

TITLE: REPORT REGARDING RETROFIT OF SHADE SAILS IN A RESIDENTIAL SITUATION

## INTRODUCTION

The project is a retrofit of the sails of an existing shade structure in a domestic situation using the new Gale Pacific Commercial Heavy 430 shade cloth. The sails needed to be replaced as the previous shade cloth had stretched greatly over several years and all the available adjustment had been taken up resulting in the sails billowing in high winds.



*Figure 1 Retrofit Installation*

## The Retrofit

The retrofit is an installation of a total of approximately 85m<sup>2</sup> of covered area consisting of a main sail with 5 connection points of some 70m<sup>2</sup> and a smaller triangular sail. Triangular sails are generally not recommended for new projects but with a retrofit the parameters had been set.

On the columns, the existing attachment system consisted of chain links which had been welded to the columns. Shade cloth had been connected to these links with webbing, and also chain and shackles.

## Design considerations

It was considered that the new Gale Pacific Commercial Heavy 430 should outperform any other monofilament shade cloth when retrofitting these sails, especially the triangular sail because of its very good stiffness and balanced warp and weft properties which will mean that the wind loads will be shared more evenly between warp and weft fibres resulting in less stretch over time.

It was also chosen to change one of the connection heights of the fabric so as to provide curvature in what was previously a rather planar (flat) main sail, a common manifestation of improperly engineered shade sails.

It was decided that the intermediate attachment point on the main sail would be lowered by approximately 1000mm to introduce a new low point. This resulted in far better curvature and thus reduced fabric forces and increase stability under wind load.

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The intermediate point was chosen as it would create a greater improvement in curvature in the sail compared to a 1 metre change of height to any other attachment point.

Reduction of the height also improved the shade protection of the Western facing patio area.

### **Shade cloth compensations and pre-stress.**

Bi-axial testing of the New Gale Pacific Commercial Heavy 430 shade cloth has shown that a fabric compensation of approximately 1.2% in both warp and weft at a prestress load of 1.2kN/m is appropriate. This effectively means that the shade cloth was patterned to be 1.2% shorter in both warp and weft directions to allow for an elongation of 1.2% under prestress.

All other heavy duty shade cloths on the market would have required very different compensation percentages between the warp and weft directions. Other available shade cloths have a wide discrepancy in compensation percentages which often results in the weft fibres taking most of the wind load with little sharing of load.

In addition, shade cloths with widely varying elongation in warp and weft percentages should be designed and installed to reflect this unbalanced elongation. However due to many contractors not understanding the significance of this difference, especially the influence upon the installation methodology, most structures are neither designed nor installed properly. Since the Gale Commercial Heavy 430 has approximately balanced performance in both warp and weft, it is more likely that most contractors will be able to design and install a long span shade cloth structure correctly.

The fabric engineer chose a prestress of 1.2kN/m with a catenary depth percentage of 10% for these retrofitted sails. This means a catenary depth of 100mm for every metre of length along a side.

As always, the choice of edge cut percentage is a balancing act between reducing load and reducing the shade area. The greater the edge cut, the lower the loads generated but also results in a lesser shaded area.

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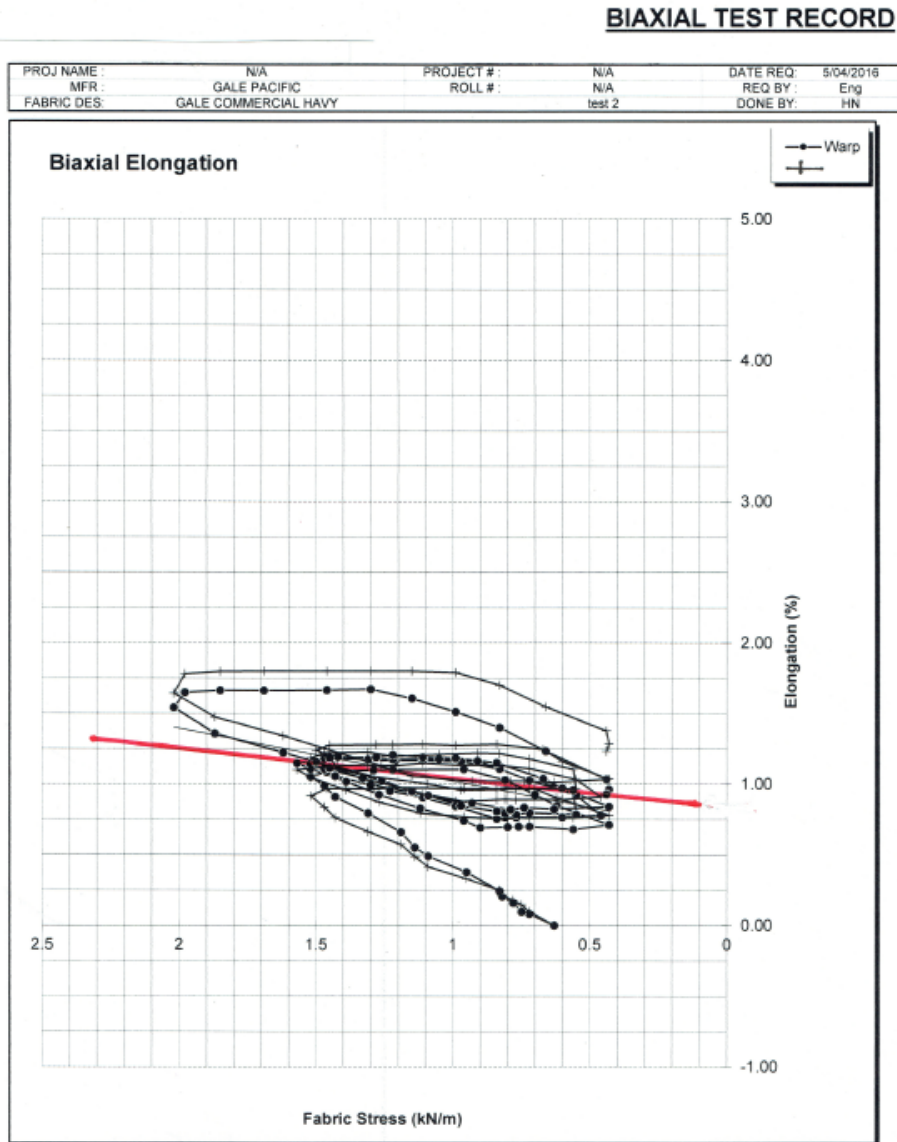


Figure 2 Gale Pacific Commercial Heavy biaxial test results

### Tensioning system and edge detail\*

The engineer detailed a webbing edge consisting of two layers of 50mm UV stabilised black polyester webbing. It was found from testing that the two layers combined to have a rate of stretch which was highly compatible with the stiffness of the shade cloth, this is an important consideration when designing any shade sail to ensure the maximum service life.

Black webbing was chosen to add a visual contrast between the edge and body of the sails and also because black webbing has the best UV resistance and thus lasts longer than any other colour of webbing. This is sewn to the shade cloth with one webbing each side of the shade cloth, using four rows of PTFE filament stitching. The PTFE (Teflon) thread used for the stitching outlasts any other available thread.



*Figure 3 Tensioner*

It was decided during the retrofit process to change to the use of very heavy duty truck style webbing ratchet tensioners at all the suitable attachment points, allowing the tensioner to swivel to match the direction of the forces.

This will also make it very simple to re-tension the shade cloth sails as required at a future date. There are safety chains and shackles that have been left in position but not under load so as to show both the old and new systems.

Figure 3 below demonstrates a sample of the webbing edge detail, however in this case the four rows of stitching have been shown on a white webbing used for demonstration purposes.

UV radiation is the main cause of degradation of shade cloth, sewing thread and webbing and it is strongly recommended that only the best quality UV resistant products be used.

*\* Please note that the 'Tensioning system and edge details' provided above do not meet standards in certain countries, this installation was undertaken in Australia and meets local standards. When installing in other countries please consider the standards appropriate to your region.*



*Figure 3 Edge webbing and sewing*

## **Installation**

The new Gale Pacific Commercial Heavy 430 shade cloth was chosen because it was the best balanced heavy duty shade cloth on the Australian market, with approximately equal warp and weft elongation under load. It would best suit the retro-fitted sails, especially the triangular sail because of its greater stiffness and also making the installation less reliant upon a carefully managed sequence of attachment tensioning, which would be required if we were installing other shade cloths that have widely varying elongation between warp and weft. The sails will also require less re-tensioning during the life of the sails because of the great stiffness and because the warp and weft fibres will better share the loads generated by the wind.

The balanced compensations of the shade cloth sails made the tensioning of the sails very simple as the attachments were all tensioned evenly and concurrently, resulting an even prestress throughout the sails. If the sail was made of another brand of monofilament shade cloth the contractor would not have been able to tension progressively and evenly in all corners and not have achieved the optimum installed result. Such a sail would actually require very different amounts of tensioning in each corner.

## **Fabricators comments**

- *“The fabric appears to be holding its cut length throughout the process as all 6 seams came together and matched on the dot.”*
- *“The fabric does not curl and is easy to handle at the machine. Using an Adler twin needle compound feed machine there were no problems. The number 26 needle shows no filament breakage so the strength should be intact.”*
- *“The fabric was moved a lot on our table. All edges have been cut with a hot knife. It has been folded a number of times in no particular fashion so it was a significant test to see how well it came out when placed under tension and shape especially as a fabric can sit on site for some time whilst site work is completed.”*
- *“The fabric laid very flat on the table and the equal compensations made the matching of adjoining seams very quick and accurate”*

## CONCLUSION

The new Gale Pacific Commercial Heavy shade cloth, webbing edges and ratchet tensioners have worked very well. Efficient and quick installation has resulted in an even level of prestress in all directions. The long term performance is expected to be favourable and superior to other monofilament shade cloths on the market since the Commercial Heavy cloth;

- Better retains its physical properties, design shape, safety factors and structural reliability over time
- This contributes to lower stretch over the life of the shade cloth structure and
- Requires less re-tensioning and thus is,
- Less likely to run out of adjustment at attachment points and,
- Better retains its UVR Block Percentage and Shade Factor throughout the life of the shade cloth

The installation will be revisited in one year or after any severe wind event should one occur before twelve months.

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