# Behaviour of a Novel Skew FlexiArchTM Bridge System

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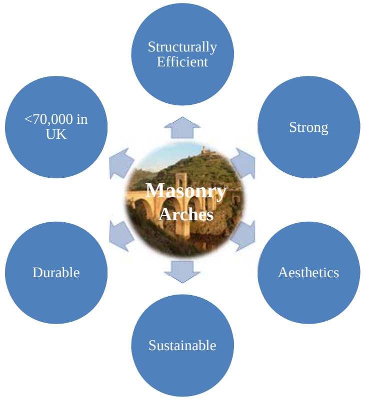
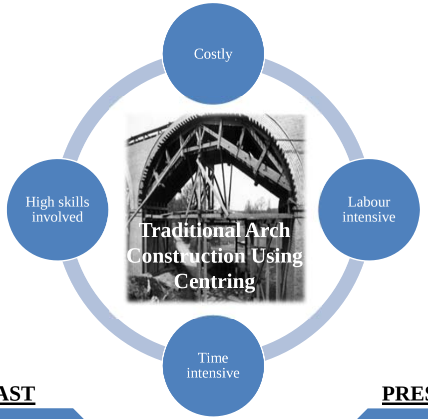
## Introducing FlexiArch



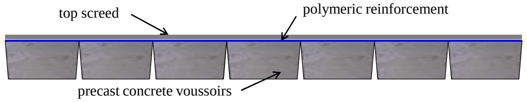

**PAST**

- Strong
- Durable
- Aesthetics

**PRESENT**

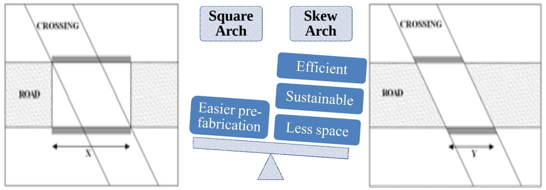
- No centring
- Fast installation (3hrs not 3 months)
- Sustainable

**FlexiArch**




**FlexiArch – From flat-pack to arch unit in a matter of seconds**

## Skew FlexiArch




**Flat geometry of skew FlexiArch**

## Research Aims & Objectives

**AIMS:**

Develop the following models for the skew FlexiArch system:

- A finite element model to accurately represent the behaviour of the arch under loading
- An analytical model to predict the forces in the polymeric reinforcement for the arch during lifting

The models are verified against the results obtained from an experimental programme, allowing a parametric study on a wider variety of variables to be conducted, eliminating the need for further physical testing.

**OBJECTIVES:**

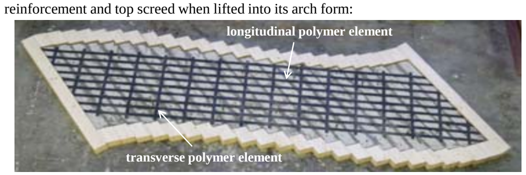
Carry out the following experimental programme:

| Experiment Name | Variable | | | |
|---|---|---|---|---|
| | Angle of Skew (degrees) | Span to Rise Ratio | Square Span (m) | Rise (m) |
| ARCH:1/3(5*2):15° | 15 | 2.5 | 1.67 | 0.67 |
| ARCH:1/3(5*2):45° | 45 | 2.5 | 1.67 | 0.67 |
| ARCH:1/3(5*2):30° | 30 | 2.5 | 1.67 | 0.67 |
| ARCH:1/5(10*2):30° | 30 | 5.0 | 2.00 | 0.40 |

The results obtained from the experimental programme are compared against a finite element analysis model of the skew FlexiArch system under loading, and an analytical model used to predict the forces in the polymeric membrane during lifting.

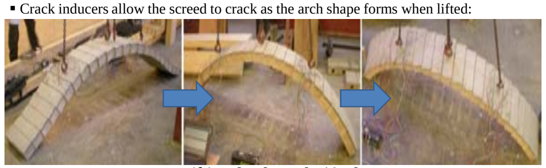
## Experimental Progress

- 15° skew FlexiArch has been built and tested; currently building 45° skew arch.
- The arch is constructed using 23 precast concrete voussoirs, held together by polymeric reinforcement and top screed when lifted into its arch form:

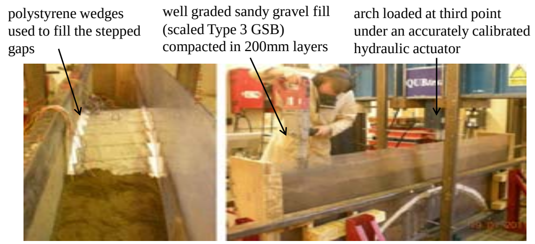



**Voussoir alignment & polymeric reinforcement prior to casting screed**

- Crack inducers allow the screed to crack as the arch shape forms when lifted:

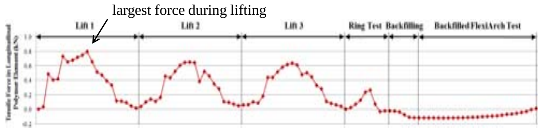


**Lifting the skew FlexiArch**

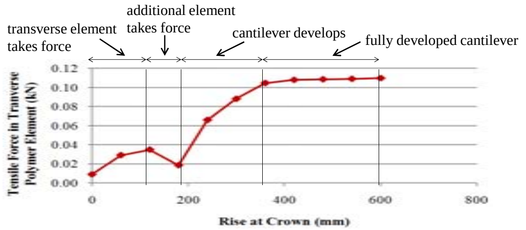



**Backfilling the skew FlexiArch**

## Experimental Results - Lifting




**Force in longitudinal polymer element at outer lifting point**

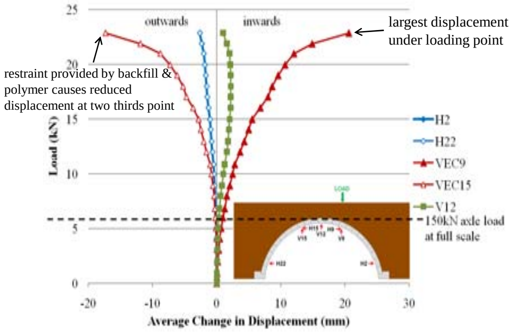



**Force in transverse polymer element at outer lifting point during lifting**

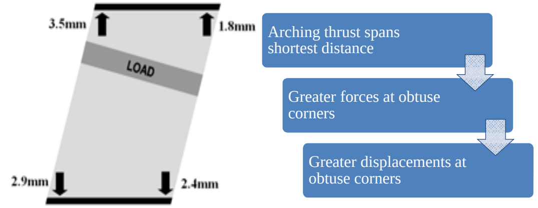
The theoretical FOS for the paragrid was calculated as 10.7, which is comparable to the measured experimental value of 9.7.

## Experimental Results – Load Test

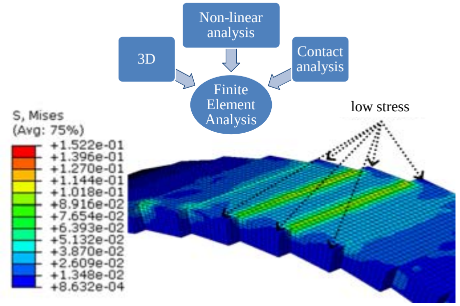
**Hinge points on failed skew FlexiArch – mechanism formed – sustained 22.9kN**



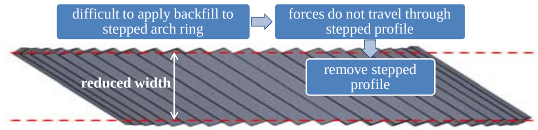

**Change in displacements during full load test**




## Finite Element Analysis



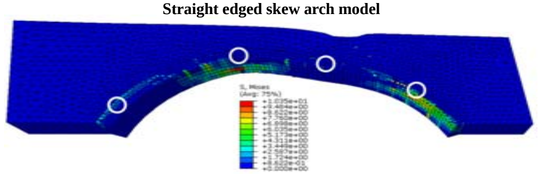

**Finite element analysis of stepped arch ring loaded at the crown**




(a) Reduced width straight edge skew arch ring model

(b) Skew arch ring model with straight edge

**Straight edged skew arch model**



**Hinge points on failed skew arch**

Failed at 23.2kN; comparable to 22.9kN from the experiment. Hinges in same locations.

## Conclusions

- The skew FlexiArch is a sustainable and viable option for bridges.
- The test results show it to be an efficient structure with the innovative polymer reinforcement working well in carrying the arches self weight during lifting.
- The largest forces in the polymer were during lifting, with the transverse elements taking a negligible force in comparison to the longitudinal elements.
- An analytical model has been developed to predict the forces in the polymeric reinforcement for the arch during lifting.
- A finite element model of the skew FlexiArch was successfully developed, with the results being similar to the experimental test.

## Acknowledgements

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