LEICHT
Structural engineering and specialist consulting GmbH

Königstraße 9
83022 Rosenheim
Germany

Tel +49 (0) 8031 352 72 - 0
Fax +49 (0) 8031 352 72 - 20
office@LEICHTonline.com

www.LEICHTonline.com

Amtsgericht Traunstein
HRB 17525

Directors
Marcel Enzweiler
Lutz Schöne

München
Rosenheim

Rosenheim, den 29.03.11

Engineering Calculations

Referring Project
Mengel residence project
Project-number
036-JOC11-11

Prepared for: Jockimo Inc. projects

Table of Content:

1 General

The glass insert panels are manufactured by “Jockimo Inc. projects”, UL approved in accordance with UL 410, the US standard for the slip resistance of insert surface materials.

Address of the Manufacturer: Jockimo Inc. projects
20101 SW Birch, Suite #276
Newport Beach, CA 92660

This report is about the glass panels only.

1.1 Project documents from the client

Submitted by mail on 21st March 2011:

8 panels: 3/8" top layer – Low Iron tempered .060 inter layer - PVB 3/8" middle layer – Low Iron tempered .060 inter layer – Sentry Glass Plus 3/8" bottom layer – Low Iron tempered

1.2 Safety concept

Due to the specific features of glass the panels are built from three single panes. For the calculations, we use two scenarios:

Scenario 1: Two panes carry the applied loads for a long period of time (usually 10 years).
Scenario 2: One pane breaks and only two panes can carry the loads for a shorter period of time (usually 1 year), assuming that the owner replaces a broken panel.

In the serviceability state, which shows the deflections, all panes are considered.

Note: The shown period of time does not reflect the lifespan, but the accumulated load duration.

2 Description of the construction

2.1 General

The considered glass panels (approx. 58” x 62, 42-1/2” x 62” and 56” x 62”) are supported by a steel structure. From an engineering point of view the 58” x 62” plates are governing because of the bigger span. Due to this in the following only these panels are considered. This approach guarantees a sufficient safety for all panels with a shorter length than 58”.

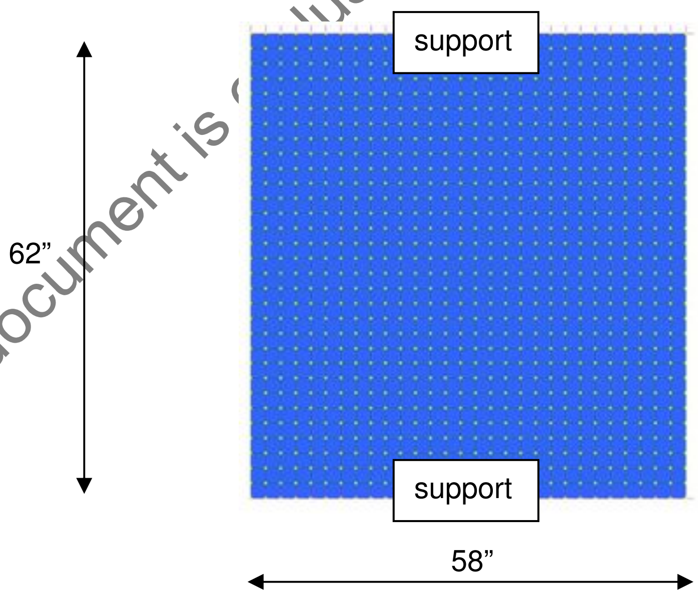
Glass build-up

Number of layers:	3

Build-up	Thickness	Material
Upper layer:	3/8”	tempered
Inter-layer:	0.06’’	Liquid lamination
Middle layer:	3/8”	tempered
Inter-layer:	0.06’’	Liquid lamination
Bottom layer:	3/8”	tempered

2.2 Geometry

Size of the calculated panel: 58” x 62”



Geometry

2.3 Bearing conditions

The panel is supported on the considered sides in vertical direction. It is assumed that the entire construction is stable without any strength of the glass. The type of silicone and setting blocks is to be specified by Jockimo. Using products other than specified can cause product failure and doing so voids any warranty. The silicone setting strips should be glued to the steel substructure before the glass is set. The silicone setting blocks should be 60 - 70 shore and have a minimum allowable stress of 500 psi.

2.4 General notes

The position of the glass sheets is to be fixed against uplift at the support, either by mechanical fixing or splicing to the support.

3 Material properties

3.1 Glass

- Young's Modulus = 10,400,000 psi
- Poisson Ratio = 0.22
- Allowable edge stress per ASTM E1300 :

3.1.1 Scenario 1:

Load duration 10 years

Allowable Design Stress of Glass acc. to GANA & ASTM E1300-04 (Appendix X8 & X9)

Glass type: FT — FT = Fully tempered, HS = Heat Strengthened, A = Annealed

Glass Slope: 0 — Degrees from horizontal (input is limited from 0º to 90º)

load duration (d): 3,15E+08 seconds

Data from Table 6 of Gana Manual:

	A	HS	FT	
Breakage 1/1,000	1900	4700	10200	psi, due to 60 second load duration.
Breakage 8/1,000	2800	5600	11200	

For overhead glazing (Slope < 75°), design values with probability of breakage of 1 lite in 1,000 will be used. For vertical glazing (Slope ≥ 75°), design values with probability of breakage of 8 lites per 1,000 will be used.

Design equation: $\sigma_{all} = \sigma_{60}\left(\frac{60\,sec}{d}\right)^{1/16}$

Where: σ_{60}= appropriate stress from values above d=load duration for current application (in days or seconds)

Allowable design stress= **3878** **psi**

Table 1: Allowable design stress of glass according GANA & ASTM with a load duration of 10 years

3.1.2 Scenario 2:

Load duration 1 year

Allowable Design Stress of Glass acc. to GANA & ASTM E1300-04 (Appendix X8 & X9)

Glass type: FT — FT = Fully tempered, HS = Heat Strengthened, A = Annealed

Glass Slope: 0 — Degrees from horizontal (input is limited from 0º to 90º)

load duration (d): 31536000 seconds

Data from Table 6 of Gana Manual:

	A	HS	FT	
Breakage 1/1,000	1900	4700	10200	psi, due to 60 second load duration.
Breakage 8/1,000	2800	5600	11200	

For overhead glazing (Slope < 75°), design values with probability of breakage of 1 lite in 1,000 will be used. For vertical glazing (Slope ≥ 75°), design values with probability of breakage of 8 lites per 1,000 will be used.

Design equation: $\sigma_{all} = \sigma_{60}\left(\frac{60\,sec}{d}\right)^{1/16}$

Where: σ_{60}= appropriate stress from values above d=load duration for current application (in days or seconds)

Allowable design stress= **4478** **psi**

Table 1: Allowable design stress of glass according GANA & ASTM with a load duration of 1 year

4 Loads

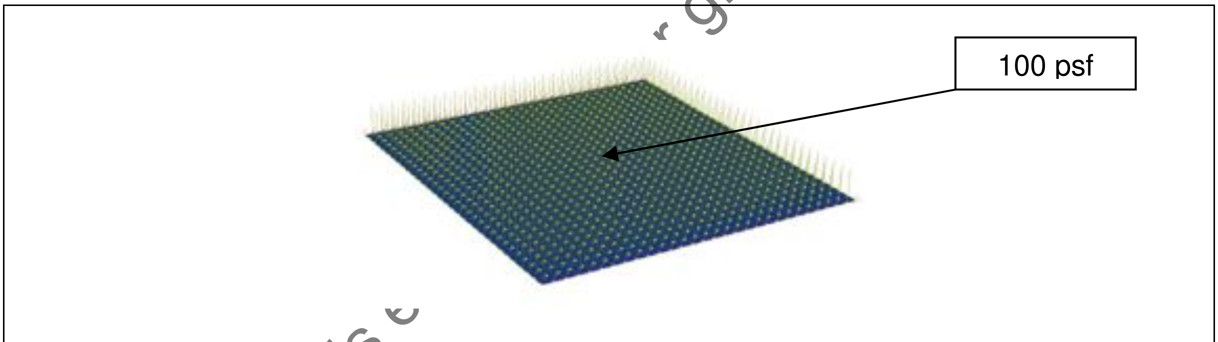
4.1 Dead Load – LC1

Material	Unit weight [pcf]	Note
Glass	159.25	The loads are considered automatically by the computer program

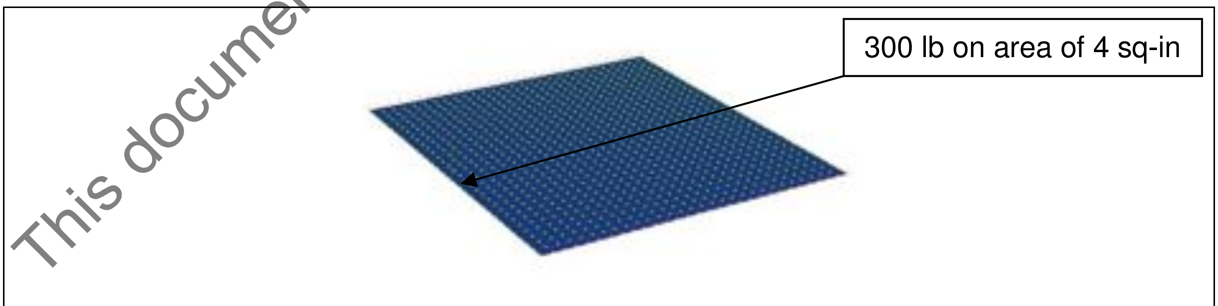
4.2 Live Load – LC2, LC3

The critical load cases are given below. They are based on the requirements in the ASCE Tab.4-1 and the IBC, Table 1607.1.

Load case	Description	Load
2	Uniformly distributed live load	100 psf $100/12^2 = 0.70$ psi
3	Concentrated live load	300 lb on area of 4 sqin $300/4 = 75$ psi



LC2: Applied load



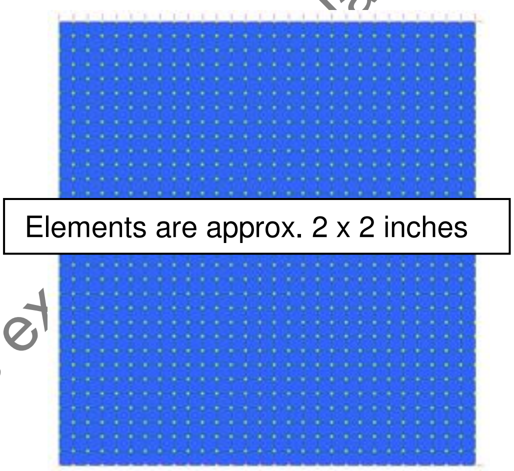
LC3: Applied load

4.3 Load case combinations

Load case combination	Description	Note
Scenario 1		
LCC 1.1	LC 1 + 2/3 LC 2	Dead load + uniformly distributed live load, 2 pane
LCC 2.1	LC 1 + 2/3 LC 3	Dead load + concentrated live load, 2 pane
Scenario 2		
LCC 1.2	LC 1 + LC 2	Dead load + uniformly distributed live load, 2 pane

5 System model

The calculations were done with the finite element method. The software package is Strand 7. The model uses plate elements.



Mesh

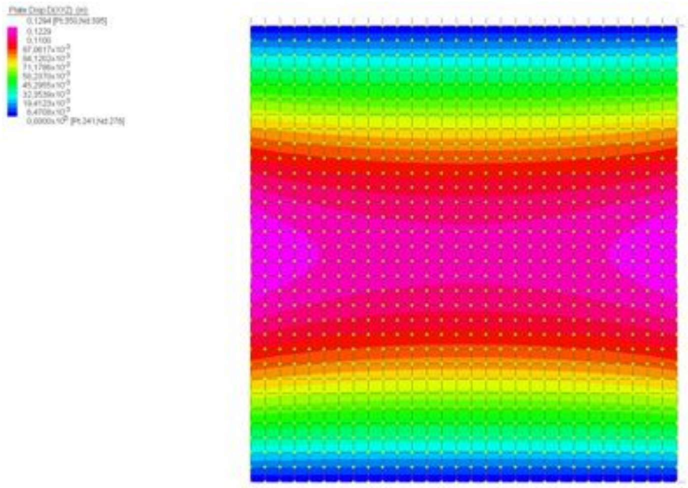
6 Stresses and deflections

The calculation includes geometrical nonlinearity.

6.1 Deflections - serviceability state

In the following calculation three panes and the lamination are considered.

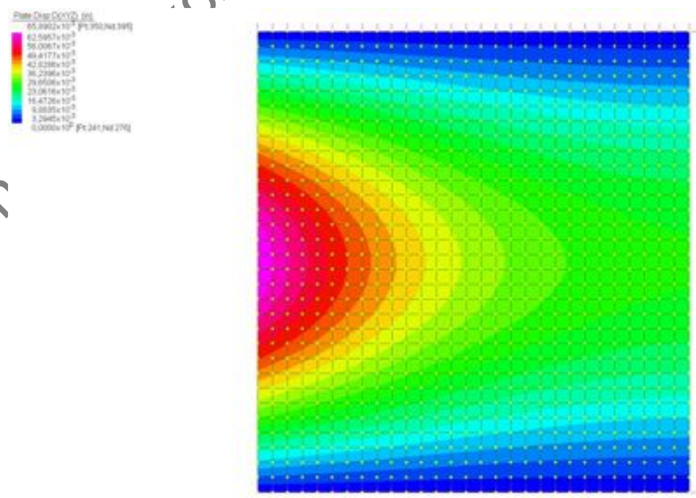
LCC 1.1: Dead load + uniformly distributed live load



Deflections LCC 1.1

Max. deflection:	0.129	in

LCC 2.1: Dead load + concentrated live load



Deflections LCC 2.1

Max. deflection:	0.066	in

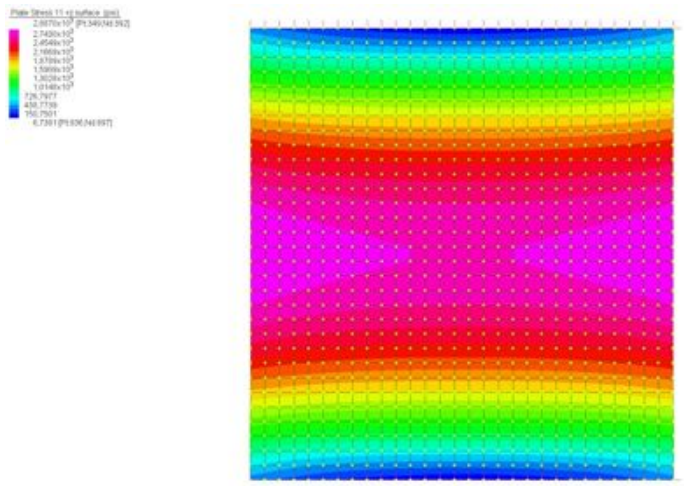
6.2 Stresses

6.2.1 Scenario 1

In the following calculation only two panes are considered with 2/3 of the load.

LCC 1.1: Dead load + uniformly distributed live load

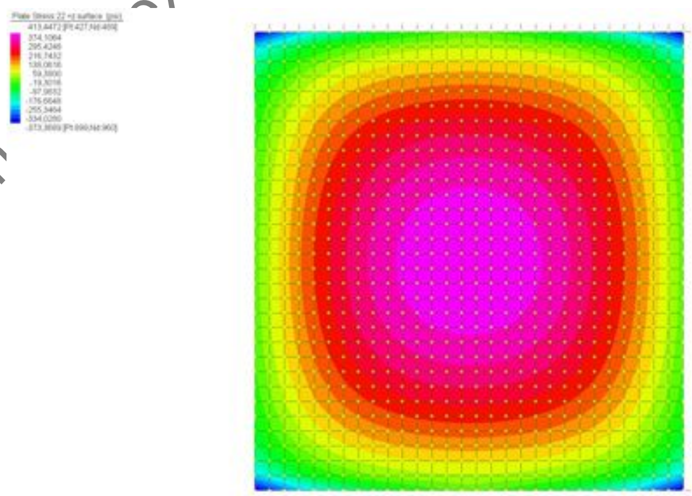
Plate stress 11



Stresses 11 LCC 1.1

Max. stress:	2,887	psi

Plate stress 22

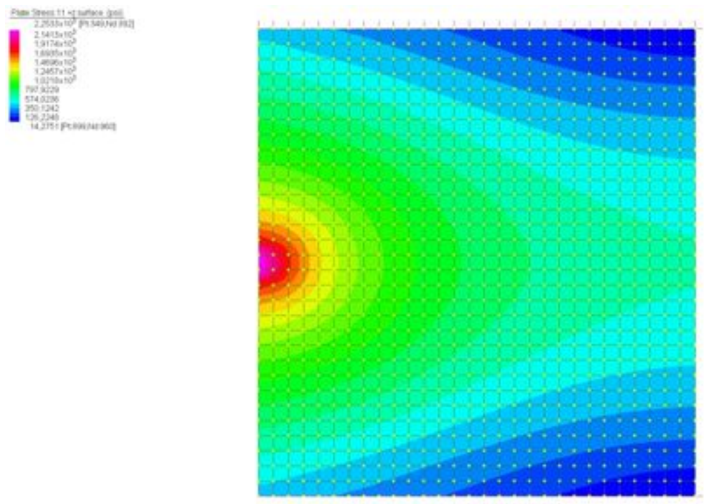


Stresses 22 LCC 1.1

Max. stress:	413	psi

LCC 2.1: Dead load + concentrated live load

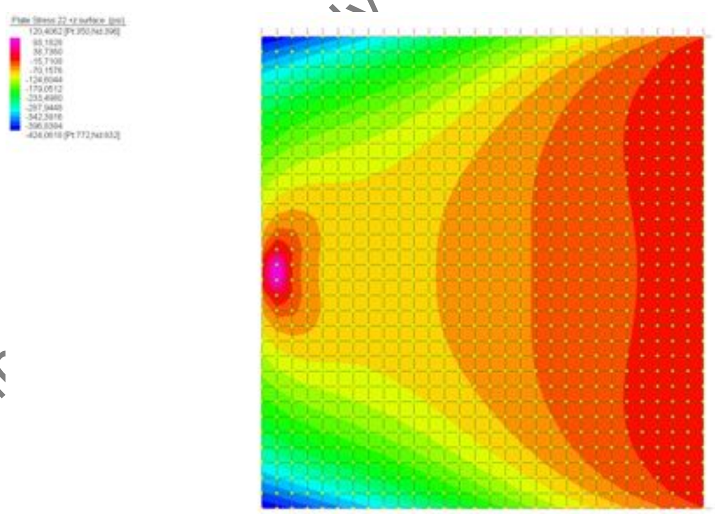
Plate stress 11



Stresses 11 LCC 2.1

Max. stress:	2,253	psi

Plate stress 22



Stresses 22 LCC 2.1

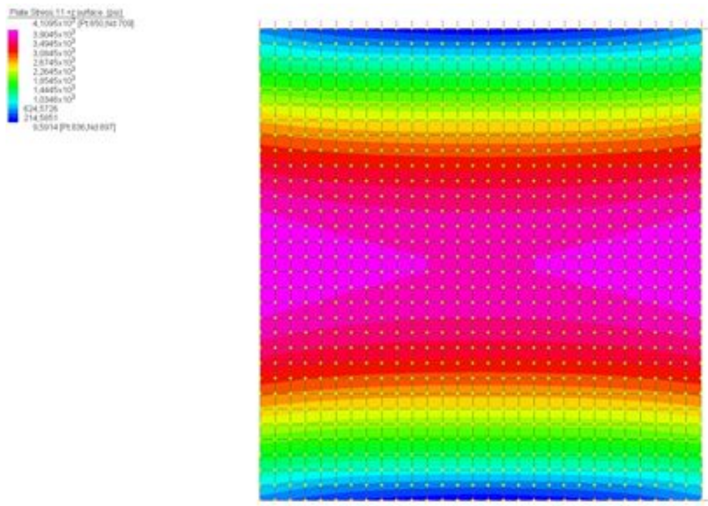
Max. stress:	(-) 424	psi

6.2.2 Scenario 2

In the following calculation only two panes are considered with full of the load.

LCC 1.2: Dead load + uniformly distributed live load

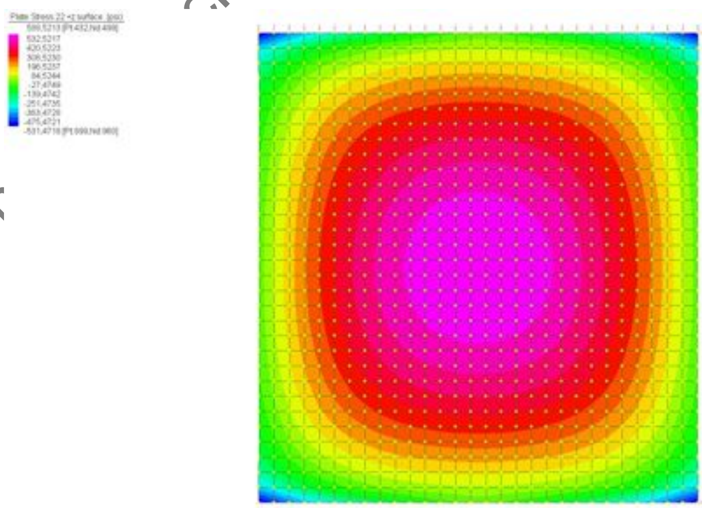
Plate stress 11



Stresses 11 LCC 2.2.

Max. stress:	4,110	psi

Plate stress 22



Stresses 22 LCC 2.2

Max. stress:	589	psi

7 Design

7.1 Requirements and Performance by Code

It is assumed that the edges of the glass sheets are seamed or polished.

Code	Criteria	Value
IBC, Chapter 16, Table 1604.3	Deflection	L/360
ASTM E1300	Stresses Load duration 10 years	3,878 psi

7.2 Requirements by the manufacturer

In this case there are no additional requirements by the manufacturer.

7.3 Deflections (Scenario 1)

L= 58”
LCC 1.1: Dead load + uniformly distributed live load

Deflections	Value	Confirmation
0.129”	L/360 = 58/360 = 0.161”	o.k.

7.4 Stresses – Scenario 1

LCC 1.1: Dead load + uniformly distributed live load

Design stress	Value	Confirmation
2,887 psi	3,878 psi	o.k.

7.5 Stresses – Scenario 2

LCC 1.2: Dead load + uniformly distributed live load

Design stress	Value	Confirmation
4,110 psi	4,478 psi	o.k.

7.6 Summary

The analysis of the stresses and deflections show sufficient safety for the glass panels.

8 References

1. IBC International Building Code
2. ASCE Standard ASCE/SEI 7-05
3. ASTM C1048 “Standard Specification for Heat Treated Flat Glass”
4. ASTM C1172 “Standard Specification for Laminated Architectural Glass”
5. ASTM E 1300-2003 “Standard Practice for Determining Load Resistance of Glass in Buildings”
6. ASTM C1036 “Standard Specification for Flat Glass”
7. CPSC 16 CFR Part 1201 “Safety Standard for Architectural Glazing material”
8. GANA, Glass Association of North America “Glazing Manual”
9. Schuler, Christian, Omer Bucak, Vincent Sackmann, Holger Graf, Gert Albrecht. Time and temperature dependent mechanical behaviour and durability of laminated safety glass. Structural Engineering International, Feb 2004.

This report includes 13 pages.

i.A. Claudia Knoll, 11-03-29