



Test Report: STL-TR-25-11

## **Structural Performance Testing of Box Truss Systems**



**Centre for Infrastructure Engineering**

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**Client:**

Lills Group Pty Ltd,  
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**Project Title:** Structural Performance  
Testing of Box Truss Systems

**Project Code:** TRS-TBTS

Western Sydney University,  
Centre for Infrastructure Engineering

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## 1. Introduction

Aluminium Box truss systems are widely used in temporary and permanent structures such as event stages, lighting frames, and modular platforms because of their high strength-to-weight ratio, modular form, and ease of assembly [1]. These systems are commonly subjected to bending and compressive actions during service, arising from equipment loads, and imposed actions. Ensuring their structural performance and integrity under realistic loading conditions is essential for safety, serviceability, and product certification.

While aluminium truss products are generally designed in accordance with relevant industry practices, there is limited experimental data available on their actual structural behaviour under controlled bending and compression loading. Factors such as geometry of their system, connection details, and material properties can influence stiffness, load capacity, and overall performance. For this reason, laboratory testing is necessary and an integral part of assessing structural response, deformation behaviour, and load-carrying capacity under representative loading conditions.

In this project, Lills Group Pty Ltd, commercially known as Transtage (the Client), engaged Western Sydney University to undertake an experimental testing program to evaluate the bending and compressive performance of selected truss products. The testing program includes compression tests and three-point bending tests conducted in a controlled laboratory environment at the WSU Structural Laboratory. The outcomes of this study will support product verification, quality control, and ongoing design development. This report describes the testing methodology, experimental setup, and key results obtained from the testing program.

### 1.1. Personnel

The following people were involved:

- 1) Mr Robert Marshall, Lab Manager, Senior Technical Coordinator, TRTS at WSU.
- 2) Professor Bijan Samali, Professor of Structural Engineering, CIE at WSU.
- 3) Dr Masoud Mohammadi, Research Project Assistant, CIE at WSU.
- 4) Mr Mehdi Saeidi Golsefidi, Research Project Technician, TRTS at WSU.
- 5) Mr Amin Delfi, Research Project Technician, TRTS at WSU.

## 2. Methodology

Upon the request of the Client, Western Sydney University (WSU) conducted experimental testing to assess the flexural behaviour and compressive strength of their box truss products using three-point bending and compression test setups [2]. The client provided the specimens and connections ready for testing, which were subsequently tested by WSU personnel. Throughout the testing process, data on applied loads and displacements were continuously collected and recorded, and all are presented in this report along with visual observations.

## 3. Experimental Program

The experimental program for this project includes two main test categories, three-point bending and axial compression, with three samples tested in each category. The tests are intended to assess the overall load capacity, deformation behaviour, and failure modes of the box truss systems. WSU personnel were responsible for preparing all test setups and conducting the sample testing. The samples were subjected to a specified displacement-controlled loading method using the universal hydraulic testing machine. Table 1 provides a summary of the sample details, including cross-sectional dimensions based on the product datasheet, and the number of specimens in each test category.

**Table 1.** Test categories and sample sizes

Test Cat.	Test Type	Test ID	Box Truss Cross-Sectional dimension, mm			Sample length	Instrument	No. of Tests
			External dimensions (HXW)	Length (L)	Length and cross way profiles, material			
1	<b>Bending Test</b> (Three Point Bending)	TRS-BSTS-1	290mm x 290 mm	3000mm	Ø50, 2mm Ø20, 2mm	6000 mm	actuator displacement and load collection+ 3 middle LPs	3
2	<b>Compression Test</b>	TRS-BSTS-2		2000mm	Extruded Aluminium	3000mm	actuator displacement and load collection	3
<b>Overall</b>								<b>6</b>

### 3.1. Specimen preparation

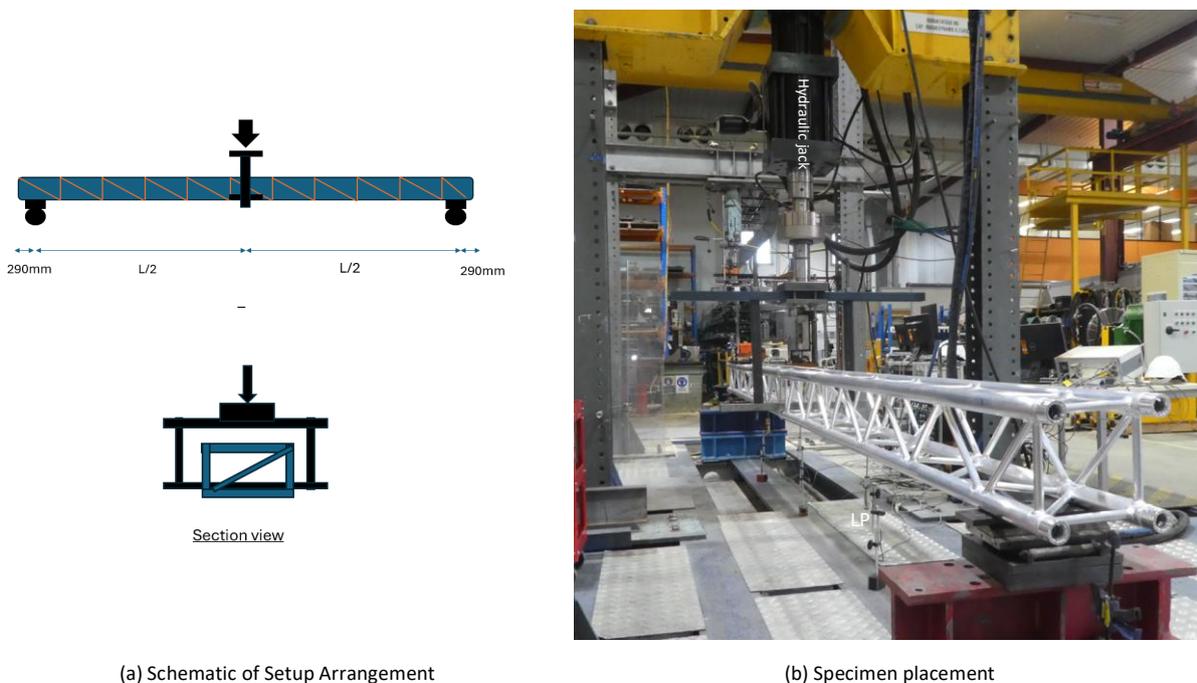
The client delivered all samples to the WSU structural laboratory in a prepared, unassembled state, ready for testing. No major modifications were made to the specimens by WSU personnel, except for assembling them for testing. The client ensured that the supplied

samples were undamaged and in optimal condition. WSU was not responsible for assessing the quality of the samples, verifying their compliance, or supervising their production process.

### 3.2. Test Setup and Loading Regime

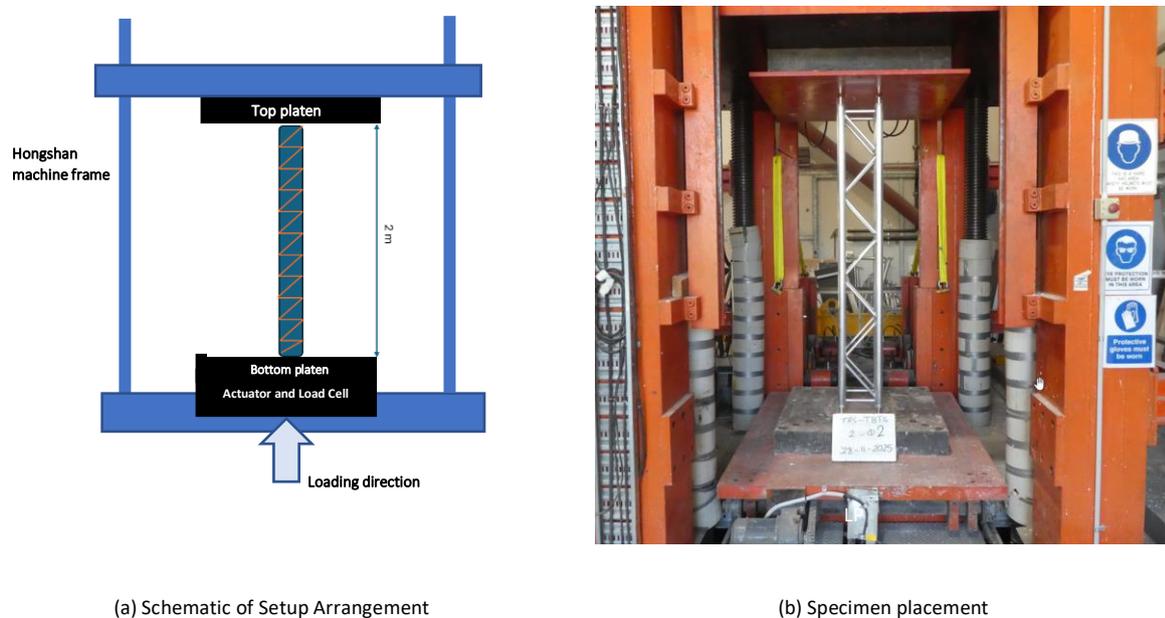
Testing was carried out using a test rig on the strong floor for the bending tests and the High Capacity Hongshan Multipurpose Testing Machine for the compression tests.

For the bending tests, a three-point bending setup was installed on the strong floor with simple supports at both ends. The setup included a universal hydraulic jack and a load cell to accurately measure the applied load and displacement. The load cell had a maximum capacity of 1,000 kN (LC2330), and the hydraulic jack was suitable for both compression and tension loading. For each bending test, two box truss samples were assembled together using the appropriate hardware, including spigots and pins provided by the client. The loading frame was fabricated by WSU to apply the load to the bottom chord of the box truss, as shown in Figure 1. Three linear potentiometers (LPs) were installed beneath the specimen to record vertical displacement at key locations, including the midspan and the centre of each span. For the loading regime, a pre-load of 2 kN was applied and held for one minute, after which the specimen was loaded at a constant displacement rate of 2 mm/min until failure. These tests were conducted to assess the flexural behaviour of the box truss systems, examine the load–displacement response, and evaluate serviceability performance in terms of load capacity and deformation.



**Figure 1.** Bending Test setup

For the compression test, the Hongshan universal testing machine was used. This testing machine is equipped with a load cell and displacement transducer that enables it to measure the applied load and displacement with a high degree of accuracy. It has a maximum load capacity of 10,000 kN and can perform both compression and tension tests. For this project, the machine was used to perform monotonic compression tests on box truss specimens using a fixed support test setup, with schematic and photo presented in Figure 2. Loads were applied by driving the bottom plate platen upward with the top platen fixed in position. The prepared test setup is shown in Figure 2 (b), which demonstrates the positioning of the specimen. For the loading regime, a pre-load of 10 kN was applied and held for one minute, after which the specimen was loaded at a constant displacement rate of 2 mm/min until failure. During the testing process, the applied load (in kN) and actuator position (in mm) were recorded continuously.



(a) Schematic of Setup Arrangement

(b) Specimen placement

**Figure 2.** Compression Test setup

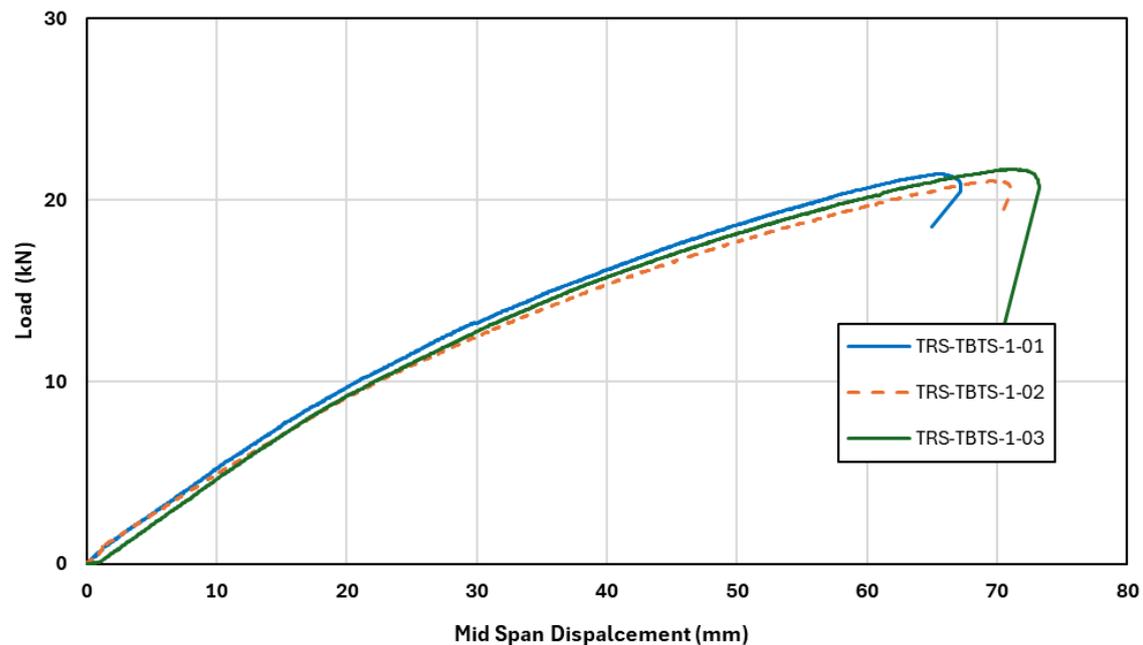
#### 4. Test results, analysis, and observations

In this section, the results of tests performed based on each specimen, including data obtained and observation pictures, and the analyses are presented.

##### 4.1. Category 1 test results

To better understand the flexural strengths of Category One (1) samples (TRS-BSTS-1) which has been made of two box truss samples of 3000mm, overall length of 6000mm, tests were conducted using a three-point bending setup. The applied load using a frame rigidly connected to the actuator to the bottom chord of the specimen and the corresponding mid-span displacement

(mm) were recorded using linear potentiometers (LPs) throughout the testing process. Graphs were generated to illustrate the relationship between pressure (load, kN) and mid-span displacement (mm) of the specimen, as shown in Figure 3. These graphs provide insights into the bearing capacity, deformation, and structural performance of specimens under specified conditions.



**Figure 3.** Load-displacement of TRS-BSTS-1 samples of category 1

Table 2 presents the bending test results for the specimens, detailing the maximum load in kilonewtons and the corresponding mid-span displacement in millimetres. Three specimens with a span length of 6000 mm were tested, with maximum loads of 21.43 kN, 21.05 kN, and 21.69 kN recorded. The average load-bearing capacity was determined to be 21.39 kN, with a standard deviation of 0.32 kN and a coefficient of variation of 1.50%, indicating very consistent results across all tests.

**Table 2.** Summary of bending test results

Test Category	Test ID	Span length (mm)	Maximum Load (kN)	Mean (kN)	Stdv (kN)	CoV (%)	Displacement at Maximum Load (mm)
1	TRS-BSTS-1-01	5420	21.43	21.39	0.32	1.50	67.21
	TRS-BSTS-1-02		21.05				70.65
	TRS-BSTS-1-03		21.69				72.23

The measured mid-span displacements at maximum load ranged from 67.21 mm to 72.23 mm, is showing similar deformation behaviour for all specimens. Overall, the results demonstrate stable and repeatable structural performance under the applied loading conditions.

#### 4.1.2. Design load calculations

A prototype testing approach in accordance with AS/NZS 1170.0 was adopted in this program to establish the design bending capacity of the box truss units. To account for variability between individual structural units, a test factor  $k_t$  was applied. Based on three prototype tests and a coefficient of variation of less than 5%, as indicated in Table 2, a value of  $k_t = 1.15$  was adopted in accordance with Table B1 of AS/NZS 1170.0 [3]. For the Ultimate Limit State (ULS) assessment based on prototype test strength, the design action effect is required to satisfy the following relationship, ignoring the self-weight.

$$\gamma k_t \psi P \leq \phi P_u$$

where  $P$  is the unfactored design point load applied at mid-span,  $P_u$  is the ultimate point load from the prototype test,  $\gamma$  is the relevant ULS action factor from AS/NZS 1170.0 load combinations,  $\phi$  is the capacity reduction factor for the structural resistance model, and  $\psi_s$  is the short-term serviceability factor for imposed load, such as temporary installation of lighting or equipment. Rearranging the terms gives the maximum permitted design point load at mid-span:

$$P_{max,ULS} = \frac{\phi P_u}{\psi_s \gamma k_t}$$

Using the measured average ultimate mid-span load from the three-point bending tests,  $P_u=21.39$  kN, and  $k_t=1.15$ ,  $\phi=0.85$ , and  $\psi_s=1$ , with  $\gamma=1.5$  (typical for imposed action), the maximum design load is calculated as:

$$P_{max,ULS} = \frac{0.85 \times 21.39}{1 \times 1.5 \times 1.15} = 10.54 \text{ kN} \approx 1074.76 \text{ kgf}$$

This corresponds to an applied load of approximately 1074.76 kgf at mid-span. At this load level, the measured mid-span displacement was approximately 23.5 mm.

For long-term loading conditions, such as permanent installation of equipment, the long-term serviceability factor  $\psi_l$  of 0.6 may be applied in accordance with AS/NZS 1170.0. Under this condition, the corresponding allowable mid-span load increases to approximately 1791.3 kgf, with an associated displacement of approximately 49.5 mm.

**Table 3.** Summary of design loads based on prototype testing

Test Category	Test ID	Sample Length (mm)	Mean (kN)	Combination factor Used		Maximum Design load (Kgf)	Displacement at Design load (mm)
1	TRS-BSTS-1	6000	21.39	Short-term factor, $\psi_s$	1	1075	23.5

#### 4.1.3 Category 1 test observations

In order to provide further insights into the results presented, this subsection presents some pictorial observations captured before and after failures of samples/specimens, serving as illustrative example as shown in [Figure 4](#). Following each test, observations and before-and-after photos taken during the experiments were provided to the designated client representative. The observed failure mode occurred at the pin connections between two adjacent truss units. Under increasing load, the connection experienced local damage, followed by rupture of the pin-joint assembly, which governed the overall failure of the system. No global member buckling or chord fracture was observed away from the connection, indicating that the joint capacity controlled the failure behaviour.



(a) TRS-BSTS-1-01, before test



(b) TRS-BSTS-1-01, after test



(c) TRS-BSTS-1-02, before test



(d) TRS-BSTS-1-02, after test



(e) TRS-BSTS-1-03, before test

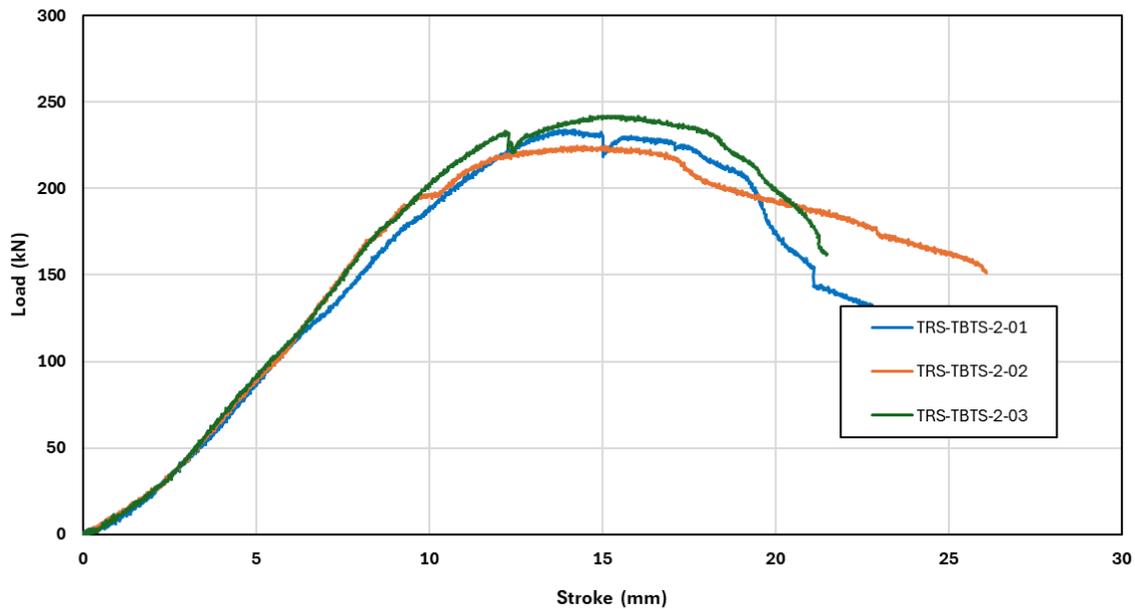


(f) TRS-BSTS-1-03, after test

**Figure 4.** Observations of category 1 specimens

#### 4.2. Category 2 test results

To evaluate the compressive strength of the Category 2 specimens (TRS-BSTS-2) with a height of 2,000 mm, compression tests were carried out. The load was applied in accordance with the loading regime described in Section 3.2, and the corresponding displacement was recorded from the stroke movement. Load–displacement graphs were then generated to show the relationship between the applied load (kN) on the box truss cross-section and the measured displacement (mm), as presented in [Figure 5](#).



**Figure 5.** Pressure-displacement of TRS-BSTS-2 specimens of category 2

**Table 4** presents the test results for the specimens, detailing the maximum load in kilonewtons and the corresponding mid-span displacement in millimetres. Three specimens with a span length of 2000 mm were tested, with maximum loads of 233.82 kN, 224.71 kN, and 242.02 kN recorded. The average load-bearing capacity was determined to be 233.51 kN, with a standard deviation of 8.66 kN and a coefficient of variation of 3.71%, indicating very consistent results across all tests.

**Table 4.** Summary of test results

Test Category	Test ID	Sample height (mm)	Maximum Load (kN)	Mean (kN)	Stdv (kN)	CoV (%)	Displacement at Maximum Load (mm)
1	TRS-BSTS-2-01	2000	233.82	233.51	8.66	3.71	13.44
	TRS-BSTS-2-02		224.71				14.65
	TRS-BSTS-2-03		242.02				15.29

#### 4.2.1 Category 2 test observations

This subsection presents some pictorial observations captured before and after failures of specimens, shown in **Figure 6**. Failure was mainly governed by local buckling and deformation of the truss members, particularly at mid-lengths and near the connection zones, which gradually led to overall instability of the specimen. Minor and localised cracking was also observed, with no full separation of

members. The failure process was gradual, with no sudden or explosive behaviour, and the specimens exhibited a controlled and progressive response under loading.



(a) TRS-BSTS-2-01, before test



(b) TRS-BSTS-2-01, after test



(c) TRS-BSTS-2-02, before test



(d) TRS-BSTS-2-02, after test



(e) TRS-BSTS-2-03, before test



(f) TRS-BSTS-2-03, after test

**Figure 6.** Observations of category 2 specimens

## 5. Summary and Conclusions

At the request of Lills Group Pty Ltd (Transtage), Western Sydney University (WSU) carried out an experimental testing program to assess the structural performance of selected aluminium box truss systems. All testing was undertaken at the WSU Structural Laboratory under controlled conditions. The test specimens were supplied by the client, while WSU personnel assembled the samples, conducted the testing, and prepared this report.

The main objective of the investigation was to evaluate the structural behaviour of the box truss systems and generate reference data for design purposes. The test program included three-point bending tests and axial compression tests, with three specimens tested in each category. The bending tests showed consistent and repeatable behaviour, with an average ultimate mid-span load of 21.39 kN, and failure governed by the pin connections between adjacent truss units. The compression tests demonstrated high axial capacity, with an average maximum load of 233.51 kN and low variation between specimens.

Overall, the results confirm that the tested box truss systems provide reliable and consistent performance under both bending and compression. The findings support product verification and provide useful data for design checks and future development of the truss systems.

## References

1. American National Standards Institute (ANSI); Entertainment Services and Technology Association (ESTA), ANSI E1.2-2021: Entertainment Technology – Design, Manufacture and Use of Aluminum Trusses and Towers, ANSI/ESTA, **2021**.
2. Standards Australia & Standards New Zealand; *AS/NZS 1664.1:1997 - Aluminium Structures – Limit State Design*, Sydney, Australia: Standards Australia, **1997**.
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