УДК 693.22.004.18
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NOWADAYS APPLICATIONS OF AIR-SUPPORTED STRUCTURES

Air-supported structures are dynamic buildings where the fabric membrane is held up by controlled internal air pressure. This design provides for a wide-span column free interior space. The air halls can be used for many application. They are perfect when there is a need to remove the building on a seasonal basis: they are easily taken down and reinstalled for seasonal requirements. Typically the cost of such a building is one third of the cost of a conventionally constructed building of equal size. In addition to the advantages of lower initial cost and application flexibility air-supported structures have the benefit of short lead times and construction schedules.

The first over ground pneumatic building was inspired by the form of the hot-air balloon. It was a hangar projected and patented by F.W. Lanchester an English engineer in 1917. However, the intensive development of pneumatic structures only became possible near the end of World War II in USA. This was a consequence of advances in the production of high quality technical fabrics, used previously to produce barrage balloons as protection against enemy aircraft.

W. Bird, from Cornell University in Buffalo USA, produced pioneering works on the rules of formation and realization of over ground pneumatic structures. The constructions realized by him served to protect radar antennas in the far North. The first such construction was built in 1946, and by 1947 Cornell Aeronautical Laboratories had constructed about 100 air halls. A rapid increase in the number of pneumatic constructions followed on from this time.

By 1962 about 50 firms were active in this field and hundreds of pneumatic structures had been built.

In the 50's air halls also appeared in other countries with fully developed chemical industries like England, Germany and the Soviet Union.

While the most common applications were mobile stores and garages, pneumatic constructions were also used to execute batteries of silos for the storage of liquids and friable materials. A set of 5 air domes was erected for the US army, where the biggest one, situated centrally, had a diameter of 45 m. An air hall was erected to protect large television antennas in Lannion in France in 1962. The coat had the form of a segment of a sphere with a diameter of 65 m. and a height of 50 m.

Since the 60's, pneumatic systems have been used in a wide variety of applications especially in agriculture and industry. Since the 70's pneumatic constructions have also been used to cover large areas, for example:

- Fuji Group Pavilion at Expo 70 in Osaka – a unique saddle shaped dome constructed from 16 air-inflated tubes, each 4 metres in diameter and about 60 metres long;
- Pontiac Silverdome erected in 1975 in Michigan – a cable restrained, low profile air supported structure;
- Carrier Dome at Syracuse University – air hall designed for football games in 1981.
- BC Place Amphitheatre erected in Vancouver in 1983 - Canada's first air supported dome.
- Nara Silk Road Exposition 1988 in Nara - Japan;
- Mitsubishi Pavilion at Expo 90 in Osaka, which has the shape of a huge plant;

In the 90's large dimension air structures have often been used to cover big sports areas. The Giants Practice dome – designed by Air Structures American Technologies Inc. was erected in 1994. It was used to cover an 1.5 acre area near the Giants Stadium in the Meadowlands, for practice during inclement weather.

Air-supported practice facilities were also built for seven other US National Football League teams: New York Jets in 1997;, Denver Broncos, New York Giants, Minnesota Vikings, Seattle Seahawks, Bufflo Bills, Philadelphia Eagles and for Super Bowl Champ in 1998.

Present application of pneumatic structures are various.

They are a lot of industrial applications: air-warehouses; rack, bag and palletized storages; grains, fertilizers, powder or sawdust storages, biogas storage tanks.

First three are used as traditional air halls. The most interesting are pneumatic biogas storage tanks. The number of such biogas units has increased, especially in Germany. Using them, organic waste from agriculture, industry and private households can be decomposed without polluting the environment. At the same time biogas is produced and could be used in a great variety of ways. That's the reason double-membrane biogas storage tanks start to be popular.

The design of the double-membrane gas storage tank consists of three, high-strenght fabric-backed membranes. A galvanized steel ring fixes them onto the reinforced slab which forms the foundation. The base membrane seals the gas space on to the foundation. The internal one takes up the biogas – depending on the filling capacity, its tension increases or decreases. The outer membrane is kept under constant tension by an explosion-proof support air blower. Thus, a solid, resistant outer skin is established which can withstand atmospheric influences, stabilizes the structure and protects the storage tank membrane on the inside. In addition, a safety valve protects the system against excessive pressure. Hundreds of biogas storage tanks are now being operated safely all over the world, even under extreme climatic conditions.

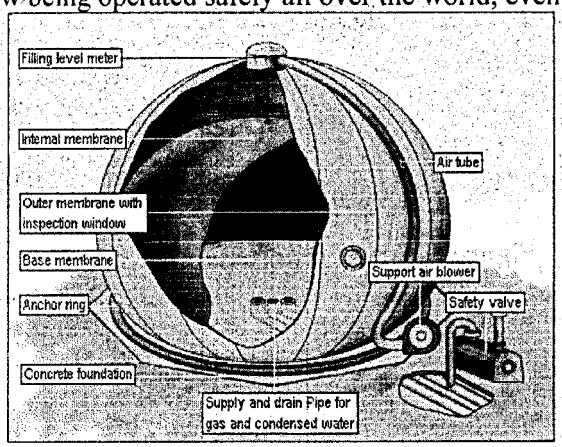

Figure1 – The double-membrane gas storage tank

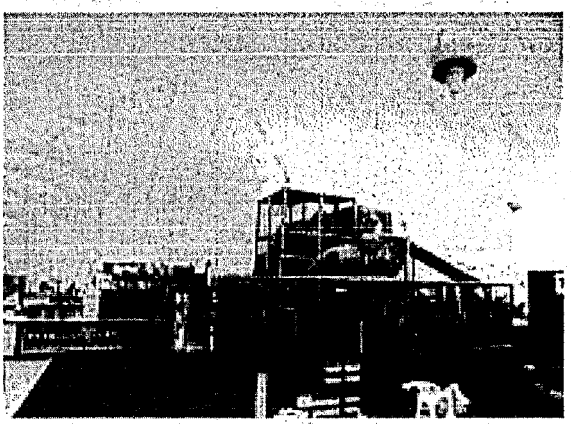

Figure 2 – Inside the family entertainment center

They are also a lot of military applications of air supported halls: radar installations; chemical, biological and radiological protection centers; tanks and military cars garages (even for huge trucks and equipment); hangars.

A rapidly growing application in USA is pneumatic family entertainment center.

Day or night in any weather, kids or the entire family enjoy a variety of activities under air supported domes. Centers could be build near of big supermarkets or house districts and helped organize entertainment for theirs clients or inhabitant. Firms have sold them including an amusement equipment.

Pneumatic constructions have many different applications, but they are the most often used as sport halls. Majority existing air halls were erected to cover tennis courts and different sport's spaces like: swimming pools, athletes training places, ice rinks, golf driving ranges, basketball practice fields etc.

Traditional air-supported hall had only one coat. Such membranes are still producing, especially for industrial applications but today three coat halls with external nets of steel cables have become the most popular in the world. The bearing coat is made of PVC dragged with special fibre (eg: Low Wick) is resistant to permanent stress, the isolating course has a blister construction and the protective coat is UV-resistent. Outer and inner membranes are made of fungus- and microbe-resistant fabrics. These three layers are fixed to external nets of steel-lines by pressure of air. Lines take up statical forces and transfer them by means anchors to the ground.

This type construction has many advantages in comparison to the older halls with only one coat and without any lines; they have better stability during extreme weather conditions (strong winds, storms); system of standings out in relief improves acoustics in the hall; three coats give very effective thermal isolation, and finally this type of halls is more durable, prolonging its working life.

Air architecture is developing dynamically, especially in USA. There exist a lot of firms offering to provide complete air halls: from design to erecting of complete hall. A good example is The Farley Group, a construction company which undertook 12 halls in 2002 and 21 halls in 2003.

In 90's that only a dozen large pneumatic constructions were in use in Poland. The majority of them are sport halls (for example: covers over swimming pools: in Inflancka st. in Warsaw and at the "Olimpia" club in Łódź; covers over tennis courts: near the Wisłostrada and in Żwirki i Wigury st. in Warsaw, in Słowiańska st. in Poznań and in Sierosławiec near Poznań). As well as an unknown number of small objects, realized by private investors. The total number of all pneumatic objects existing at that time could be approximately estimated at less than one hundred. Air halls are treat as temporary objects in Poland, so they do not require planning permission to build. It is for this reason that the data we could receive from the provincial and regional offices of the departament of architecture and town-planning were incomplete.

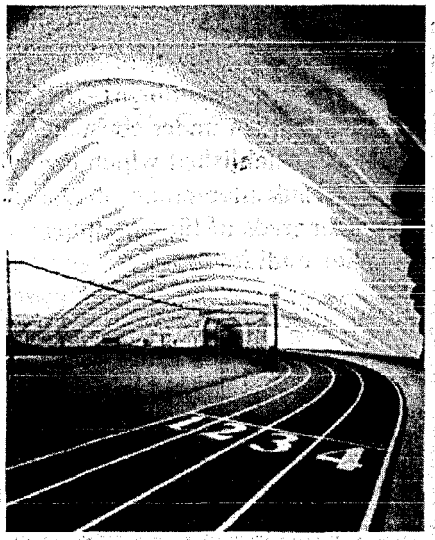

Figure 3 – Inside the air-supported sport hall

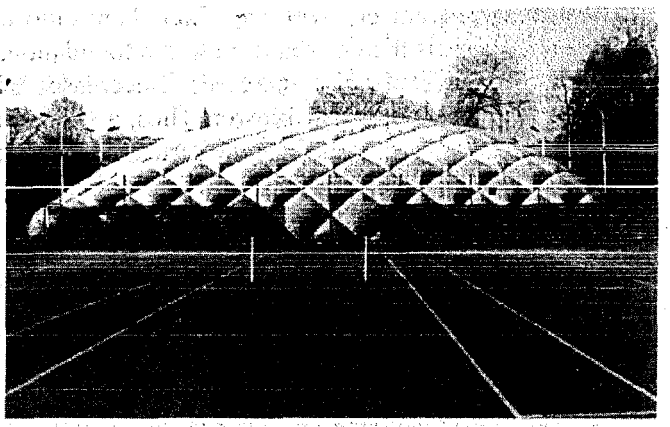

Figure 4 – Three coat tennis hall with external nets of steel cables

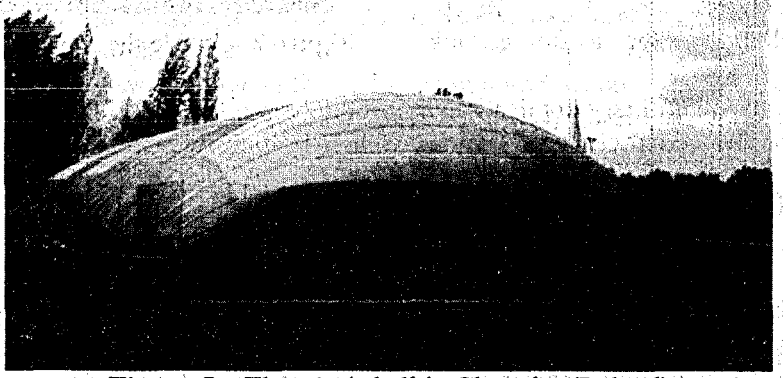

Figure 5 – The tennis hall in Chorzów (Poland)

Today the number of pneumatic structures in Poland is increasing slowly. There seems to be a pattern: the number of halls is increasing in those cities where hall have been built that in those cities where in the past (eg. there are 7 air sports halls now in Poznań), but there are some provinces where this type of construction is still unknown. So even today there is a need to popularize pneumatic structures in our country, letting more people know about their advantages and wide range of possible uses.

REFERENCES

1. T. Domagała: Hala Pneumatyczna na Krakowskich Błoniach. Kalejdoskop Budowlany, marzec 2004.
2. J. Filipkowski: Wybrane realizacje z przekryć pneumatycznych oraz zwiazane nimi problemy konstrukcyjne. Materiały II Konferencji Naukowej „Konstrukcje Cięgnowe i Wiotkie Powłoki" Rydzyna 1983.
3. F. Otto: Pneumatische Konstruktionen, Ratgeber. Stuttgart 1983.
4. A. Repelewicz, E. Ochocka: O konstrukcjach pneumatycznych. Zeszyty Naukowe Politechniki Częstochowskiej. Budownictwo. Częstochowa 2000.
5. J. Schlaich, R.Bergerman, W.Sobek: Tensil Membrane Structures. Bulletin-of-the-international-Association-for-Shell-and-Spatial-Structures v.31, no 102/103, p 19-32.
6. A. Tarczewski: Dlaczego celowe jest stosowanie konstrukcji pneumatycznych? Przeglad Budowlany nr 4 1981r.
7. Web site: www.airbldg.com.
8. Web site: www.architekci.pl
9. Web site: www.ceno-tec.de
10. Web site: www.esa-dopme.com.
11. Web site: www.fabricarchitecture.com.
12. Web site: www.interhall.pl
13. Web site: www.thefarleygroup.com