

Chapter 3 – Structural Design

3.0 General

3.0.1 Design Overview

Greenhouse buildings are a complete structure including the structural support and enclosure elements.

The primary structural system includes:

- **The Primary Roof system** - This is typically a truss, rigid frame, arch or similar system
- **Secondary Structural System** - This includes bracing elements and enclosure support components such as purlins, glazing bars, ridge beam and gutters as well as girts. End wall framing may be a primary or secondary structural system. Many of these secondary components have several roles, supporting the glazing, dead and live load, as well as bracing a structure, and axial load.
- **Columns** - Columns, end walls, enclosing walls or other elements
- **Foundations** - The foundation may be spread footings, continuous concrete footings or flagpole type foundations placed directly in the earth. Sometimes the flagpole type footings may be backfilled with concrete or other fill. In greenhouse design, flagpole type footings are usually designed as unrestrained foundations. Where there is a slab on grade present, a restrained pole footing may be used. Such a footing requires a positive "loop" tie that extends into the slab and around the pole, and the pole footing cannot be isolated by an expansion joint.
- **Cladding** - Cladding may be of many materials including glass, polycarbonates, fiberglass or polyethylene. Cladding support and fastening systems vary by material. Cladding is not part of the structural system and is not covered in this structural design manual. Cladding, and its design criteria, is discussed at length in a separate document.

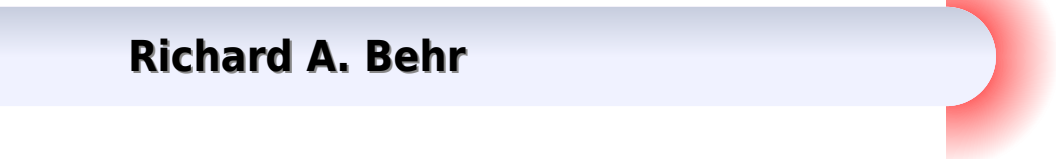
3.0.2 Structural Design

The IBC requires all buildings to have a rational analysis. Rational engineering analysis is a computational analysis, either by hand or computer, that uses accepted load distribution and determination methods. Such analysis shall follow acceptable engineering practices. Where the code is non-specific in the method of analysis, as with trusses vs. arches, the engineer shall analyze the system using a method acceptable to the approving authority. Thus, each engineer will analyze the system using an accepted method. However, the detailed design must accommodate all the forces and moments on the individual members as discussed above.

Manual or graphical solutions are permissible if such analysis can account for the various unbalanced load or other special design requirements. For most structures a computer modeling type analysis will be necessary. Based on the typical greenhouse design, the sections herein

Ngma Structural Design Manual

Richard A. Behr



Ngma Structural Design Manual:

Greenhouse Engineering Ilhami Yildiz, 2021-05-23 Sustainable energy development concept requires and maintains multiple linkages among energy production energy consumption human well being and environmental quality Greenhouse Engineering Integrated Energy Management puts forward the concept of integrated energy management and modeling pertinent to greenhouses that will eventually help reduce the load on power grids demand for fossil fuels and water and supply CO₂ for the greenhouse production This book helps enhance the competitive position of the global greenhouse industry by introducing economically environmentally and socially sustainable technologies and management strategies Exclusive title on integrated energy management approach for greenhouse designing Addresses energy for heating concept Includes case studies from real work greenhouse systems Incorporates a design energy management approach Contains updated material on greenhouse heating with examples and case studies Aimed at researchers professionals and students in the fields of energy systems mechanical agriculture and biosystems engineering

Controlled Environment Engineering Ilhami Yildiz, 2025-12-15 This integrated book introduces broad engineering concepts and relevant physiological principles and environmental parameters and demonstrates in a step by step approach how controlled environment engineering knowledge can be put in use in designing plant animal and aquatic bioenvironmental systems It covers integrated energy and waste management approaches and clean energy technologies including real world case studies and complete design examples with state of the art technologies and updated material globally Provides exclusive material on plant animal and aquatic systems engineering and relevant waste management systems in a single book Introduces broad engineering concepts relevant physiological principles and environmental parameters Incorporates a design and integrated energy and waste management approach Demonstrates how controlled environment engineering knowledge can be put in use in designing plant animal and aquatic production facilities Includes calculations and controlled environment design examples including homework problems This book is aimed at researchers and graduate students in agricultural aquacultural and biosystems engineering control systems aquaculture and agriculture

Architectural Glass to Resist Seismic and Extreme Climatic Events Richard A. Behr, 2009-09-14 Glass is a popular cladding material for modern buildings The trend for steel framed glass clad buildings instead of those using traditional materials such as brick and concrete has inherent problems These include for example the performance of architectural glass in extreme climatic events such as windstorms and heavy snow loads and also during earthquakes This book reviews the state of the art in glass and glazing technology to resist failure due to these natural events Building code seismic requirements for architectural glass in the United States are considered first of all followed by a chapter on glazing and curtain wall systems to resist earthquakes The next two chapters discuss snow loads on building envelopes and glazing systems and types and design of glazing systems to resist snow loads Wind pressures and the impact of wind borne debris are then considered in the next group of chapters which also review special

types of glazing systems to resist windstorms A final chapter reviews test methods for the performance of glazing systems during earthquakes and extreme climatic events With its distinguished editor and team of contributors Architectural glass to resist seismic and extreme climatic events is an essential resource for architects structural civil and architectural engineers researchers and those involved in designing and specifying building glazing and cladding materials in areas where severe windstorms snow and earthquakes are a threat Considers the state of the art in glass and glazing technology to resist failure due to extreme climatic events Reviews specific building techniques and test methods to enhance glazing performance during snow storms wind storms and earthquakes

Greenhouse management & production ,1995 **A Manual of Facts on Concrete Masonry** ,1966 Sweet's General Building & Renovation ,1999 *Transactions of the ASAE*. American Society of Agricultural Engineers,1979 Geothermal Training in Iceland ,1996 **Scientific and Technical Organizations and Agencies Directory** Margaret Labash Young,1987 **Annual Report - Director-General, Mines and Energy** South Australia. Department of Mines and Energy,1993 Western Machinery and Steel World ... ,1954

Geophysics and Geochemistry at the Millenium Arnis G. Gubins,1997 Design Manual ,1967 **Structural Design** ,1978 Structural Engineering United States. Naval Facilities Engineering Command,1980 **Manual of Structural Design** Jack Singleton,1947 Structural Design James R. Underwood,Michele Chiuini,1998 Structural Design presents the conceptual and practical underpinnings of basic building design and technology in a single comprehensive source It provides essential coverage of the integral relationships of structural architectural form and spatial organization and an understanding of the impact of load configurations and other key determinants of design Essential principles as well as structural solutions are visually reinforced with hundreds of architectural drawings photographs and other illustrations making this book truly architect friendly Ideal for use as a general and technical reference in the design studio as a study aid for the architectural registration exam or as an office resource Structural Design is a superb companion for the architecture student and practicing professional It includes In depth coverage of steel wood reinforced concrete and masonry including lateral force generation and design Over 1 000 illustrations and photographs Real world examples sample problems and useful references throughout Conventional and SI unit systems

Structural Engineering ,1980 Structural Design Criteria for Buildings ,1992 *Structural Engineering Reference Manual* Alan Williams,2005 Complete review for the NCEES Structural I and II exams and the California state structural exam Includes practice problems and step by step solutions Updated to reflect new codes tested on the exams

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