Straker Engineering Services

ENGINEERING REPORT

RE11049

Subject	Analysis of Proposed Load Restraint Configurations for Round Cotton Modules
Client	B-Safe Winches Australia (a Division of Dangerous Goods Equipment Pty Ltd)
Client Address	PO Box 4029 Eight Mile Plains QLD 4113
Revision	5
Date	3rd April 2014
Report By	Noel Straker

1 Scope and Introduction

B-Safe Winches Australia requested that Straker Engineering Services assess the suitability of a proposed load restraint system for the transport of round cotton modules, and its ability to comply with the requirements of the Load Restraint Guide 2nd Edition (2004).

Two configurations were examined; one for a flat bed trailer, and one for a drop deck trailer. These configurations were similar, however not identical, to that examined and proposed in work performed by John Lambert and Associates in March, 2011.

2 Exclusions

This analysis is an assessment of the load restraint capacity, and does not include any assessment of trailer or load dimensions for the purposes of highway regulation compliance.

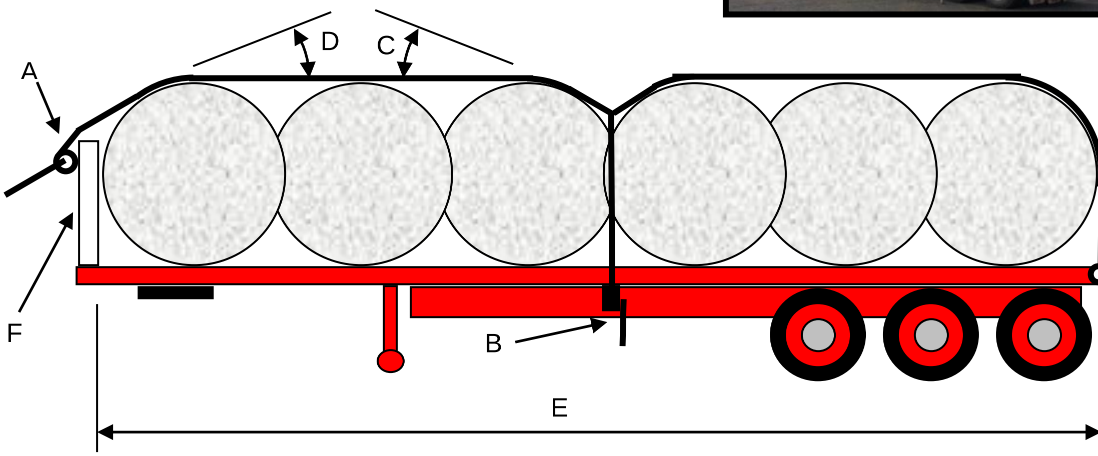
3 Reference Material

- Load Restraint Guide, 2nd Edition (2004), *National Transport Commission and Roads and Traffic Authority NSW.*
- Cotton Bale Load Restraint Draft Report – March 2011, *John Lambert and Associates*.[1]

[1] Significant prior works on this restraint system had been carried out by John Lambert and Associates Pty Ltd. These works have been used both for comparison and as a source of experimental data.

4 Proposed Restraint Configurations

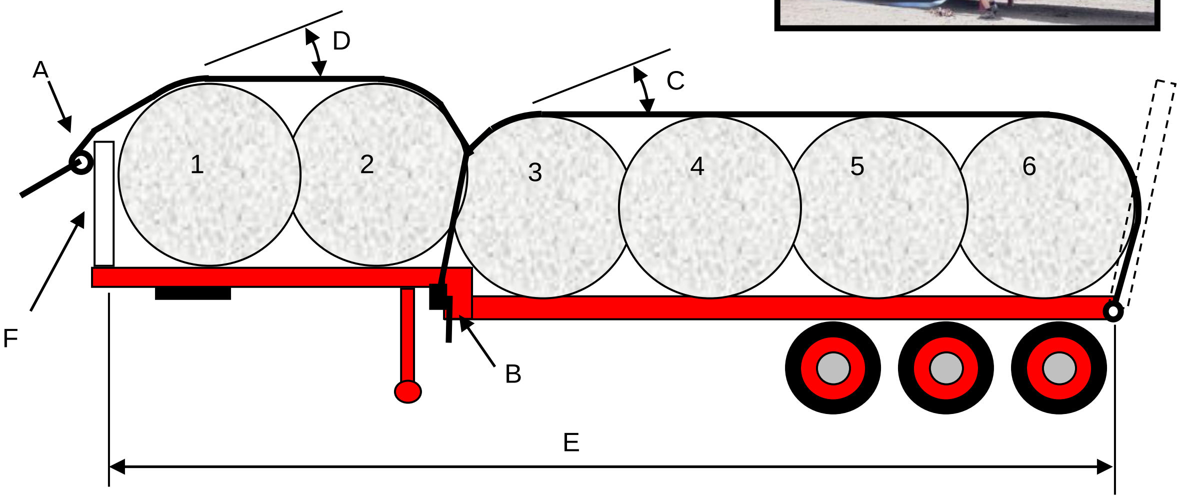
4.1 Flat Bed Trailer



A	B-Safe 75mm or 100mm webbing strap winch (may be located at front or rear) with minimum lashing capacity of 4000kg.
B	B-Safe 50mm webbing strap winch, run across top of 100mm strap to opposite tie rail.
C	30° minimum
D	45° minimum
E	14400mm maximum
F	Reinforced headboard with minimum forward restraining capacity of 6000kgf
Load	6 off Plastic wrapped cotton modules
Maximum module weight	2500kg
Module nominal dimensions	2438 mm wide x 2286 mm diameter
Trailer Surface	Smooth Steel or Floor plate
Tensioning Sequence	1. Tension 100mm longitudinal strap using winch "A" to 1150 kgf[2] 2. Tension 50mm lateral strap using winch "B" until angle "C" is obtained in 100mm webbing strap.

[2] Work performed by John Lambert and Associates demonstrated the ability of the 50mm B-Safe winch to readily generate this level of webbing tension. As the 100mm winch utilizes the same leverage and winding mechanisms, it is expected that the same tension will be developed with the same reasonable level of manual effort.

4.2 Drop Deck Trailer



A	B-Safe 75mm or 100mm webbing strap winch (may be located at front or rear) with a minimum lashing capacity of 4000kg.
B	B-Safe 50mm webbing strap winch, run across top of 100mm strap to opposite tie rail.
C	30° minimum
D	45° minimum
E	14400mm maximum
F	Reinforced headboard with minimum forward restraining capacity of 6000kgf
Load	6 off Plastic wrapped cotton modules
Maximum module weight	2500kg
Module nominal dimensions	2438 mm wide x 2286 mm diameter
Trailer Surface	Smooth Steel or Floor plate
Tensioning Sequence	1. Tension 100mm longitudinal strap using winch "A" to 1150kgf. 2. Tension 50mm lateral strap using winch "B" until angle "C" is obtained in 100mm webbing strap.

5 Experimental Method

Whilst substantial data could be drawn from the works performed by John Lambert and Associates, additional tests were required to adequately assess the load restraint configurations detailed in section 4. In particular, test data was required to empirically quantify the following parameters:

- Inter-module friction
- Coaming rail contribution to lateral restraint

To gather the required data for the proposed configurations, cotton modules were loaded and lashed to the two test trailers. An individual cotton module (module 5) was then pulled out laterally. In the process, the force applied to module was monitored using a load cell. Details of the experimental setup are given below:

Test Location	Kents Road, Jimbour, QLD
Test Date	13th December 2011
Load Cell	10 t S-type load cell (#001) c.w. VC210 digital readout
Trailer Details	Flat bed trailer – QLD reg 433 QCB Drop Deck Trailer – QLD reg 808 QHG
Cotton Modules	6 off Round Plastic Wrapped Cotton Modules Typical mass – 2300kg Approximate Mean Diameter – 2300mm Approximate Mean Width – 2400mm
Loading Apparatus	JCB Telescopic Handler, with chains and a spreader bar across the back of the module (see image below)

6 Test Results and Design Data

6.1 Test Results

	Data	Flat Bed	Drop Deck	Source
A	**Applied Force to Module Slip**	1500 kgf	1700kgf	Straker Engineering Services testing December 2011
B	**Additional Force at Coaming Rail**	150 kgf (min[3])	n/a	Straker Engineering Services testing December 2011

6.2 Design Data

	Data	Value	Source
C	**B-Safe 50mm winch pretension capability**	1150kgf	John Lambert and Associates – March 2011
D	**Module Sliding Force – not secured**	920kgf	John Lambert and Associates – March 2011
E	**Friction Co-efficient – Module on Smooth Steel**	0.4	John Lambert and Associates – March 2011
F	**Inter-module Friction**	290 kgf[4]	Calculated = (A – D)/2

[3] test halted to prevent any damage to plastic wrapping

[4] The lower value measured from the flat bed test was conservatively adopted for subsequent calculations

7 Calculations

7.1 Forward Direction Restraint

Forward direction restraint is provided by frictional contact with the trailer floor and load blocking contact with the headboard. A summary of the calculation is provided below:

A	maximum module mass	2500kg	
B	number of modules	6	
C	total mass	15000kg	= A x B
D	forward restraint required	12000kgf	= 0.8 x C (Load Restrain Guide 2nd edition 2004)
E	friction due to self weight	6000kgf	= friction co-efficient x C
F	headboard capacity	6612kgf	calculated for 2 off 75x75x3.0 SHS Gr350 reinforcing uprights
G	**total forward restraint**	**12612kgf**	**= E + F (exceeds D therefore acceptable)**

The proposed restraint system has been calculated to provide a forward direction restraint force exceeding the performance standard set out in the Load Restraint Guide 2nd Edition (2004).

NOTE: The following sources of additional restraint were conservatively omitted from the calculation above:

- *Friction due to lashing downforce*
- *Blocking and friction due to step in drop deck configuration*

7.2 Rearward direction restraint

Rearward restraint is provided by the longitudinal 100mm webbing strap. A summary of the calculation is provided below:

A	maximum module mass	2500kg	
B	number of modules	6	
C	total mass	15000kg	= A x B
D	friction due to self weight	6000kgf	= friction co-efficient x C
E	100mm webbing strap capacity	4000kgf	Lashing capacity for 100mm webbing
F	**total rearward restraint**	**10000kgf**	**= D + E (exceeds G therefore acceptable)**
G	rearward restraint required	7500kgf	= 0.5 x C (Load Restrain Guide 2nd edition 2004)

The proposed restraint system has been calculated to provide a rearward direction restraint force exceeding the performance standard set out in the Load Restraint Guide 2nd Edition (2004).

NOTE: The following sources of additional restraint were conservatively omitted from the calculation above:

- *Friction due to lashing downforce*
- *Blocking and friction due to loading ramps in drop deck configuration*

7.3 Lateral direction restraint

The proposed restraint system acts in two fashions to restrain the load of cotton modules. Firstly, it provides a lashing force to prevent relative movement between the modules. Secondly, it provides lashing downforce to clamping the load to the deck of the trailer.

To determine the efficacy of this restraint system, the ability of the longitudinal 100mm strap to prevent relative movement between the modules was first examined. By performing the module pullout test, the inter-module friction was empirically determined to be 290kgf when secured using the proposed restraint system. Taking the worst case (modules 4 and 5 in the drop deck configuration) a calculation was performed, a summary of which is provided below:

A	Module Mass	2500kg	Specified maximum module mass
B	Friction Coefficient	0.4	John Lambert and Associates – March 2011
C	Friction Due to weight	1000kgf	= A x B
D	Inter-module friction	290kg	Straker Engineering Services – December 2011
E	Total relative restraint between modules	1290kgf	= C + D
F	Required restraint (per module)	1250kgf	= 0.5 x A (Load Restrain Guide 2nd edition 2004)

From this it was seen that the inter-module friction would prevent relative movement between the modules until loads exceeding the 0.5g performance requirement.

The load was then considered as a whole unit, and the total lateral restraint requirements were assessed as follows:

A	maximum module mass	2500kg	
B	number of modules	6	
C	total mass	15000kg	= A x B
D	lateral restraint required	7500kgf	= 0.5 x C (Load Restrain Guide 2nd edition 2004)
E	friction due to self weight	6000kgf	= friction co-efficient x C
F	Friction at headboard	660kgf	= friction co-efficient x clamping force (John Lambert and Associates – March 2011)
G	lashing restraint required	840kgf	= D – (E + F)
100mm strap –Module 1			
H	pretension	1150 kgf	John Lambert and Associates – March 2011
I	angle effect	0.7	
J	effective downforce	805 kgf	= H x I
100mm Strap –Ahead of cross strap			
K	pretension	1150kgf	
L	angle effect	0.5	
M	effective downforce	575kgf	= K x L
100mm Strap –Behind cross strap			
N	pretension	1150kgf	
O	angle effect	0.5	
P	effective downforce	575kgf	= N x O
100mm Strap –Module 6			
Q	pretension	1150kgf	
R	angle effect	1	
S	effective downforce	1150kgf	= Q x R
T	total lashing downforce	3105kgf	= J + M + P + S
U	Lashing lateral restraint	1242kgf	= T x friction co-efficient
V	**total lateral restraint**	**7902kgf**	**= E + F + U (exceeds D therefore acceptable)**

The proposed restraint system has been calculated to provide a lateral restraint force exceeding the performance standard set out in the Load Restraint Guide 2nd Edition 2004.

NOTE:
The following factors were conservatively omitted for the purposes of this calculation:

- *increases in the tension of the longitudinal strap caused by the tensioning of the mid-strap, and*
- *mechanical interaction present between the strap and end modules where the strap buries into the module.*
- *The additional frictional contribution provided by the step in the drop deck configuration*

While not necessary to achieve the required lateral restraint, the presence of coaming rails provides additional resistance to lateral movement of the cotton modules. From the tests conducted by Straker Engineering Services it has been determined that this will provide a minimum of an additional 150kgf per module for a 25mm coaming rail. It is therefore considered advisable that, where practical, vehicles be fitted with coaming rails to a minimum height of 25mm.

7.4 Vertical direction restraint

Vertical restraint is provided by the combination of the clamping actions of the longitudinal 100mm webbing strap, the lateral 50mm webbing strap and inter-module friction.

It has previously demonstrated for lateral restraint that the inter-module friction generated by the longitudinal clamping effect of the 100mm webbing strap should prevent relative motion of the cotton modules to loads exceeding the 0.5g. In turn, this indicates that the 0.2g vertical direction performance standard should not cause relative movement between modules.

Considering the load as a whole unit, the following calculation was made:

A	maximum module mass	2500kg	
B	number of modules	6	
C	total mass	15000kg	= A x B
D	vertical restraint required	3000kgf	= 0.2 x C (Load Restrain Guide 2nd edition 2004)
	100mm strap –Module 1		
E	pretension	1150 kgf	John Lambert and Associates – March 2011
F	angle effect	0.7	
G	effective downforce	805 kgf	= E x F
	100mm Strap –Module 3		
H	pretension	1150kgf	
I	angle effect	0.5	
J	effective downforce	575kgf	= H x I
	100mm Strap –Module 4		
K	pretension	1150kgf	
L	angle effect	0.5	
M	effective downforce	575kgf	= K x L
	100mm Strap –Module 6		
N	pretension	1150kgf	
O	angle effect	1	
P	effective downforce	1150kgf	= N x O
Q	**total vertical restraint**	**3105kgf**	**= G + J + M + P (Exceeds D therefore acceptable)**

The proposed restraint system has been calculated to provide a vertical restraint force exceeding the performance standard set out in the Load Restraint Guide 2nd Edition 2004.

8 Conclusion

The load restraint configurations detailed in section 4 have been calculated to comply with the performance standards set out in the Load Restraint Guide – 2nd Edition – 2004.

Approved by

Noel Straker	Principal Engineer		5th March, 2014
Name	**Position**	**Signature**	**Date**

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