General design considerations

Structural provisions and loading

TOOLBOX

GREENHOUSE CONSTRUCTION AND SAFE OPERATION

Basic requirements

There are many greenhouse design considerations undertaken by engineers. It's important to have an understanding of these considerations to better plan, develop and operate your greenhouse so that it can safely support the specified loads.

High and medium technology greenhouses are usually designed by an experienced protected cropping engineering firm. However, low technology structures are often designed and certified by engineering service providers located closest to the farm and may not have adequate experience in designing greenhouses. For further information on the technology levels please refer to the Getting the basics right toolbox fact sheet in this series.

The table below outlines the types of considerations and relevant standards that engineers use when designing a greenhouse in Australia.

Table 1: Types and design consideration and relevant loading standards

CONSIDERATION	RELEVANT STANDARD
General	AS/NZS 1170.0:2002 Structural Design Actions – General Principles
General	AS/NZS 1170.1:2002 Structural Design Actions – Permanent, Imposed and Other Actions
General	AS/NZS 1170.2:2011 Structural Design Actions – Wind Actions
General	AS/NZS 1170.4:2007 Structural Design Actions – Earthquake Actions in Australia
General	Steel, aluminium, timber, concrete and glazing standards: - AS 4100 and AS 4600 Steel Structures - AS 1664 Aluminium Structures - AS 3600 Concrete Structures
Special	EN 13031-1 Greenhouses – Design and Consideration (European Standard used If wind loadings on structures cannot be appropriately estimated through the use of AS/NZS 1170.2 due to geometries not covered in the standard)
Special	Further research, which may include wind-tunnel testing to improve AS/NZS 1170.2 to include actions upon all relevant structures to Australia and its industries and to cover GRP support systems and international based design codes if applicable

Administrative issues

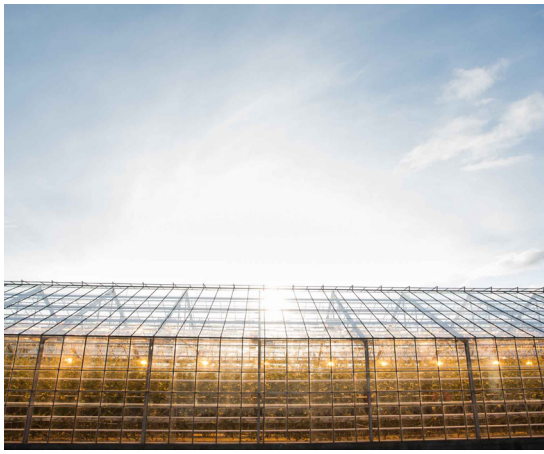
Design requirements

The manufacturer of the greenhouse or structure needs to know the following local information:

- Relevant local government area
- Determination of loads (e.g. roof live load, wind speed)
- Soil type and allowable pressure.

KEY MESSAGES

- There are many greenhouse design considerations undertaken by engineers, which are important in understanding how to better plan, develop and operate your greenhouse
- The administrative issues to consider include design requirements, required information on plans, additions and alterations, and load testing. These will inform the design methodology
- There are many types of loads on greenhouse structures. These include dead, live, collateral, plant, wind, flood and hydrostatic
- Engage a professional structural engineer with experience in the design and construction of greenhouse and grow structures, that has appropriate qualifications to practice in your state or territory



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Required information on plans

There is certain information that should be shown on construction drawings and plans. This includes, but is not necessarily limited to:

- Dead loads
- Roof live loads
- Collateral loads, which covers irrigation equipment, including water
- Plant loads
- Wind load, which includes basic wind speed 3-second gust, wind importance factor Iw and building category, wind exposure category, applicable internal pressure coefficient and prevailing wind direction, and design wind pressure on components and cladding
- Earthquake load, which includes seismic use group, spectral response coefficients (SDS and SD1), site class, basic seismic-force resisting system, design base shear, and analysis procedure
- Flood load if a structure is in a flood zone or overlay as indicated by the relevant local government.

Additions and alterations

Additions to existing greenhouses can be made provided the new structure does not make the existing structure unsafe. This relates to the percent of overstress in structure members, as well as the ability of the structure to withstand any loads superimposed by the greenhouse, including lateral loads due to attachment.

Alterations can be made to any greenhouse provided the new work complies with the current National Construction Code (NCC) and any loads imposed on the existing structure do not make it unsafe. It should be noted that such alterations may potentially require a further development application. Read the toolbox fact sheet Local government approval processes in this series for further information on additions and/or alterations.

Load testing

Load testing is usually not required unless specialty products such as cladding components have been used in construction. Any load testing must be undertaken by an independent approved testing agency.

Design methodology

The engineer needs to consider the following steps in designing the greenhouse:

- Allowable stress design versus strength design requirements
- Safety factors for greenhouse components
- Greenhouse classification
- Deflection and drift
- Reactions of the structure in fire (NCC Part CP1).

Types of loads

The different types of loads engineers need to consider and an explanation of each are outlined in the table to the left.

Table 2: Types of loads

LOAD	EXPLANATION
Dead (permanent)	Includes structure weight and cladding weight.
Live (imposed)	Includes imposed loads applied to the structure through general use, maintenance loading and temporary concentrated loads. Typically prescribed in a uniformly distributed load (kPa) or concentrated load (kN).
Collateral	Weight of support equipment used for the operation or maintenance of plant material, including: - Mechanical equipment such as irrigation, transfer systems, including water - Permanently mounted service equipment (heaters, fans, water lines)
Plant	Weight of supported or suspended plant material: - Hanging plants, 0.1 kPa minimum, applied as a concentrated load at the truss panel points.
Wind	The calculation of wind loading on the main windforce-resisting system and the components and cladding (including glazing) of the structure. Read the toolbox fact sheet Wind loads in this series for further information.
Earthquake	Uses maps, soil type and occupancy to determine the seismic design.
Flood and hydrostatic	Soil and hydrostatic pressure and flood loads (local government regulations will identify flood design zones).
Other	- Thermal expansion and the need for joints - Rainwater - Fire

Professional structural engineers

It is recommended that you engage a professional structural engineer with experience in the design and construction of greenhouses and grow structures. The structural engineer should also have the appropriate qualifications and certification to practice in your location, as these vary by state or territory as outlined in the table below.

Queensland and Victoria are the only Australian states to have legislation requiring registration to perform professional engineering services.

Table 3: Certification required for professional structural engineers by state and territory

STATE/TERRITORY	QUALIFICATIONS	REGISTERING BODY	TYPE
New South Wales	National Professional Engineering Registration (NPER)	National Engineering Registration Board (NERB)	Voluntary
	Professional Engineer – Chartered Professional Engineer (CPEng)	Engineers Australia	Voluntary
Victoria	Registered Professional Engineer (RPEng) Structural Victoria	Professionals Australia	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Queensland	RPEng Structural Queensland	Board of Professional Engineers Queensland (BPEQ)	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Western Australia	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
South Australia	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Tasmania	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Northern Territory	Certifying Engineer (Structural, Mechanical, Hydraulic)	Building Practitioners Board NT	Mandatory
	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary
Australian Capital Territory	NPER	NERB	Voluntary
	CPEng	Engineers Australia	Voluntary

IMPORTANT QUESTIONS TO ASK

- What experience does my engineer or designer have with protected cropping structures? Do they have the appropriate qualifications to practice in my state or territory?
- What design considerations and relevant standards do I need to consider in planning, developing or operating my greenhouse?
- Is the designer of my greenhouse aware of the necessary administrative requirements, such as local government regulations?
- Has the engineer adequately considered all the necessary loads in my greenhouse structure?

REFERENCES AND FURTHER READING

National Greenhouse Manufacturers Association (2010) Chapter 2 – Design Considerations, Pennsylvania, https://www.ngma.com/standardpdf/Chap22010.pdf

Engineers Australia (2017) National Engineering Register, https://www.engineersaustralia.org.au/national-engineering-register