International Journal of Engineering Research
Volume No.7, Issue Special 3, pp : 321-324
ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

Shape Memory Polymers in Deployable Architecture

[1]**Ar. Sanika Pimple; [2]Ar. Shilpa Nagapurkar**
[1] Assistant Professor, MIT School of Architecture, Pune
[2]Principal In charge, MIT School of Architecture, Pune
Email Id: shilpa.nagapurkar@mituniversity.edu.in, sanika.pimple@mituniversity.edu.in

Abstract: This paper aims to demonstrate the use of shape memory polymers (SMPs) in deployable architecture. Increase in use of SMPs will certainly bring a paradigm shift in the field of construction and technology also it is cost cutting material in terms of time and labour. Time required to erect a structure in SMPs is half of the time required through conventional techniques for the same structure. Present day architecture is at the verge of shifting to Parametricism and digital architecture which mostly comprises of techniques like folded plate structures, blobitecture, scissor mechanisms, etc. Widely used materials for such techniques are metals like aluminium, steel or glass or concrete. Structures under the umbrella of Parametricism are generally large scale and permanent structures. Use of SMPs can bring small scale and temporary structures under one umbrella.
Keywords: SMPs, Parametricism, Construction techniques, Materials, Time and Scale.

I. Introduction

In recent years field of architecture has experienced a lot of change. There is a paradigm shift in the field and whole architecture along with construction techniques are at the verge of shifting to Parametricism and digital architecture. Advance construction techniques like folded plate structure, blobitecture, scissor mechanism, morphing, etc. club under the branch of parametricism. Along with techniques; materials used for construction have also experienced lot of changes. Other than conventional materials like concrete and bricks use of glass and metals like aluminium panels is increased. Mostly large scale permanent steel structures come under umbrella of parametricism and digital architecture. The major concern is encompassing small scale temporary structures and to reduce the time required for construction of these structures also to emphasis on reduce reuse and recycle. Present day parametric architecture majorly includes structures like corporate buildings, hotel buildings, exhibition pavilions, bus terminus, railway stations, etc. Time constraint for erecting such structures is quite large due to its scale, design, and many a times challenge in handling materials. Bending metals or casting concrete in curve forms is bit difficult and time consuming and also can't be reused for another design form.

Shape Memory Polymers (SMPs) is the material that can used for such temporary structures as this material is able to regain its original form and can be reused for another structures making the structures cost effective and also optimising the time required for erecting the structures.

Figure 1 a: Parametric Structure with curved surface in concrete

Figure 2 b: Parametric Structure with curved surface in Steel

II. Deployable Structures

Structures that are able to be dismantled easily are framed to be deployable structures. Usually these structures include small scale buildings as retractable houses, small display areas or small exhibit areas, temporary shelters, or temporary parking areas. The best example of deployable structures is Tent. Tent works on folded plate mechanism central ridge acts as hinge while surface on either side can be folded along the hinge.

Figure 2 a: Tent with central Ridge

ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

II. A. Folded Plate Mechanism

Deployable structures that operate with folding of plates through hinges; such structures are termed to be working on folded plate mechanisms. Such structures or design of such structures majorly involve Japnese art form "origami" that is paper folding. Design process includes selection of folds, decoding algorithms of the same and entering it to softwares like grasshopper. Considering folding as one of the parameters opening and closing of structure is decide ob the same. One of the examples of such structure is **Canary Wharf Kiosk** in **London**. Its designed is based on simple origami folds with counterweight for opening and closing. It is completely steel structure with hinges attached to steel panels for opening with central steel pivot along which the movement takes place.

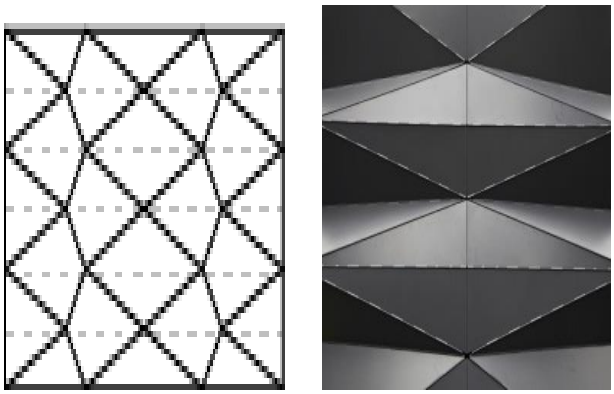

Figure 2.A a: Origami Folds with hinges

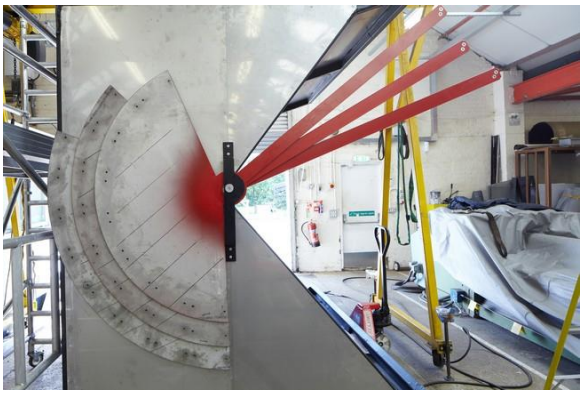

Figure 2.A b: Central steel pivot for opening & closing of Kiosk

Figure 2.A c: Final prototype of Kiosk

II. B. Blobitecture

Blobitecture is portmonteau of blob and arcitecture. The term blobitecture was coined initially during archigram movement but latter on it was officially used by architect Greg Lynn in the 1995. Blobism and blobismus along with blobitecture are the terms used for free flowing soft surfaced amoeba sahped buildings. Blobitecture is another branch of parametricism or digital architecture where in the forms of buildings are simply not possible to achieve without software manuplations. The huge curvilinear facads of structures or many a times facdes are modulated into roofs due to free flowing forms are not easy to construct. Again the curves are to be mathematically decoded and the algorithms generated are to be entered to parametric softwares for generating the final form of building. One of the examples of blobitecture is **Selfridges department store Birmingham UK.** Just as anyother building under the umbrella of blobitecture would appear Selfridges department store appears like a huge blob. Whole concrete surface of building covered with aluminium discs which appears as scales on the body of fish or snake, form of building also resembles to a huge whale. There is no flat surface or right angle in whole building.

Figure 2.B a: Selfridges department store Birmingham UK

Figure 2.B b: Aluminium discs resembling scales on fish body

II. C. Limitations of Folded plate mechanism and Blobitecture

Floded Plate Mechanism and blobitecture both being totally different styles of architecture have its base of design same that is generative algorithms in parametricism. Small Scale

ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

stuctures with deployable assembly can be designed using folded plate mechanism but designing small stuctures under blobitecture is not that easy as it requires lot of funding and stuructures being free flowing are not easy to be constructed using conventional materials and techniques. Structures with folded plate mechanisms are easy to disassemble though but are not easy to transport due to the elements that are used such as steel members and hinges. Other major limitation of both styles is material cant be reused for some other totally different design.

Figure 2.C a: Inconvenience in transportation

III. Shape Memory Polymers

Architecture today is experiencing a great revolution yet the materials used for constructions are conventional ones like steel or concrete which many a times have limitations of time or achieving a particular form. Technology has made it easy to overcome all limitations though it is not easy all times. There is need of material where structure can easily be assembled and disassembled; can be easily transported and reused in another form. One such material extensively used in aircraft and biomedical fields is shape memory polymers. *"Shape-memory polymers are an emerging class of active polymers that have dual-shape capability."* Marc Behl Andreas Lendlein. Shape memory polymers are elastic polymer networks that consist of molecular network and switch points. They are also equipped with stimuli sensitive switches. Shape memory polymers when heated or applied with external simulation changes its form this changed form is restored untill the material is again heated or applied with external simulation. E.g. *Extruding or injection moulding, the polymer is formed into its initial, permanent shape B. Afterwards, in a process called programming, the polymer sample is deformed and fixed into the temporary shape A. Upon application of an external stimulus, the polymer recovers its initial permanent shape B.* Marc Behl Andreas Lendlein. This Programming cycle can be repeated several times which makes it easier to reuse material making it cost effective. At Present shape memory polymers are extensively used in fields of aerospace and for medical treatments. They are used to cast plasters or fibres for stitches in medical field where as can be used as drones or actuators in aerospace engineering.

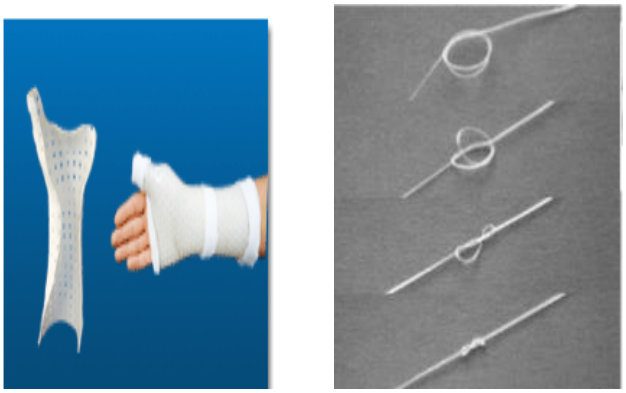

Figure 3 a: Shape memory polymer in field of medicine

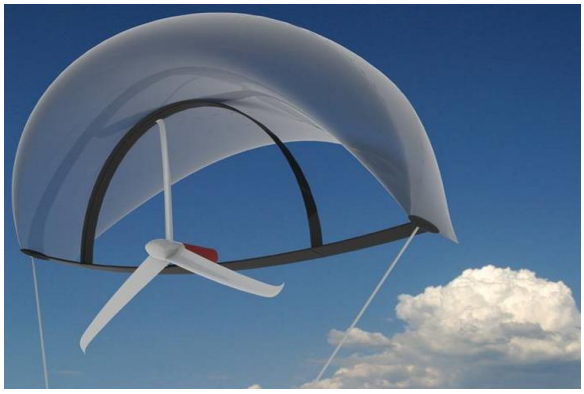

Figure 3 b: Shape memory polymer in field of aerospace

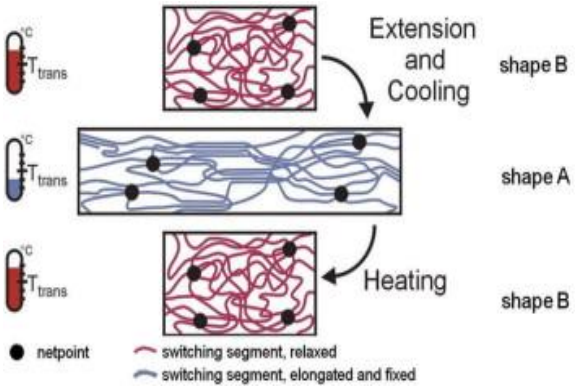

Figure 3 c: Shape memory polymer with molecular network & switch points

IV. Conclusion

Shape memory polymer can envisage a great future to field of architecture and construction. It can be used to construct temporary structures like exhibit areas, tents, retractable houses, etc. with at ease. Both examples mentioned above of folded plate mechanism and blobitecture are much easier to erect than what they are actually done specially small scale structures. Blobitecture generally encompases large scale structure but use of SMPs helps easily construct blobus structures, also erecting origami folds with SMPs are much easier than erecting in steel or other conventional methods.Property of restoring and regaining original shape can help optimizing construction cost as same material can reused several times without any damage also transportation

ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

of such light weight materials can be done very easily without any damage to material.

V. Acknowledgements

I take the privilege to thank MIT School of Architecture for giving the opportunity to write paper. I also like to express my gratitude towards my colleagues Ar. Pashmeena Ghom & Ar. Mohammad Rajaullah for their valuable support and encouragement.

VI. References.

i. *http://www.sciencedirect.com/science/article/pii/S1369702107700470*
ii. *http://studiokimiis.com/shape-memory-polymer-deployable-architecture-2/*
iii. *https://www.google.co.in/*
iv. *search?biw=1366&bih=667&tbm=isch&sa=1&ei=3DFMWsX_B4y0vwSU8p24Cw&q=shape+memory+polymer+space+craft&oq=shape+memory+polymer+space+craft&gs_l=psy-ab.3...38701.47664.0.48121.19.16.3.0.0.0.162.1781.0j14.14.0....0...1c.1.64.psy-ab..2.2.206...0j0i24k1.0.8hypd01eXho#imgrc=_FE_m2p21A58sM*
v. *http://homepages.vub.ac.be/~ndtemmer/Thesis_Niels_De_Temmerman.pdf*
vi. *https://smartech.gatech.edu/bitstream/handle/1853/29676/james_andre_m_200808_mast.pdf*