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Parametric Study on Deployable Membrane Structure

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ABSTRACT: *The Analysis of frame supported Deployable membrane structures is done. The parametric study is carried out on the structure considering the structure as deployable anywhere in India. For this purpose the wind loads are calculated for all wind zones from 33m/sec to 55m/sec basic wind velocity specified in I.S.875 (part 3)-1987.the loads are calculated as surface pressure and are applied over the surface of membrane modeled as membrane shell element. The element output from SAP 2000 v9.0 for the elements identified as critical under the action of axial forces is obtained. The element output is checked for the capacities of the section under the action of tension and compression.*

I. INTRODUCTION

The author [1] describes about the importance of the Seismic and Wind load for the Temporary Structures. The author has provides the related studies carried out, some of these studies mentioned here are The California Department of Transportation CALTRANS provides a definition for temporary structures and defines a temporary structure as one with a life of less than five years. CALTRANS specifies that their definition for temporary structures does not cover falsework CALTRANS 2004.CALTRANS and AASHTO have specific provisions on the design loads for temporary structures. However, outside of highway structures, and with the exception of SEI/ASCE 37-02 ASCE 2002 , there are not enough guidelines and/or design procedures that would specifically address temporary structures and cover their variety. The calculation of earthquake load is recommended per provisions specified in ASCE7-95 ASCE 1995. Outside of these recommendations, the effect of reduced service time, which is a distinct feature of temporary structures, on selection of a design earthquake and wind load is not covered in detail and would still require additional investigations.

The author of the guide in this chapter no.7 [3] “Design Loading Conditions” for Tensile Structures suggested the loading to be applied on the Tensile structure. The following are the loads which are to be considered while analyzing Tensile Structure:

Prestress: The level of prestress in a membrane surface affects all the elements within the supporting structure (masts, frames, cables etc.). Prestress is an inherent part of its structural behaviour. The prestress levels are chosen as a result of the “form finding” process, and have to be achieved and sustained during the erection and life of the structure. These forces have to be included in all other load cases.Long term effects, such as creep of the membrane material may alter prestress levels. Foundation settlement may also, though rarely, be an influence. These effects must be considered and appropriate measures taken to ensure the retention of sufficient prestress.

Self weight: The self weight of the membrane is commonly between 0.7 and 2.0 kg/m2.

Wind: The site wind speed and dynamic pressure can be derived as described in EC1, part 2.4

Snow: Ground snow load should be investigated using guidance from EC1. For long-span structures, it is recommended that the ground snow load be investigated using available data from the local meteorological office. In areas not subjected to snow loads, a nominal uniformly distributed load of 0.3kN/m2 should nevertheless be considered. This figure may be reduced for structures with spans over 50m by applying a detailed statistical investigation accounting for loading by rain, fallen leaves, sand/dirt etc.

Temperature :Temperature effects in respect of overall structural behaviour and load analysis are usually found to be less significant on fabric structures when compared with rigid construction. Temperature change manifests itself in relatively small ± variation in prestress levels. However, temperature effects are more important for steel cable nets.

Seismic Loading: In general seismic loads are not a problem as membrane structures weigh so little and so will not pick up substantial acceleration forces under seismic action. Should the structure contain relatively massive components such as struts or connections, then these will be subject to accelerations under seismic loading.

Load Combinations: To take account of the large deflections of membrane structures, analysis has to be made using unfactored loads. It is very important that the results of a load combination are found by adding loads and then analysing, rather than analysing each load separately and then adding the results.

The prestress and self-weight loads should be part of all load cases. This is a deviation from the EC Codes as the self-weight of the membrane need not be reduced for wind uplift cases as it is negligible.

Example load cases to be considered:

a) self weight + prestress
b) self weight + prestress + snow
c) self weight + prestress + wind
d) self weight + prestress + wind (downward pressures) + snow
e) etc.

However, for load combinations including multiple imposed live loads (i.e. wind downward + snow) one of the applied loads might reasonably be reduced.

Deployable Membrane Structure

As the structure is deployable type the effect of wind zone on member forces in the frame to check the validation of F.O.S 1.0 was the objective of study.

PROBLEM STATEMENT

The Deployable Membrane Structure with following details was considered as shown in fig. 5.1

Total Length of Structure = 18m.
Total Width of Structure = 16m.
(c) Total Height of Structure = 6m.
(d) All Other Data such as Terrain Category, Topography etc. are kept relevant.

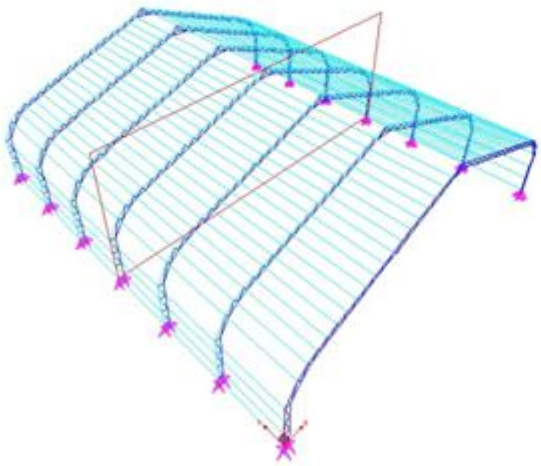
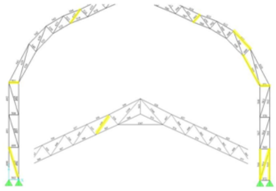


Figure. 1 Finite element model for deployable Frame supported tensioned membrane structure

Members Under Consideration

The members of the frame at critical locations in the rafter and column section were observed as shown in fig.2 these are applied with prefix as R and C for their identification as rafter and column members respectively.



Details at ridge of frame
Details of left part of frame (c) Details at right part of frame
Figure .2 (a),(b),(c) considered members at
critical locations of middle frame of structure

Analysis of Deployable Structure

The complete structure modeling was done in SAP 2000 v9.0. The frame is modeled with bar elements and the roofing membrane as membrane shell element. The loads are applied on the roofing membrane as surface pressure.

The following are the load combinations considered as per I.S.875 (part3) – 1987:

1.0 Dead Load + 1.0 Imposed Load
1.0 Dead Load + 1.0 Imposed Load +1.0 Wind Load
1.0 Dead Load + 1.0 Imposed Load -1.0 Wind Load

4. 1.0 Dead Load + 1.0 Wind Load
5. 1.0 Dead Load - 1.0 Wind Load

In the above load combinations it can be observed that the factor of safety for all loads is considered to be as 1.0. Because, as such no codes are available for the analysis and design of such type of structures throughout the world. But a European group by the name Tensinet has prepared a design guide for the analysis of Tensioned membrane structures. The factor of safety 1.0 has been suggested in Chapter No. 7 of [3].

In order to study the wind zone effect on these structures the design wind pressure was calculated for all six zones of basic wind velocities as per [2] with the use of prepared spread sheets. The analysis result in terms of axial forces in the Main, Inclined and Vertical members in rafter and column of the frame for all load combinations when structure is in zone of basic wind velocity 33m/sec, 39m/sec, 44m/sec, 47m/sec, 50m/sec and 55m/sec.

The maximum values of axial tension are tabulated and checked in Table 1 and 2 respectively. Similarly, the maximum values of axial compression are tabulated and checked in Table 3 and 4 respectively. The sections used in for frame is shown in Fig. 3 and 4.

Table.1 Maximum Tension force

MAX. AXIAL FORCE TENSION (in kN)												
MAIN ELEMENT					INCLINED ELEMENT				VERTICAL ELEMENT			
Vb (m/sec)	R589	R611	C560	C566	R632	R646	C495	C565	R571	R593	C501	C571
33	50	43	46	46	11	12	48	49	22	11	22	22
39	62	45	57	48	13	13	51	51	27	12	27	27
44	75	46	69	50	16	13	55	53	33	12	33	33
47	81	47	75	51	17	13	56	53	36	12	36	36
50	90	48	84	52	19	14	59	54	40	13	40	40
55	101	50	94	54	21	14	62	55	45	13	44	45

Table .3 Maximum Compression force

MAX. AXIAL FORCE COMPRESSION (in kN)												
MAIN ELEMENT					INCLINED ELEMENT				VERTICAL ELEMENT			
Vb	R589	R611	C560	C566	R632	R646	C495	C565	R571	R593	C501	C571
33	-80	-27	-83	-28	-17	-8	-30	-25	-36	-7	-36	-36
39	-83	-33	-86	-35	-18	-10	-38	-32	-37	-9	-38	-37
44	-86	-40	-89	-41	-19	-12	-45	-38	-39	-11	-40	-39

47	-88	-44	-90	-45	-19	-13	-49	-42	-39	-12	-41	-39
50	-90	-49	-92	-50	-20	-14	-55	-47	-40	-13	-42	-40
55	-93	-54	-95	-56	-20	-15	-61	-52	-41	-14	-43	-41

II. CONCLUSION

It is observed that the sections used are coming safe in all wind zones except for C495 is coming unsafe under the influence of axial compression in wind zone of basic wind velocity 55 m/sec. Although the members are safe in compression it is observed that sections used for R589,C495,C560,C565 are coming unsafe under the influence of axial tension. Hence higher sections shall be used. The F.O.S 1.0 suggested in [3] holds good to be used for such type of structures.

REFERENCES

Journal Papers:
Jamshid Mohammadi and Amir Zamani Heydari ,Seismic and Wind Load Considerations for Temporary Structures, Practice Periodical on Structural Design and Construction, August (2008), ASCE, 128–134.
Books:
I.S 875 (Part 3)-1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
Markus Balz and Mike Dencher ,European Design Guide for Tensile Surface Structures, (TensiNet, Chapter No. 7)