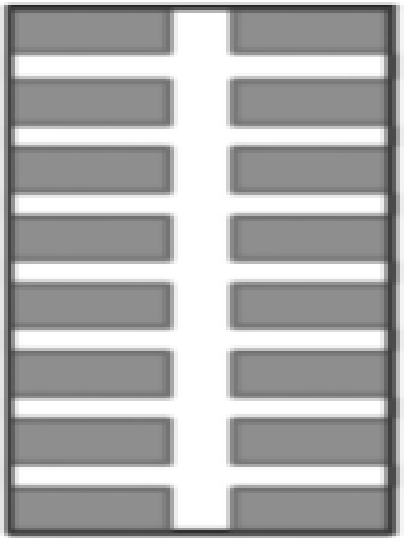
# LAYOUT OF GH WITH SUPPORT FACILITIES



# BENCHES AND BED ARRANGEMENTS



Longitudinal
Easy access
mechanization



Peninsular
Easy access
with maximum
growing area

Cross Benching
Easy access
but less growing
area

## Climatic factors for plant growth:

- Light intensity- 25,000- 50,000 lux
- Temp-

  Air temp- 18-25$^0$ C

  Soil temperature- 20-25$^0$ C.
- Relative humidity- 60% (desirable).
- $Co_2$ intake- (350-1000)ppm.
- Air movement & wind movement ( the inflow outflow ratio must be 1:1 per hour.
- Rainfall

# Structural design

- The most important function of the greenhouse structure and its covering is the protection of the crop against hostile weather conditions (low and high temperatures, snow, hail, rain and wind ), diseases and pests.
- The structural parts that can cast shadows in the greenhouse should be minimized.

# Size

- These **greenhouses** are defined by their independent structure and location.
- They can be any shape and **size**.
- However, the most common freestanding **greenhouse size** is **30 feet wide** and **96 feet long**.

# Height

- The height of greenhouse directly impacts natural ventilation, stability of the environment and crop management
- The ideal height is 3.5-4.5m and 5.5-6.5m in case of large GH.
- The side/gutter height should be 2.5-3m and 4.5-5m for small and large GH respectively.
- A multi-span GH can be constructed for an area more than $200m^2$ .
- Height of the GH having fan & cooling pad systems should be less than the naturally ventilated GH and in any case not more than 5.5m.

# Indian standards for greenhouse

- The BIS has formulated following standards with respect to greenhouse technology.

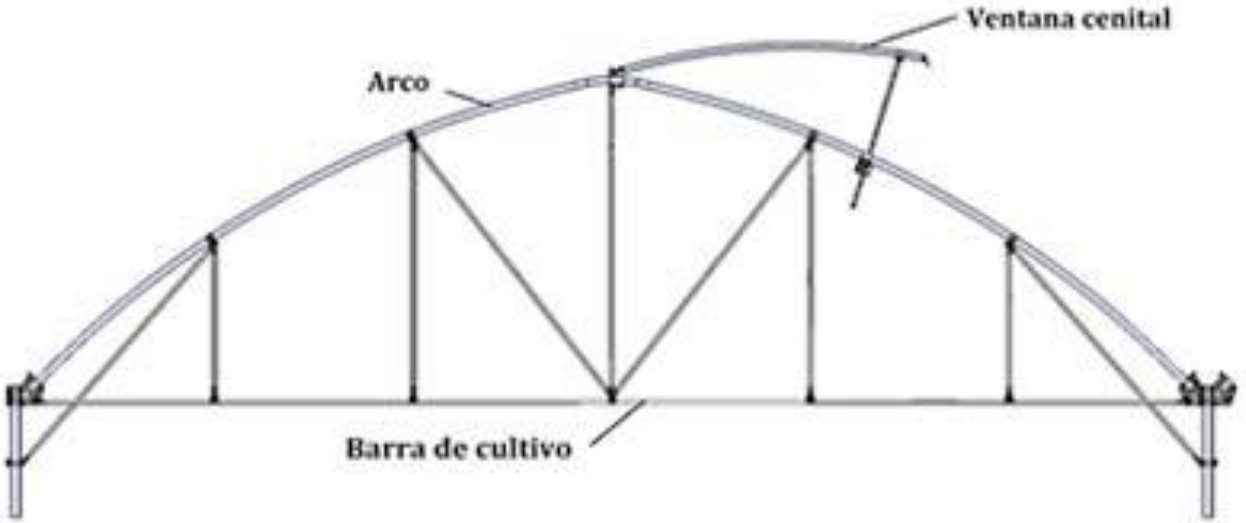
- **IS 14462:1997** - Recommended for layout, design and construction of greenhouse structures.

- **IS 14485:1998** - Recommendation for heating, cooling and ventilation of greenhouse.

# Structural designs of greenhouse based on the types of frames are:

- A straight side wall and an arched roof is the most common shape for a greenhouse, but the gable roof is also widely used.
- Both structures can be free standing or gutter connected with the arch roof greenhouse.
- The arch roof and hoop style greenhouses are most often constructed of galvanized iron pipe.

# Arch type green house

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# Gable roof type green house

# Hoop type green house

# Gothic type green house

# HOOP TYPE GREENHOUSE

- It is suitable for low growing crops, such as lettuce, or for nursery stock which are housed throughout the winter in greenhouses located in extremely cold regions.
- It can be designed to provide adequate side wall height without loss of strength to the structure.
- It is fabricated by bending the pipes or wooden stripes in a gothic manner.

- Greenhouse structures should be designed to resist a 130 km/h wind velocity.

- The actual load depends on wind angle, greenhouse shape and size, and the presence or absence of openings and wind breaks.

# Covering materials

- The following factors are to be considered while selecting the greenhouse covering material i.e.,

i. Light,
ii. Transmission,
iii. Weight,
iv. Resistant to impact, and
v. Durability to outdoor weathering and
vi. Thermal stability over wide range of temperatures.

**Before selecting the covering material, two important points should be taken into consideration:**

- The purpose of greenhouse.
- Service life of material.

- In temperate regions where high temperatures are required, the covering material with high light transmission and far IR absorption must be selected.
- Also the loss of heat by conduction should be minimum.

| SL NO. | COVERING MATERIAL | LIFE SPAN |
|---|---|---|
| 1. | **Glass and acrylic sheet** | **20 years** |
| 2. | **Polyethylene** | **2-6 months** |
| 3. | **Polyethylene stabilized for UV rays** | **2-3 years** |
| 4. | **Polycarbonate and fiberglass-** | **5-12 year** |

## The ideal greenhouse selective covering material should have the following properties:

1. It should transmit the visible light portion of the solar radiation to plants for photosynthesis.
2. It should absorb the small amount of UV in the radiation and convert a portion of it to fluoresce into visible light, useful for plants.
3. It should reflect or absorb IR radiation which are not useful to plants and causes overheat.
4. Should be of minimum cost.
5. Should have usable life of 10 to 20 years.

# The following materials commonly used to build frames for greenhouse are

- Wood,
- Bamboo,
- Steel,
- Galvanized iron pipe,
- Aluminum and
- Reinforced concrete (RCC)
- Glass
- Polyethylene film
- PVC film
- Tefzel $T^2$
- Polyvinyl chloride rigid panel
- FRP rigid panel
- Acylic and polycarbonate rigid panel

# Different loads acting on a GH.

- Dead load
- Live load
- Wind load
- Snow / Frost load

a) **Dead load:** Weight of all permanent construction, cladding, heating and cooling equipment, water pipes and all fixed service equipments to the frame.

**b) Live load:** Weights superimposed by use (include hanging baskets, shelves and persons working on roof).

- The greenhouse has to be designed for a maximum of 15 kg per square meter live load.
- Each member of roof should be capable of supporting 45 kg of concentrated load when applied at its centre .

- **Wind load**:  It depends on wind action.
- It creates upward thrust.
- ANSI code a 25 year of mean recurrence interval is taken.
- It depends upon the height of the building and location of the structure like urban, rural, open area etc.

- **Calculation of wind load:**
- Effective pressure of wind (q)= 2.37 ($v^2$ /$10^5$ )

  where,

  q=wind pressure( pa) and

  v= wind velocity (m/s).
- Load factor (W)= $q*q_p$

- $q_p$= external pressure acting at the level area

# Minimum values of GH design loads

| Sl. no | load | Minimum load (kg/cm$^2$ |
|---|---|---|
| 1 | Dead load | |
| | Pipe frames | 10 |
| | Cladding materials | 25 |
| | Crops likes tomato, cucumber | 20-25 |
| 2 | Live load | 15-25 |
| 3 | Snow load | 75 |
| 4 | Wind load | Site specific |