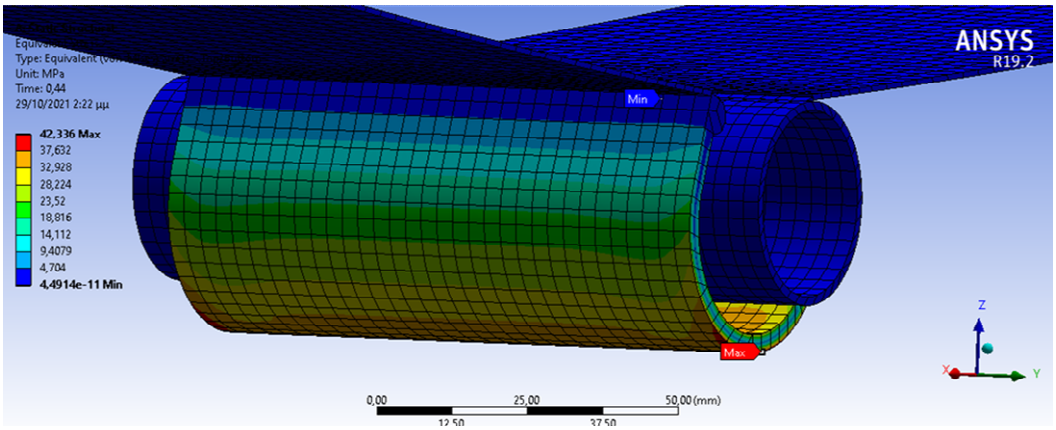
Institute of Steel Structures

School of Civil Engineering

National Technical University of Athens

Design optimization of steel structures for nethouse systems



Master Thesis

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1.Project Objectives and goals

This research work investigates an integrated design methodology for nethouse systems that incorporates an innovate overload release mechanism. Nethouses are lightweight steel structures that intent to protect the high value horticultural production against climatic actions. By now, there is no European or International design Standards for nethouses and they are constructed following empirical procedures. In particular, the weakness of design standards focuses on determining wind pressures on a permeable structure such as a nethouse as well as the lack of commentary on the inability of such structures to carry significant snow loads. As a result, the majority of the installed nethouses are either unsafe or overdesigned structures. This study aims to investigate the ability of the nethouses to be installed in areas where significant snow loads are forecast. The static behavior of tensile nethouse structures is investigated and through a holistic parametric and comparative analysis the influence of each structural design parameter (cable prestressing, inclination of cables) is indicated. In addition, nethouse under snow loads, without being supported by an expensive structural system should be designed with an innovative overload release mechanism to get rid of the sudden overload with safety. The conceptual design of the release mechanism is given and numerical models of gradual complexity are developed to predict the load level of the release, examining several geometrical configuration of its components.

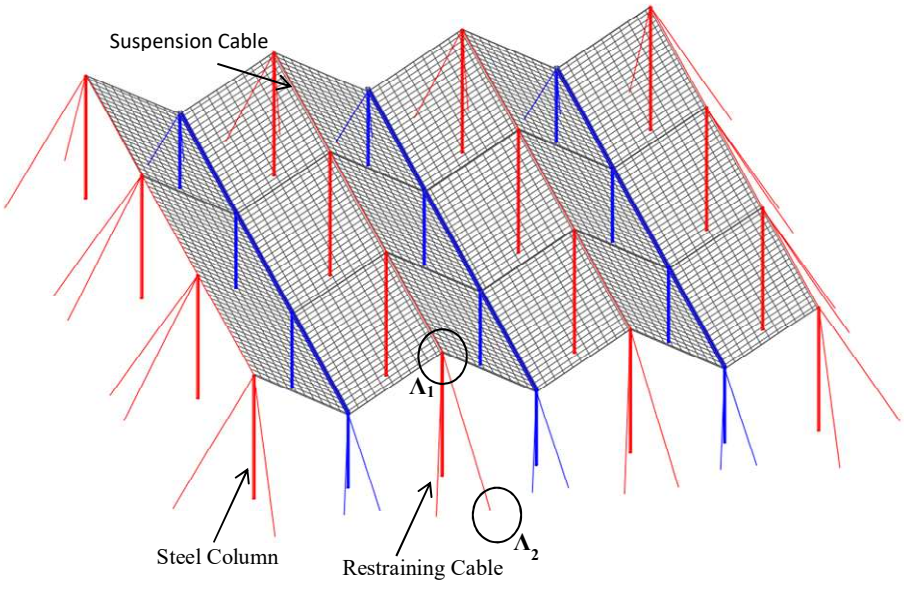

Figure 1. Tensile structure for nethouse system

2.Description of method -Results

The analysis should take into account the transient construction phase including the sequential placement of the members, the pre-tensioning of the cables and the final form finding of the geometric structure. In order to predict the actual collapse load of the slender steel nethouse support systems, a nonlinear analysis should be performed. The prediction of collapse, especially when cables are involved in the static system, is a highly nonlinear phenomenon and the elastic linear analysis is inappropriate. Collapse may occur due to exceeding the developed stresses beyond the material capacity at certain cross section, a condition known as material nonlinearity, or due to buckling, associated with an steep increase deformation for a small increase in imposed load, a condition known as geometric nonlinearity.

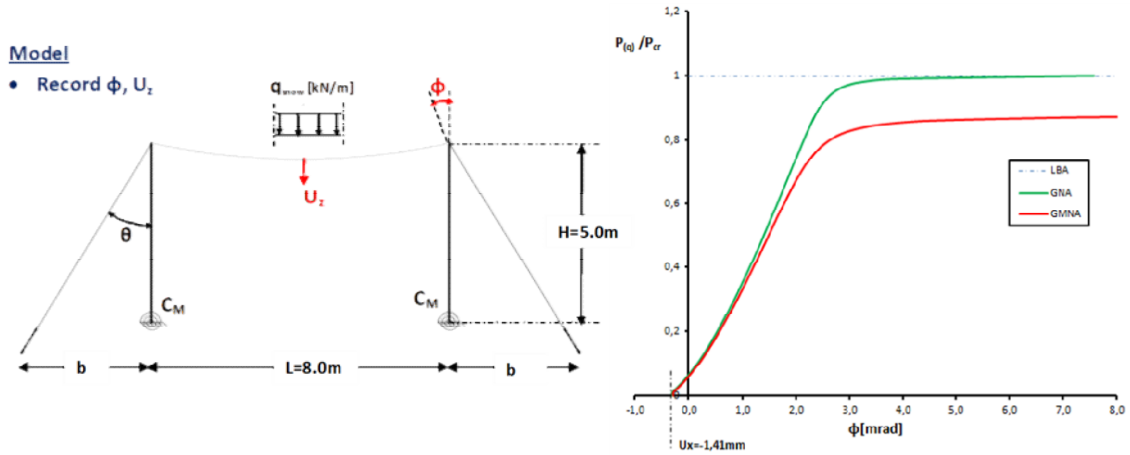

Figure 2.a) Finite element model b) Investigation of nonlinearity

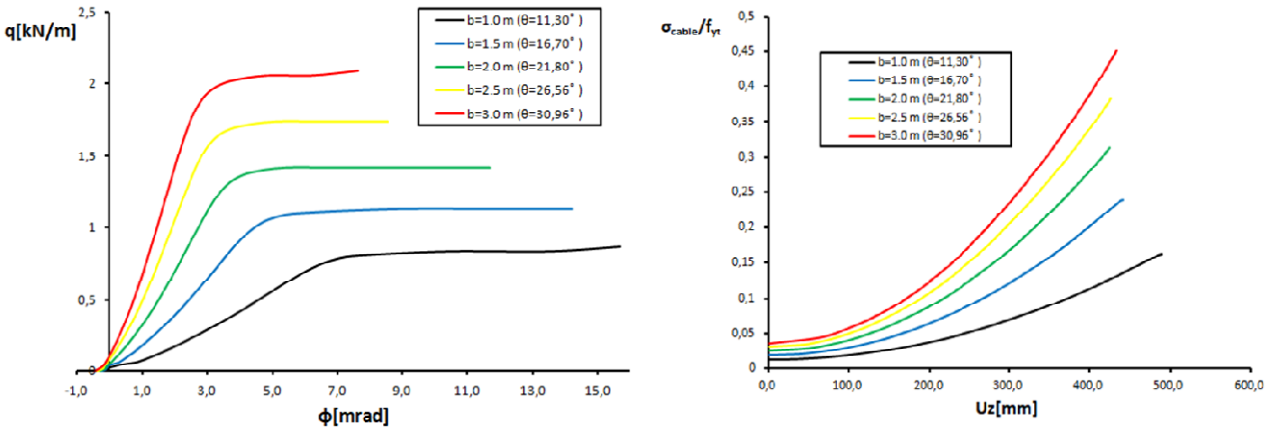

Figure 3.a) The influence of increasing of anchor distance a)of column b) of suspension cable

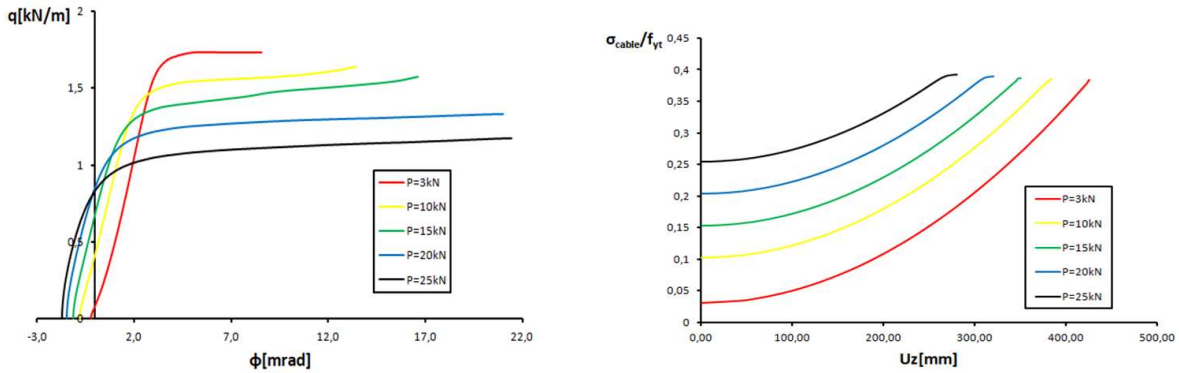

Figure 4.a) The influence of prestressing magnitude a) of column b) of suspension cable

The release mechanism should be composed of distinct components while its operation should be as simple as possible. The incorporated mechanism must be able to deform as the load increases and release the accumulated load automatically, without human intervention, when the load exceeds a predefined limit-value.

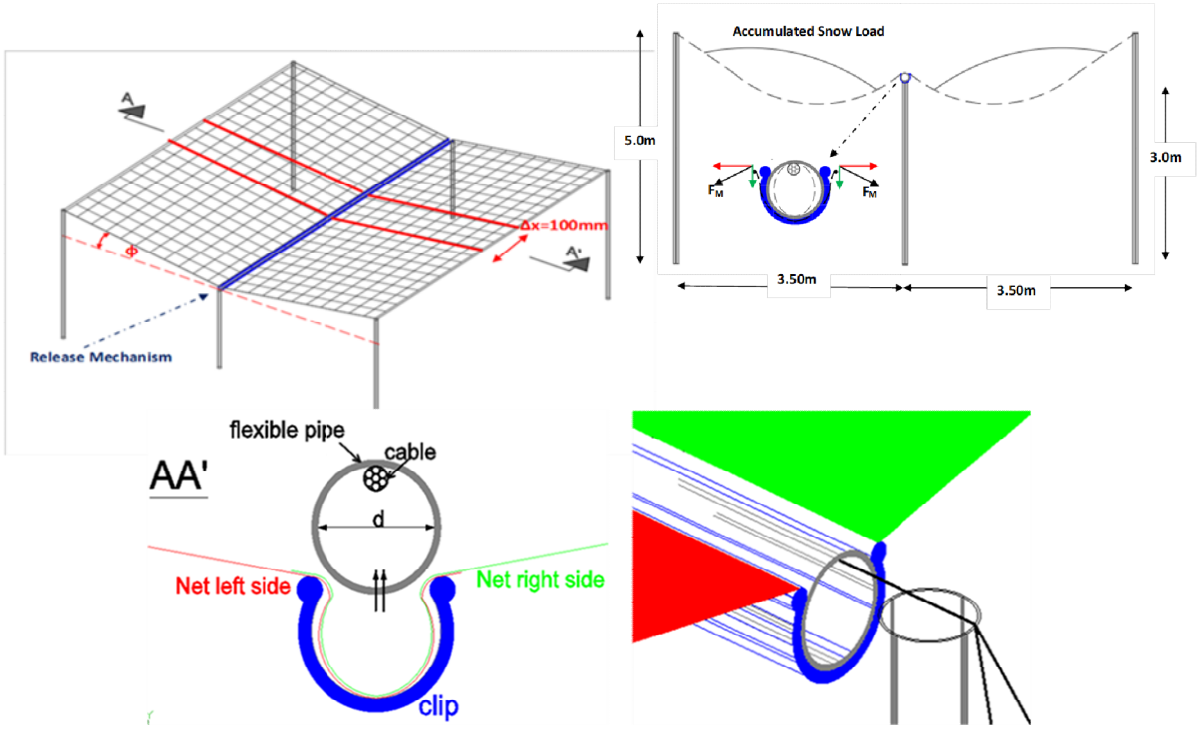

Figure 5 The position, the deformed shape and the components of the release mechanism.

In order to examine the static behavior of the release mechanism two different finite element model in Ansys software is created. Basic assumption of first model, is that the clip is considered pinned for the purpose of directly evaluating the resistance of the clip to the opening and the second is a advanced contact model.

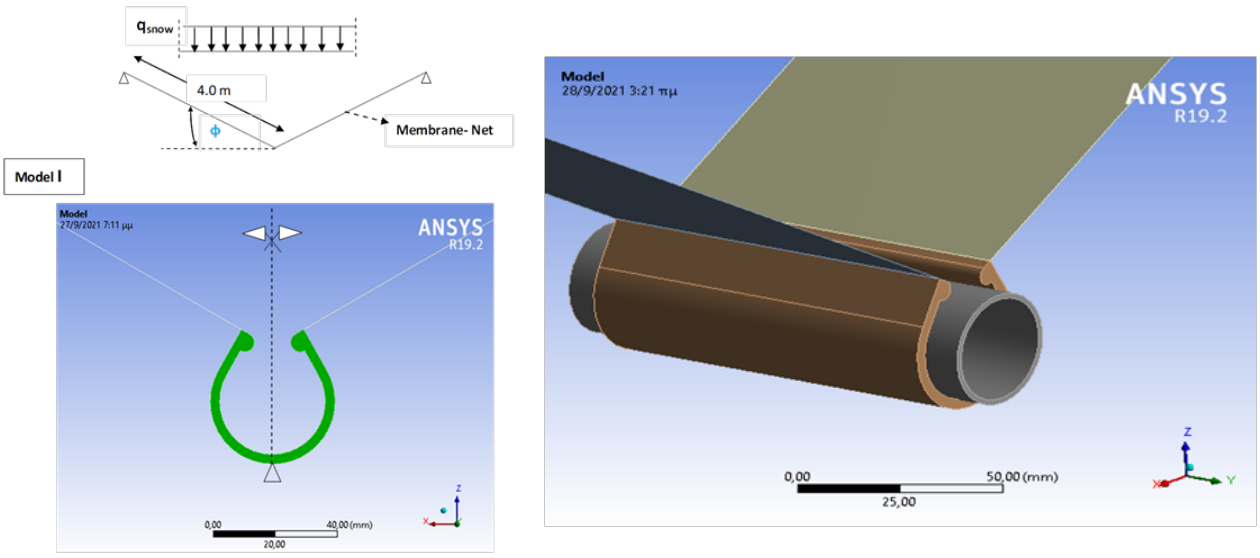

Figure 6. a) Simply supported and **b**) contact model

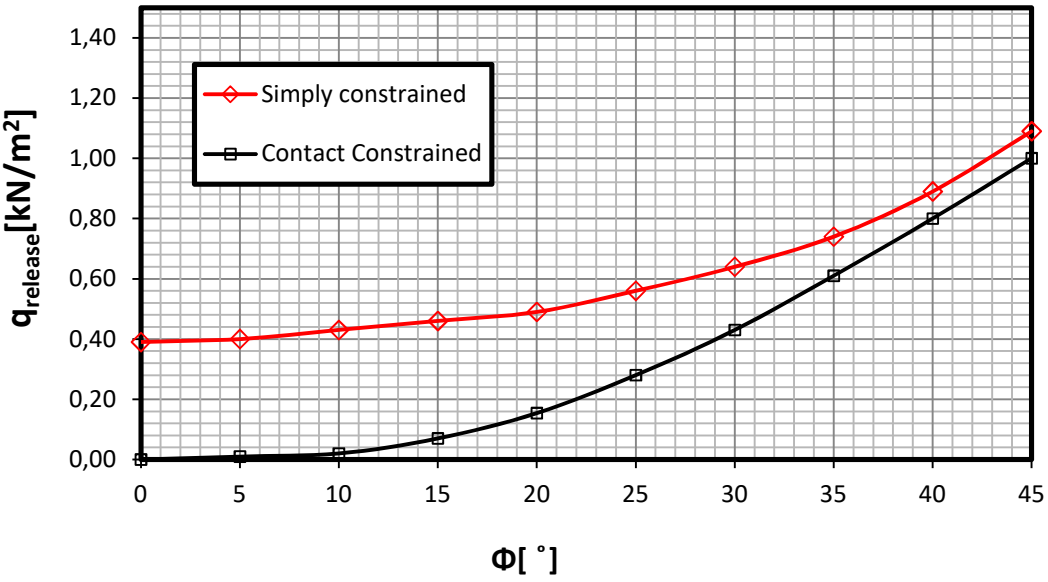

Figure 7. Comparison of the simply and contact supported Model for different angles of duopitch nethouse.

The desired outcome of the innovative design of the release mechanism is the structural independency of the mechanism, which will ensure that the bearing members of the main structure (cables, columns, etc.) will not have to be modified in order to include the release mechanism or to carry the extra snow/hail loads. Such a design would render the release mechanism applicable for the entire Greek territory, irrespective of the local climatic conditions.

References

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