Mobile and Rapidly Assembled Structures III, C.A. Brebbia & F.P. Escrig (Editors)

Self-erecting pneumatic structures

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Abstract

The paper presents one type of structure of the group of self-erecting structures. Like other structures of that group, it gains its final shape by means of post tensioning of the plane basic structure. This is a pneumatic structure. It is composed of many small 'pneumatic cushions' connected together on the borders by tape connectors. A tensioned bottom chord made of the cable allows self-erecting. Opposite to other types of pneumatic structures, system does not require increased air pressure neither inside whole the structure nor in large span elements. Air pressure in each cushion doesn't depend of the pressure in the others and it makes the system not sensitive on local perforation and lost of pressure in several elements. In order to easy keep a constant pressure inside cushions a special plug-in connectors placed at each contact surface enables use of the central compressor without any external pressure conduit. The structure can be successfully applied for temporary covers of any type, for example for field hospitals, temporary covers of building sites or for military applications.

1 Introduction

Most of presently realised pneumatic structures can be divided into two groups: in the first one the structure is made of single layer fabric cover kept in position by means of increasing air pressure inside the object above atmospheric. Structures of the second group consists of large scale tubes made of fabric. Air pressure in each tube is supplied separately. Tubes' span is usually equal to the span of the structure. Both types of the pneumatic construction have important disadvantages that limits its usage. Special air-locks and high output compressors are usually applied. Thus effects both in architectural shape and usability in difficult local conditions. Structures like these are rather expensive in maintenance and uncomfortable in use. They are

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used much more often for spectacular objects at international exhibitions than for everyday service.

In his former papers the author proposed a pneumatic structure composed of many small elements made of fabric and filled by air (Tarczewski [1] [2]). Elements, named 'cushions' are easy assembled on basic surface and erected by means of tensioning in the same way that metal self-erecting structures are (Schmidt [3], Tarczewski [1] [2]). After erection structure is ready to use. No higher pressure inside the object and air-locks are needed. The object can be open at the sides and the openings in its surface are allowed. The structure is not sensitive on local damage of elements – even if many cushions are out of service whole the structure can be safely used.

2 System description

Two basic assumptions are in the background of the proposed system:

- use of small pre-fabricated elements suitable to be used for realisation of many various structures
- self-erection of the structure after it is assembled at the ground level

2.1 Basic elements

Proposed system consists of elements of two types: air cushions and bottom cable. A cushion is small and able to keep a higher air pressure inside. 'Small' means that it can be carried by one or two men and its size is at least ten times smaller comparing to required span of the structure. A cable can be made of steel or fibre rope.

2.2 Connections

The cushions are made of synthetic fabric and equipped with tape connectors at the edges (Figure 1). It is the same type of tape connector that is used in clothes.

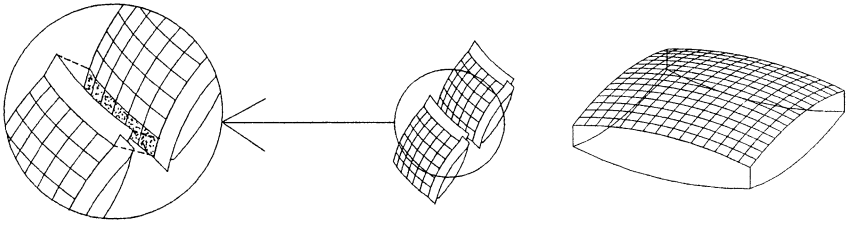

Figure 1: Air cushions with tape connectors at the edges.

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It must be able to carry tensile forces tangent to the curve of deformation. The cable goes through the holders located at the bottom corners of the cushions. It is fixed at the one terminal holder and can slide through the all the other holders. The holders have a form of small hoops connected to cushions corners.

2.3 Air pressure

The air pressure in the cushions must be above atmospheric. Cushions are filled before assembling. As the pressure loss always happens, the cushions must be re-filled after assembling. An internal system of pressure maintenance is designed. It consists of thin pressure conduit placed inside the cushion and plug-in connectors placed at two sides of it. Connectors allows to make a pressure conduit continuos and works also as non-return valve supplying air inside the cushion. Pressure conduits can be connected to the central compressor supplying air to all cushions.

3 Realisation of presented pneumatic structures.

3.1 General idea

The structure is assembled at the ground level (Figure 2) and than self-erected by means of post-tensioning of cable placed at the bottom (Figure3). Post-tensioning as a method of shaping structures is not presented here as it is well described in references. After erection the cushions corners are placed along a smooth curve (Figure 4). Tensile forces in upper fabric layer and cable and compression of the air in the cushions allows the force transmission in the structure (Figure 5).

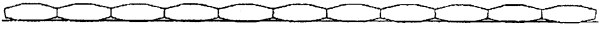

Figure 2: Assembling of pneumatic structure in initial position.

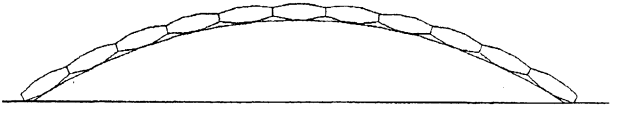

Figure 3: Pneumatic cover after erection.

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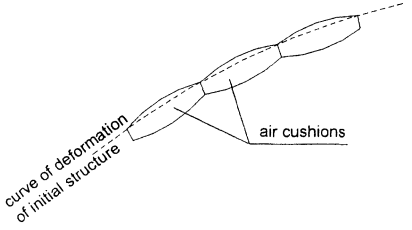

Figure 4: Curvature of pneumatic structure after erection.

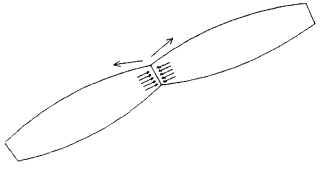

Figure 5: Distribution of forces in coushions connection.

3.2 Erection of the structure

Erection of the structure starts with fixing a bottom cable in one of terminal nodes. Cable goes through all the holders connected to cushions and turns back in the opposite terminal node. Than by means of shortening of the cable, the structure is erected till the final position is achieved (Figure 6).

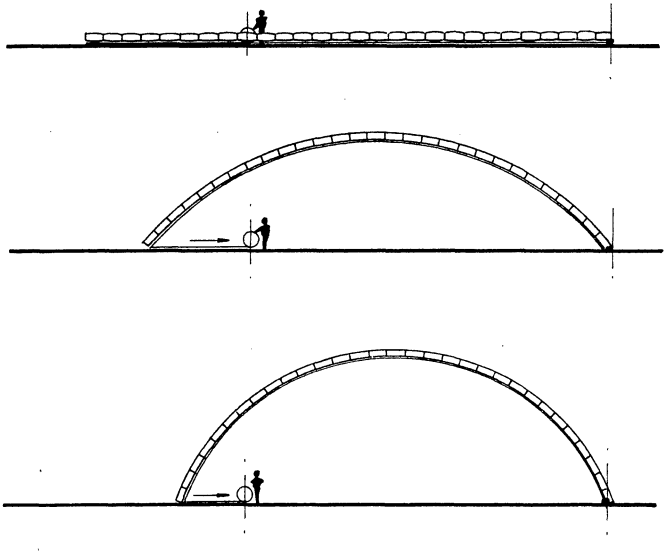

Figure 6: Erection of pneumatic cover.

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The entire structure can be erected of smaller units which can be joined after erection (Figure7).

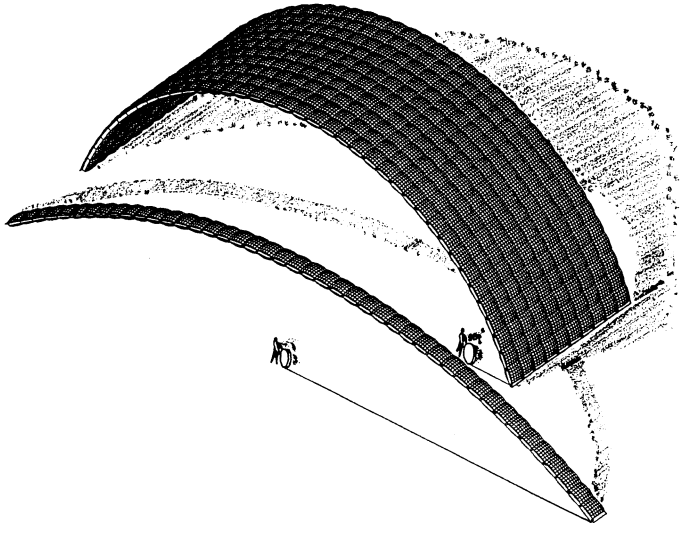

Figure 7: Acsonometric view of the pneumatic cover during successive erection.

After erection bracing ropes can be placed if needed (Figure 8).

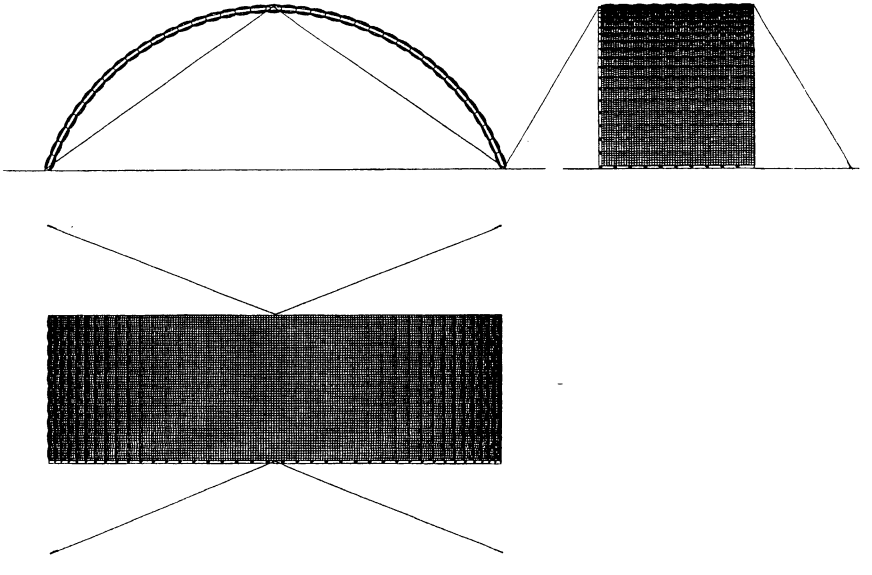

Figure 8: Acsonometric view of the pneumatic cover after erection.

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4 Conclusions

Presented system of pneumatic structures eliminates many defects of other existing systems. It is easy to operate and maintenance and it is ready for multiple use. It seems to be a good shape from the architectural point of view (Figure 9), however much more complicated configuration can be achieved.

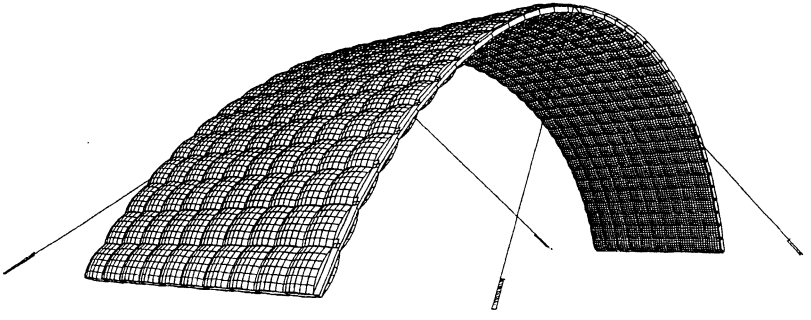

Figure 9: Acsonometric view of ready pneumatic cover.

A wide range of domes can be designed when the use of cushion of the polygon shape are used instead of rectangular ones. Large openings in the structure can be designed as well as opened sides. Another opportunity for shaping structures of this type is to use a 'variable rigidity' method proposed by the author (Tarczewski [1]). In that case the bottom cable is not directly connected to the cushions but through distance cross braces of variable length. It allows to change achieved curvature of the structure along the longitudinal axis.
This type of structures can be applied for any temporary, rapidly assembled covers, like exhibition halls, field hospitals, temporary covers of building sites or for military applications.

5 References

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