

Introduction

Lightweight Façade Systems

James Marr


LSAA
LIGHTWEIGHT STRUCTURES ASSOCIATION OF AUSTRALASIA

Aglient Façade, Melbourne

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Introduction

- What are lightweight façade systems?
- Why look at planar tensioned cable supported facades?
- How do we deal the difficulties of these? (lessons to learn)
- When should they be used?



Wintergarden Artwork Façade, Brisbane – Studio505

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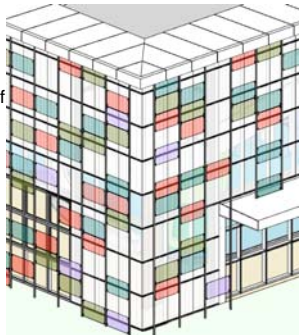
Introduction

What are lightweight façade systems?

- Minimal materials – lightweight and economical
- Large spans – relative to structural sizes
- Transparency – minimum visual impact of structure

Planar Tensioned Cable supported systems

- Have to deflect to resist wind loads
- use pretension to control deflections
- deflection limits can be higher for screen type applications than those for the weatherproof façade elements
- lower prestress = less structure which make this cost competitive option compared to conventional framing
- can be fitted to new buildings or existing
- Present a number of engineering challenges

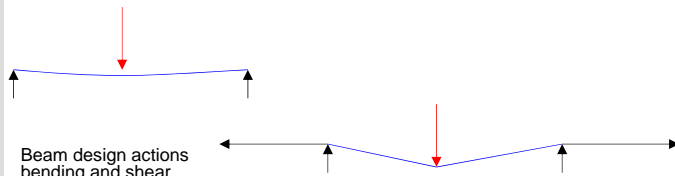


MARC Façade, Perth –
DovanPayne

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Planar Tensioned Cable support systems

Beam compared to Cable supports



Beam design actions bending and shear independent of beam properties

AS4100 design code

Cable design action tension is a function of cable prestress, material and area

Large displacement Non linear analysis needs to be used

ASCE 19-10 or EC3 1-11 design codes

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Planar Tensioned Cable support systems

Beam compared to Cable supports

Proportions of in plane force to out of plane force can be found from cable geometry

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Planar Tensioned Cable support systems

Beam compared to Cable supports

Beam design actions bending and shear independent of beam properties

Cable design action tension is a function of cable prestress, material and area

Lower these and the design force reduces

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Planar Tensioned Cable support systems

Beam compared to Cable supports

<p>Beam deflection a function of</p> <p>E material I section geometry (depth cubed) L^3 span length cubed</p> <p>Typical deflection limit span/250 to 150</p>	<p>Cable deflection a function of;</p> <p>E material A section geometry (area) L span length P cable pretension</p> <p>Typical deflection limit span/50 to 20 i.e. 5 to 6 times more than beam 3 to 7 degrees rotation 10 to 4 times applied force</p>
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Planar Tensioned Cable support systems

Planar Tensioned Cable supported systems design challenges

- Determination of design loads
- large displacements
 - acceptance limit
 - rotations at end terminations
 - dynamic implications
- large in-plane loads
- mid cable connections (saddles/deflectors and clamps)
- creep
- installing and maintaining desired prestress levels

Taronga Zoo Chimp Enclosure, Sydney

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Planar Tensioned Cable support systems

Determination of design loads

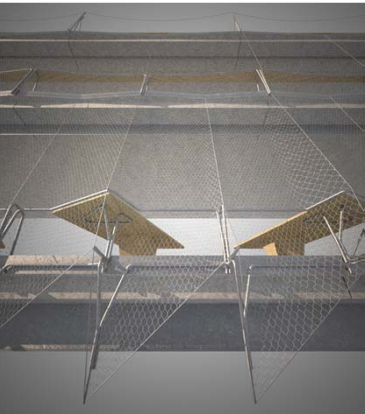
- AS1170 covers imposed loads on barriers and wind loads on buildings
- barriers (balustrade in-fills) have different design loads depending on what the space is being used for
- wind loads on porous screens near face of building not covered by code, wind tunnel testing required but this is too expensive for many projects

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Large displacements

Large displacements – acceptance limit

- Tensioned SS cable net with additional cables
- Provides edge protection
- Designed to barrier loads from AS1170 and BCA requirements for balustrade infills

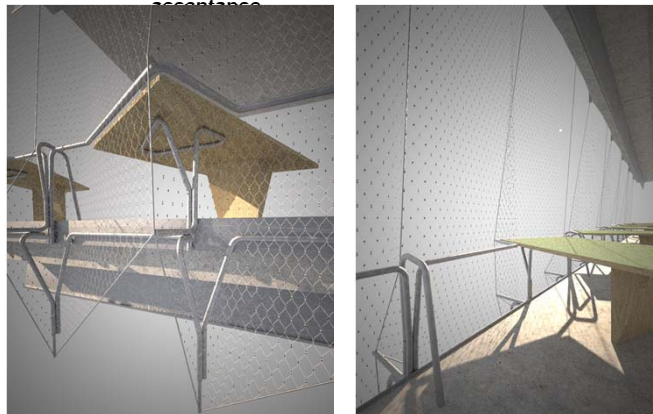


Uni of Melbourne New Architecture Building – NADAA / Wardle

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Large displacements

Large displacements - user acceptance



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Large displacements

Large displacements - user acceptance

Displacement can be desirable



Ned Khan Wind Veil, MASDAR, UAE – Foster and Partners

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Large displacements

Large displacements - user acceptance




Wind Veil, prototype – UAP

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Large Displacements

Large Displacements - Rotations at End Terminations



TYPICAL BOTTOM

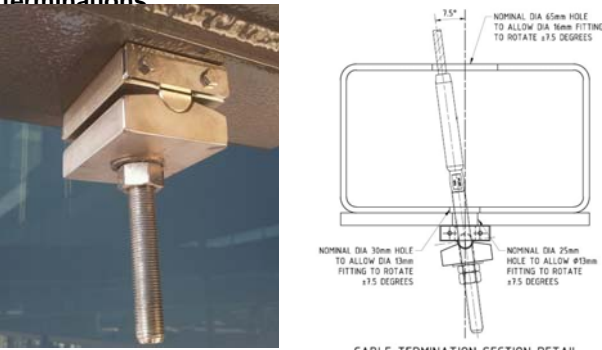
Aglient Façade, Melbourne – Locker/Ronstan

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Large Displacements

Large displacements - Rotations at end terminations



CABLE TERMINATION SECTION DETAIL
SCALE 1:2.5


Walga Façade, Perth – Hassell

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Large Displacements

Dynamic Implications



Park Beach Plaza Carpark Screen, Coffs Harbour – Hassell

A number of wind induced dynamic responses possible

- Vortex shedding
- Galloping
- Divergence and Flutter

Difficult to get correct results even from up to software

- dampening hard to predict
- correct modeling of large displacement cables

Fatigue

- Function of number of cycles and change in stress level

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Large Displacements

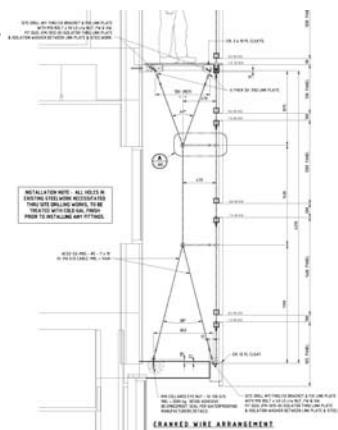
Dynamic Implications

Michie Facade, QUT, Brisbane –
Wilson Architects

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Large Displacements

Dynamic implications

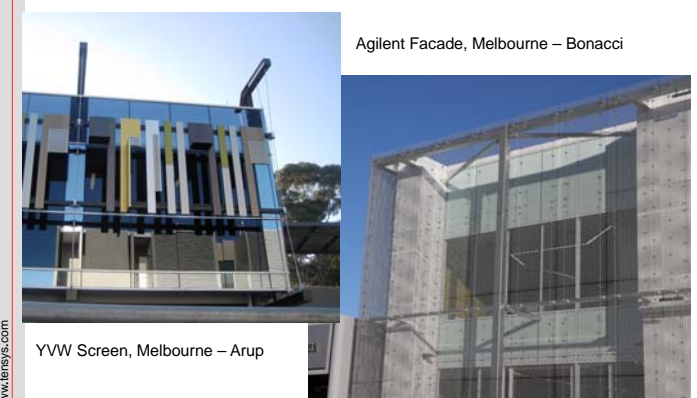


Michie Facade, QUT,
Brisbane –
Ronstan

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Planar Tensioned Cable support systems

Large In-plane Loads



Agilent Facade, Melbourne – Bonacci

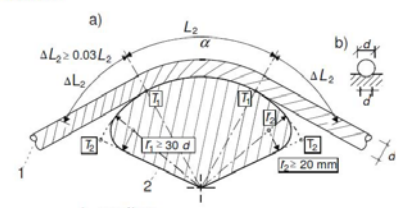
YVW Screen, Melbourne – Arup

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Planar Tensioned Cable support systems

Mid Cable Connections

BS EN 1993-1-11: 2006
EN 1993-1-11: 2006 (E)



1 strand/rope
2 saddle
 L_2 length of strand/rope between the two theoretical tangent points T_1 and T_2 under the most unfavourable characteristic combination of loads and the catenary effects
 ΔL_2 additional length of wrap

Figure 6.1: Bedding of a strand/rope over a saddle

NOTE: Compliance with the requirements in (1) above will result in the breaking resistance of the strand and rope being reduced by not more than 3%.

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Planar Tensioned Cable support systems.

Mid Cable Connections

BS EN 1993-1-11: 2006
EN 1993-1-11: 2006 (E)

1 hole for preloaded bolts
2 preload F_k from preloaded bolts

Figure 6.2: Clamp

NOTE: F_k is not directly related to ULS. By the use of F_k capacity design (see EN 1993-1-1, 1.5.8) is applied.

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Mid Cable Connections

Table C-1 Clamp Groove Diameter Tolerances

Wire Rope Diameter (in.)	Tolerance (in.)		Strand Diameter (in.)	Tolerance (in.)	
	Min.	Max.		Min.	Max.
3/8 to 1-1/8	+1/32	+3/32	1/2 to 1-1/2	+1/32	+3/32
1-3/16 to 1-1/2	+1/16	+1/8	1-9/16 to 2-1/2	+1/16	+1/8
1-9/16 to 2-1/8	+3/32	+5/32	Over 2-1/2	+1/8	+3/16
2-3/16 to 3	+1/8	+3/16			
Over 3	+5/32	+1/4			

Note: 1 in. = 25.4 mm.

FIGURE C-1. Cable Clamp Fitting.

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Mid Cable Connections

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Mid Cable Connections

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Creep

Inelastic cable elongation over time due to long term stress level

Occurs to concrete support structure and foundations also.

Typically between 0.01% and 0.06% after prestretching

- pre-stretching
- install at higher prestress
- inspect, measure and re-tension

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Planar Tensioned Cable support systems.


Installing and Maintaining Desired Prestress Levels

Adjustment required for support structure

- misalignment
- deflection due to prestress

Inspection and monitoring

Re-tension capability



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Concluding comments

Conclusions

Tensioned planar cable supported façade systems

- Real potential to 'touch the earth lightly'
- Minimal visual impact
- Minimal space
- Minimal materials
- Economic

for appropriate use

Getting the Design Right

- Understanding the movement
- Resisting the in place forces efficiently
- Appropriate connections
- Design for long term performance

Where next – doubly curved cable nets, cable trusses

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