The largest industry in the world is covered by civil infrastructure and has about 10% share in the GDP [1]. As a result, technical textiles for this market may govern an important turnover.

Unreinforced masonry walls are particularly vulnerable for earthquakes and landslides. The use of technical textiles as reinforcement in both masonry and ground works is increasing and efficient methods for the retrofitting of existing masonry buildings and earthworks and related monitoring systems make it possible to prevent structural damage. In architecture, technical textiles are used in large-span and temporary structures, such as air domes, stadiums, airport terminals, sport halls, hangars or stations. Fabrics are particularly suited for lightweight façades for new and existing buildings. In addition, due to the intrinsic efficiency of tensioned membrane structures, technical textiles are successfully used in several industrial applications such as biogas plants, floating dams, inflatable flood barriers and flexible tanks.

Sensor embedded textiles for structural health monitoring (SHM) of constructions have been demonstrated though many building practitioners are unfamiliar with the behavior and the characteristics of these materials. The lack of information about the use and the properties of these materials limit their implementation and thus prevent achieving the highest possible standards in quality assurance and control for construction projects.

Hampered breakthrough of textiles for construction

Building materials are strictly regulated by the Eurocode building practices and materials. However, despite the fact that technical textile materials are available today for use in a variety of building and construction applications, textiles are not mentioned by the eurocodes [2]. As a consequence, their use is limited to small temporary pavilions or iconic structures and buildings where ad-hoc authorization can be obtained. The future Eurocode 12 on membrane structures is currently under development by the European Committee for Standardization - CEN TC250 and it is supported by one of the working groups of the EU funded COST action TU1303 on Novel Structural Skins [3].

A new generation of architectural fabrics

The use of sensible and adaptable envelopes is increasing in recent years and building industry is looking for means to interact with the surroundings via temperature, humidity or solar irradiation monitoring [4,5]. For structures designed for extreme applications (e.g. large span structures prone to fluttering and...
Defining a form for a tensile structure is a crucial step in designing new structures. The form finding methods and finite element modeling tools are key to predict the forces and tension distribution along the fabrics ensuring a stable structure. However, the transformation of a digital geometry into a real structure is a process characterized by several intermediate steps such as textile production, confection and build-up. In all of these, minor inaccuracies may influence the result and add-up to unforeseen instabilities. This is particularly of interest for wind loads causing fluttering, water ponding and snow pile-up on the fabrics. These dynamic loads endured by the fabric, can result in extreme tension or unpredicted forces on rigid restraining devices.

An early warning system may be advantageous for signaling increased loads endured by the fabric, but it may also act as a feedback loop between modeling and real life conditions. This would allow the architect to refine the design and the computational processes. In order to achieve such warning system, thin, flexible pressure sensors were integrated in a PVC coated fabric. By connecting the sensor to integrated electric leads in the fabric and subsequent coating, the sensor is well protected while the leads allow for easy connection of the sensor to the readout at the fabric brim (Fig. 3).

While pressure and temperature can clearly contribute to safer or better designed tensile structures, stability is a combined effort of the designer, developer and end user. It is unfortunately not uncommon that fabrics for tensile structures are used in a way they were not designed for. The user then easily points to the manufacturer in case of a defect, while misuse is sometimes the real cause of failure. Corrosive gases emitted by for example cattle or biological waste may compromise the materials integrity and cause hazardous situations when inadequate materials have been used. For two of such gases, an irreversible indicator patch has been developed. Color will change irreversibly upon exposure to ammonia or hydrogen sulfide, indicating that the fabric properties can no longer be guaranteed (Fig. 4).

Conclusion

Technical fabrics for construction offer a wide range of new possibilities in building applications. However, exploitation is hampered by the lack of clear standardization and harmonized legislation. In addition, building practitioners may feel reluctant to use novel materials they have limited experience with. By integrating sensing, monitoring and early warning systems in technical textiles for construction, confidence in textiles as building material may be increased. Moreover, the sensing tools highlighted here may also offer solutions to improve design and modeling of tensile structures and aid to a better understanding between architects, developers and end users.

Acknowledgements

The research leading to these results has received funding from the European Union’s Seventh Framework Program managed by REA-Research Executive Agency (http://ec.europa.eu/erafp/). It received funding from the European Union’s Seventh Framework Program (FP7/2007-2013) under grant agreement n° 606411.

REFERENCES

2. The eurocodes. What are they?, DG Enterprise and Industry Joint Research Centre.