Load Testing – Theatre Lighting Rig

116 Bank Street, Whangarei.

For *OneOneSix Trust*

Consulting Engineers

17st February 2022

CC Project Number: 16211

Contents

Executive Summary

The lighting rig has undergone inspection, structural assessment and testing to determine its capacity.

The safe working load of each individual rig is **160kg**.

The lighting rig consists of 6 individual rigs.

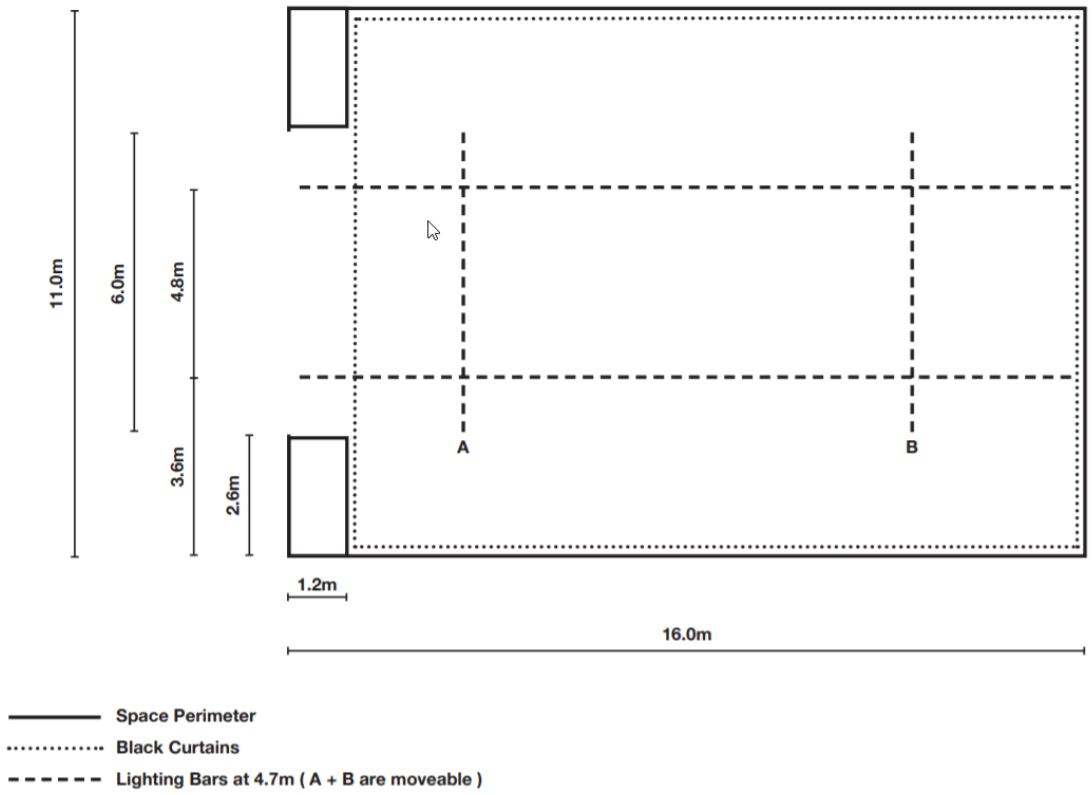
The maximum expected weight across entire lighting rig is 750kg.

Introduction

Cook Costello have been engaged to determine the load capacity of the lighting rig installed in the theatre. Values have been determined through visual inspection of the lighting rig, its members and their connections to the superstructure. Loading and re-inspection of the members and connection was carried out to confirm structural integrity against calculated loads.

Structural Inspection

Structural inspections were carried out for the lighting rig located in the main hall of the theatre.



Ceiling plan with location and orientation of lighting rig.

Aluminum scaffold-bars are suspended approximately 300mm below ceiling height. Each bar has three supporting struts.

Photo showing lighting rigs.

These are suspended using three 25mm SHS Aluminum members, connected to rafters with M8 bolts.

Photo of strut to rafter connection.

Technical Review and Calculations

Structural assessment of member and connection capacities have determined a load capacity of 400kg per section. The limiting factor for load capacity was due to earthquake forces with capacity reduced by approximately half verses gravity loads.

Rig Load Testing

The load testing was carried out on the 25th of January. The applied loads were in place for over 30 minutes.

Each support beam was loaded with approximately 160kg. This was applied through a point load on each span. While this load is lower than the desired loading to confirm calculations, it is beyond the maximum load expected during use.

A pre-inspection assessing the condition of the members and any incline values were recorded and compared with measurements and inspection at the time of loading. No significant change was noted. Some flexure of the main support beams could be observed.

Rated Load Capacity

The maximum load capacity of each lighting support rig was calculated at 400kg, applied uniformly along its length. A safe working load of **160kg** is to be used, as confirmed through testing.

Loads should be removed after use to avoid sagging of timber rafters through long-term creep and to avoid undo stress from potential earthquake action.

Limitations

This report has been prepared solely for the benefit of OneOneSix Trust as our client with respect to the structural assessment. This report has been compiled using non-intrusive visual examination and structural assessment and review. The reliance by other parties on the information or our opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Opinions and judgments expressed herein are based on our interpretation and should not be construed as legal opinions. Where opinions or judgments are to be relied on, they should be independently verified with appropriate legal advice. Any recommendations, opinions, or guidance provided by Cook Costello in this report are limited to technical engineering requirements and are not made under the Financial Advisers Act 2008. In any event it is essential that Cook Costello are contacted if there is any variation in conditions from those described in the report as it may affect the design parameters recommended in the report.

Cook Costello have performed the services for this project in accordance with the standard agreement for consulting services and current professional standards for environmental site assessment. No guarantees are either expressed or implied.

There is no investigation which is thorough enough to preclude the presence of materials at the site which presently, or in the future, may be considered hazardous. Because regulatory evaluation criteria are constantly changing, concentrations of contaminants present and considered to be acceptable now may in the future become subject to different regulatory standards which cause them to become unacceptable and require further remediation for this site to be suitable for the existing or proposed land use activities.

If there are any queries regarding the content of this letter, please do not hesitate to contact the undersigned.

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BE (hons)

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Appendix

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Engineer AMC

Summary sheet

750kg load ok for member & connection in gravity

750kg load not okay for EQ loads

400kg Max load w/ EQ

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Engineer Anachie McLaughlan

Brief : Assessment & testing of lighting rigs to determine load capacity

Components

50 x 130mm Timber roof members

~~M10 bolts~~ M8 BOLT (See P6 for revised)

25x25mm box AC hangers

Load testing amount

750kg. = 7.4kN

Space between supports

2.4m

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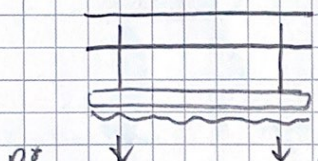

Check 750kg load
Load factor
1.2G + 1.5Q

W = 8.8 kN
R* = 4.4 kN

Bolt Shear Capacity

$V_f = 0.62 \cdot f_{uf} \cdot k_1 \cdot n \cdot A$

$= 11.5$ kN

$\phi V_f = 9.2$ kN

A = 58 mm²
f_{uf} = 400 MPa
k_1 = 0.8

$R^* < \phi V_f$ ∴ OK

Timber Connection Capacity.

Bolts loaded perp to grain.

lower of $k_{12} \cdot f_{ej} \cdot d^{1.5}$ or $\frac{1}{2} b_e f_{ej} d$

$b_e = 2b = 100$ mm

$Q_{sup} = 6.07$ kN

$\phi Q_n = n\, k\, Q_{sup}$

$\phi Q_n = 6.8$ kN

n = 2
k = 0.6
ϕ = 0.7

$R^* < \phi Q_n$ ∴ OK.

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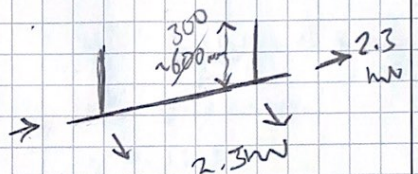
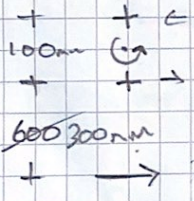
$C_d(T_1) = 0.31$

$W_{max} = 7.4\,kN$

$W(C_d(T_1)) = 2.3\,kN$



BOLTS ON IN PRYING



$M^* = 0.80\,kN/m/2$

$V^* = M^*/0.1$

$= 4.0\,kN$

$V^* = 4.0\,kN$

Check capacity of 2 M10 bolts parallel to grain.

$k_{1,1} f_{cj} d_a^2$ or $0.5\, b_e f_{cj} d_a$

7.22 8.12

$k_{1,1} = 2$

$f_{cj} = 36.7$

$d_a = (10mm)^2$

$b_e = 45$

$n = 1$

$k_1 = 1$

$\phi = 0.8$

$\therefore Q_{kL} = 7.22\,kN/bolt$

$\phi Q_n = n\, k_1 k_{12} k_{1,1} Q_{sk(L)}$

$\phi Q_n = 5.8\,kN$

$V^* < \phi Q_n$ ∴ OK.

NEED TO CONFIRM DIMENSIONS

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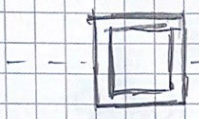

25SHS
(Assume 2mm thick)

$f_{tu} = 276\ MPa$
$f_{ty} = 165\ MPa$
$f_{cy} = 145\ MPa$
$E = 72\ GPa$
$I = 1.63 \times 10^{-8}\ m^4$

$\sigma^* = \frac{M^* y}{I}$

$M^* = \left(\frac{2.3\ kN}{2} \times 0.35\ m\right)$

$M^* = 0.4\ kNm$

$y = 12.5\ mm$

$\sigma^* = 307\ MPa$

$\phi_y f_{cy} = 0.95 \times 145\ MPa$
$= 138\ MPa$

$\sigma^* > \phi_y f_{cy}$ ∴ FAIL IN COMPRESSION

Options: Add bracing
Increase member size

Max EQ load for strut

$M_{Allow} = (\phi_y f_{cy})\, I / y$

$= 0.18\ kNm$

$F_{EQ} = \frac{2 M^*_{Allow}}{0.35\ m}$

$= 1.01\ kN$

$w = F_{EQ} / C_d(T_1)$

$= 2.32\ kN$

$= 338\ kg$

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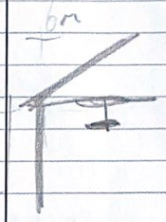
Parts & Components

$C_p(T_p) = C(0)\, C_{Hi}\, C_i(T_p)$

$C_{Hi} = 1 + \frac{h_i}{6} = 1.6$ $\quad h_i = 4m$



$C_i(T_6) = 2.0$

$C_i(0) = 1.33 \Rightarrow C_6(0) = 0.13$

$C_p(T_p) = 0.22$

$F_{ph} = C_p(T_p)\, C_{ph}\, R_p\, W_p \leq 3.6 W_p$

$\mu_p = 1.25$, $C_{ph} = 0.85$

$R_p = 1$

$F_{ph} = 0.35\, W_p$

$C_d(T_1)\, W = 2.28$

$F_{ph}\, W = 2.62$

$\therefore W_{max} = 338kg \times \frac{2.28}{2.62}$

$\Rightarrow 300\,kg$

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Bolt Shear Capacity w/ M8 bolts

$V_f^* \leq \phi V_f$

$\phi V_f = 0.62 \cdot f_{ut} \cdot k_r \cdot (n_n A_s + n_x A_b)$

$0.62 \cdot f_{ut} \cdot k_r \cdot n \cdot A_s$

$= 18\,kN$

$\underline{\phi V_f = 16.5\,kN}$

$f_{ut} = 400\,MPa$
$k_r = 1$
$A_s = 37\,mm^2$
$n = 2$

Timber Connection Capacity

$k_{11} \cdot f_{pj} \cdot d_a^{1.5}$ or $\frac{1}{2} \cdot b_e \cdot f_{pj} \cdot d_a$

$b_e = 2_b = 100mm$

12.3 5.16

$k_{11} = 14.9$
$f_{pj} = 36 \rightarrow 12.9$
$d_a = 8mm$

$Q_{sy} = 5.16\,kN$

$Q_n = n\,k\,Q_{sy}$

$\phi Q_n = 5.8\,kN$

$n = 2$
$k = 0.8$
$\phi = 0.7$

660kg
720kg

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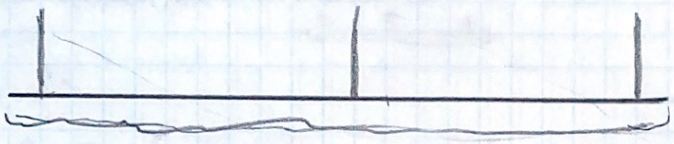

$V_{max} = \frac{10wl}{8}$

$L = 4.8m$
$w = 1.85kN/m$

$R_{max} = 4.6kN$

Rig loading okay in gravity for 750kg load.

CHECKS

$\frac{10wl}{8} \leq 5.8$

$\frac{10 \cdot w \cdot 2}{8} = 5.8$

$w_{max} = 2.32kN/m$

$W_{max} = 9.28kN$

$W_{max} = 945kg.$ (grav)

$w = 2.32kN/m$
$l = 2.2m$

$M^* = wl^2/8$

$= 1.4kNm$

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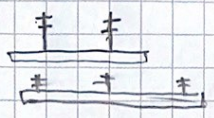
Revised Checks w/ 3 support struts vs 2.

Initial Condition:
Revised :



EQ Case:

from Pg 5 ; $W_{max} \times \frac{3}{2}$ = 440 kg

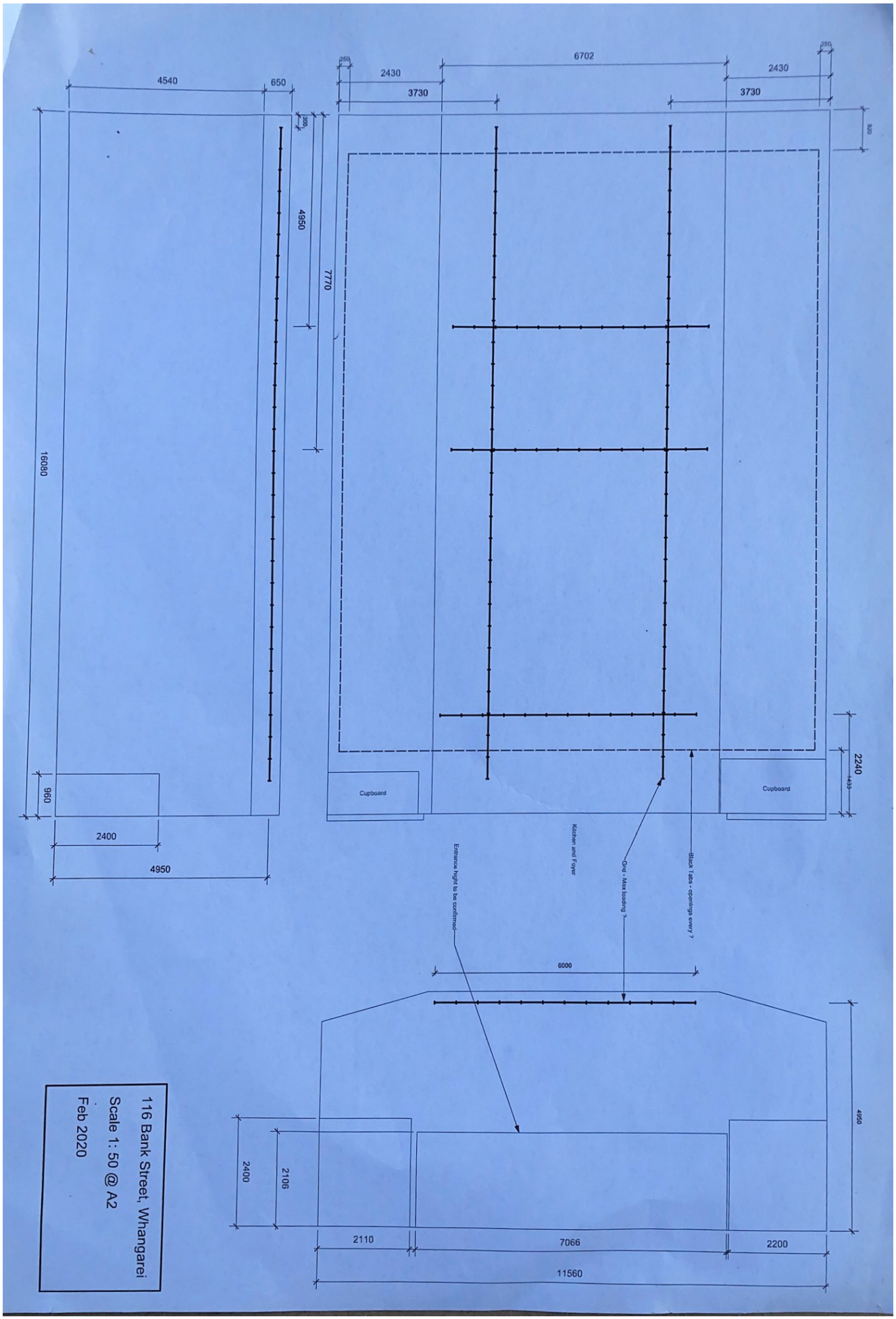
$\triangleq$ 400 kg

Gravity Load

ϕQ_n = 5.8 kN

$V^* = 7.4\,kN \times 0.62$
$= 4.6\,kN$

$V^* < \phi Q_n$ ∴ OK


4540
650
260
2430
3730
6702
2430
3730
250
320
399
4950
7770
16080
960
2400
4950
Cupboard
Cupboard
2240
1433
Kitchen and Foyer
Entrance hight to be confirmed
Grid - Max loading ?
Block Tabs - openings every ?
6000
4950
2400
2106
2110
7066
2200
11560
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Scale 1: 50 @ A2
Feb 2020