TERMS OF REFERENCE FOR R&D PROJECT

Food and Agriculture Department

Agricultural Systems and Management Sectional Committee, FAD 22

1 Title of the Project

Study on Structural Stability and Design Specifications of Greenhouse Structures for different wind zones of India

2 Background

2.1 Bureau of Indian Standards has developed two important Indian Standards pertaining to greenhouse cultivation such as IS 14462:1997 'Recommendation for layout, design and construction of greenhouse structures' and IS 14485:1998 'Recommendations for heating, ventilation and cooling of green houses', which can be accessed at https://standardsbis.bsbedge.com/ free of cost.

2.2 A typical greenhouse in India is basically steel tube structure covered by UV stabilized polythene sheet on top and insect proof screen on sides. However, due to non-availability of scientific standards, there is frequent structural failures of greenhouse across India. Overall greenhouse design is strongly influenced by the climate. Moreover, various load requirements depend on climatic conditions. This is reflected in various European National standards which is missing in Indian context. Much research has not been done so far in the way of analysing the various types of loads and its distribution in the greenhouse. Existing Indian Standards, IS 14462:1997 and IS 14485:1998 also do not provide a methodology for the design of greenhouses under varying environmental conditions. Therefore, the design is more or less empirical.

2.3 Considering the above, the sectional committee decided to conduct a detailed study on greenhouse structuring along with design specifications and conduct a controlled study on greenhouse design through wind tunnel test for generating requirements suitable for different wind zones of India. A typical wind-tunnel test is done to evaluate structural loading on a structure by simulating the natural wind environment in the tunnel, including profiles of mean speed and turbulence, including both the far field (ambient approach conditions) and near field (the localized effects of nearby structures or topography).

2.4 Based on the recommendations and findings of the project, the necessary modifications, additions or deletions in the existing Indian Standards will take place. The rationale for the research project is to address the critical need for standardized greenhouse designs that can effectively withstand varying wind conditions across different geographic regions.

More information on rationale and relevance of the project is provided at Annex A.

3 Objective of the Project

To develop the design and structural specifications for greenhouse for various wind zones of India using primary & secondary research and wind tunnel experiment.

4 Scope

4.1 Study of existing literatures related to published research conducted, international/ regional guidelines & standards related to greenhouse structuring and design specification for different wind zones of India and any other relevant national/ international documents.

4.2 Collection of available design and structure recommendation available in India for different wind zones

4.3 Visit to at least one Laboratory/Research institute/Farms/Agriculture universities/Government facility having working greenhouse structure present in each wind zone of India for data collection.

4.4 Wind tunnel test experiment with Optimized dimensions of greenhouse structure and Geometric scaled down greenhouse.

4.5 Preparation of the technical report and provide recommendations in the form of requirements for standardization of design and structure of greenhouse for different wind zone

4.6 Comparative analysis of existing design and structural specification of greenhouse with the proposed recommendations after wind tunnel experiment.

5 Research Methodology

5.1 Study the existing literatures related to published research conducted, international/ regional guidelines & standards related to greenhouse structuring and design specification for different wind zones of India and any other relevant national/ international documents.

5.2 Conduct pan India data collection on available greenhouse structuring and design specifications for different wind zones of India through secondary as well as primary survey using structured questionnaire and structured interview.

5.3 Conduct primary survey through structured interview/ structured questionnaires with various stakeholders during visit to at least one Laboratory/Research institute/Farms/Agriculture universities/Government facility having working greenhouse structure present in each wind zone of India for data collection. The survey should focus on ongoing researches, existing design and structure specifications, related issues, recommendations for design & structure, if any.

5.4 Conduct primary survey through structured interview/ structured questionnaires with at least 2 large scale and 2 small-scale commercial stakeholders (Industry, consulting firm) involved in greenhouse development projects in different parts of India for collection of information/database on existing design and structure specifications, related issues, recommendations for design & structure, if any.

5.5 Conduct the wind tunnel testing experiment on greenhouse model which includes Geometric scale down of greenhouse, Simulation of suitable terrain wind characteristics to a selected geometric scale in the wind tunnel, Wind pressure measurements on scaled model of green house, Evaluation of mean external pressure coefficient for various angles of wind incidence based on technical report, Preparation of the technical report and provide recommendations in the form of requirements for standardization of design and structure of greenhouse for different wind zone.

5.6 Conduct the comparative analysis of existing design and structural specification of greenhouse in different parts of India with the proposed recommendations after wind tunnel experiment.

5.7 Prepare the report which includes research findings and data collected as per the deliverables of this project.

6 Deliverables

Detailed project report of the work done, in hard copy and digital formats, as per the scope specified under 4, with the following as appendices:

a) Research findings and data collected through the secondary as well as primary study.
b) Design and structural requirements of a structural safe greenhouse for different wind zones of India as per findings of wind tunnel experiment along with the details of the method used, calculation formula used, environmental factors used, any other relevant information.
c) Information on available structural and design specifications of existing greenhouses as per different wind zones of India.
d) Engineering drawings/layout for various structures/ designs of greenhouse recommended in the report.
e) Comparative analysis of existing structural as well as design requirements of greenhouse with the recommended specifications.
f) Any other requirements for a safe and effective greenhouse design in addition to requirements provided under IS 14462:1997 'Recommendation for layout, design and construction of greenhouse structures' and IS 14485:1998 'Recommendations for heating, ventilation and cooling of green houses.
g) Challenges faced and suggested forward path.

7 Timeline and Method of Progress Review

7.1 Timeline for the project is 6 months from the date of award of the project.

7.2 Stages of review

Stage	Timeline
Stage I : Review of the literature and existing stipulations, visit to stakeholders in different wind zones of India, complete plan for wind tunnel experiment	Second Month
Stage II : Database creation for existing structural and design specification of greenhouses in different wind zones of India and completion of wind tunnel experiment. Submission of interim report to Sectional Committee at the end of fourth month for review.	Third Month to Fifth Month
Stage III :	End of Fifth Month

Draft report submission – Sectional Committee will evaluate the draft report and provide feedback/recommend changes, if required.	

At the end of 6th month, project allottee to submit final project report incorporating recommendations/feedback of Committee.

***Note**: The timelines given above are indicative and calculation of time will start from the date of award of sanction letter for the project to the Project leader.*

8 Support from BIS

8.1 Access to Indian and International Standards

8.2 Letters from BIS to concerned stakeholders for support in research project.

9 Nodal Officer

Shri Debasish Mahalik, Scientist-B/ Assistant Director, FAD, BIS may be contacted at fad22@bis.gov.in for any queries on the research project

Annex A

A.1 Rationale /Need of Project

The rationale for the project "Developing Wind Tunnel-Tested Standardization for Greenhouse Structures Across Different Wind Zones" is to address the critical need for standardized greenhouse designs that can effectively withstand varying wind conditions across different geographic regions. This project is essential for several reasons:

1. Regional Variation in Wind Conditions: Wind patterns and speeds can vary significantly from one geographical area to another. Greenhouses in different locations face unique challenges related to wind, including gusts, sustained high winds, or occasional storms. Standardized designs currently in use may not provide optimal solutions for all these scenarios.
2. Agricultural Sustainability: Greenhouses play a vital role in modern agriculture, allowing for year-round crop cultivation and protection from adverse weather conditions. However, the structural integrity of these greenhouses is essential to ensure the safety of both crops and personnel. Standardization based on wind tunnel testing can enhance greenhouse resilience, contributing to sustainable food production.
3. Cost Efficiency: Developing region-specific greenhouse designs can lead to more efficient use of materials and construction methods, reducing overall costs. By tailoring structures to local wind conditions, it is possible to avoid over-engineering in some areas while reinforcing others where needed, optimizing resource utilization.
4. Risk Mitigation: In areas prone to high winds or storms, the risk of greenhouse damage or collapse is significant. Standardization based on wind tunnel testing can help mitigate this risk by providing guidelines and design principles that account for local wind patterns, ultimately reducing the likelihood of structural failure.
5. Environmental Impact: The construction and maintenance of greenhouses have environmental implications. By optimizing designs to withstand wind conditions efficiently, greenhouse structures can potentially have a reduced environmental footprint, including lower energy requirements for climate control and reduced waste from repairs and replacements.
6. Knowledge Transfer: The project aims to generate valuable data and knowledge that can be shared with greenhouse designers, engineers, and agricultural practitioners worldwide. This knowledge transfer can contribute to a broader understanding of greenhouse design and its adaptation to varying environmental conditions.

In summary, the project seeks to enhance the resilience, sustainability, and cost-effectiveness of greenhouse structures by developing standardized designs based on wind tunnel testing. By addressing the unique challenges posed by different wind zones, the project aims to ensure the long-term success and safety of greenhouse agriculture in various regions.

A.2 Relevance of the study

According to the Intergovernmental Panel on Climate Change (IPCC), if average atmospheric temperatures rise by 2°C, global food production potential will decline and particularly it will be pronounced in lower-latitude tropical regions. The combined effect of increasing population growth, strong income growth vis-à-vis limiting natural resources and changing climate necessitates control environment agriculture (CEA) and greenhouse is one such example. The India Greenhouse Horticulture market held a market value of USD 190.84 Million in 2021 and is estimated to reach USD 271.25 Million by the year 2030. The market is expected to register a growth rate of 4.19% over the projected period. A typical greenhouse in India is basically steel tube structure covered by UV stabilized polythene sheet on top and insect proof screen on sides. However, due to non-availability of scientific standards, there is frequent structural failures of greenhouse across India.

In France, there are altogether different standards for different kinds of greenhouse such as glass, Multiplan, tunnel etc. (CEN 1995, CEN 2001 and CEN 2003). Similarly, in Germany, depending on the geometric shape of the building, appropriate aerodynamic coefficients is standardized for surface of every sector of the structure. Moreover, in Greece, financing of greenhouses is subjected to approval of the structural design as per greenhouse specification with clear cut mention in the concentrated vertical load at various nodes, crop loads for various crops etc. In Italy, the building rules are adjusted for greenhouse despite the fact that building characteristics and uses are quite different from those of greenhouse. In Netherlands, since storms are frequent causes of damage so a testing authority was set up to verify design calculation and to test specific construction details experimentally. Overall greenhouse design is strongly influenced by the climate. Moreover, various load requirements depend on climatic conditions. This is reflected in European National standard which is missing in Indian context. Much research has not been done so far in the way of analysing the various types of loads and its distribution in the greenhouse. Existing Indian standards (IS 14462:1997- Recommendation for layout, design and construction of green house) unlike Eurocodes do not provide a methodology for the design of greenhouses. Therefore, the design is more or less empirical.

Hence, there is an imperative demand to engineer the greenhouse on structural considerations for a greenhouse. The output of the study will benefit for the regional development of agriculture in the country in the changing scenario of climate by providing standardized guidelines for structural design of greenhouse. The systematic application of the proposed design methodology for specific greenhouse systems is expected to allow for developing better-designed location specific greenhouse.