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Test Results

For

SADEV SABCO Glass Balustrade System

Issued: May 25, 2017

Prepared For: SADEV Architectural Glass Systems

Project No. 2016-061

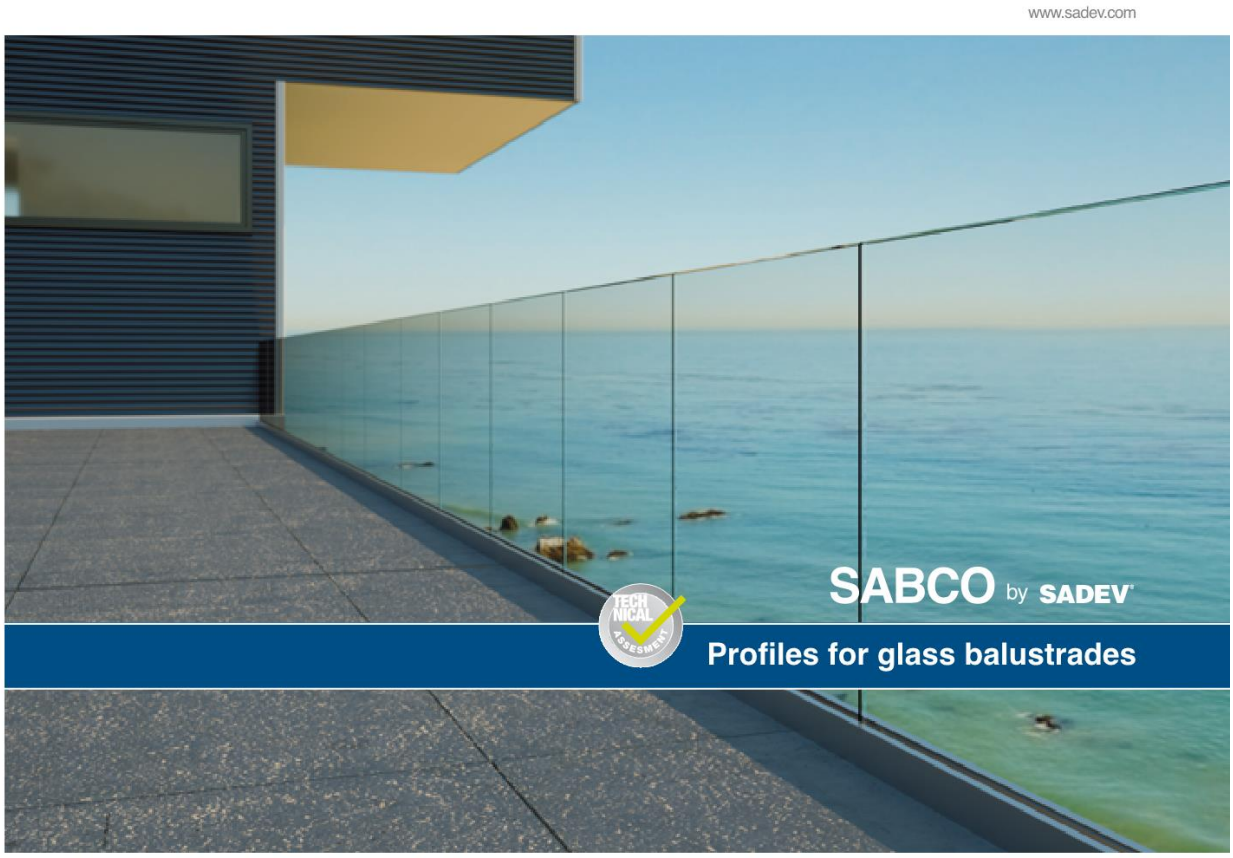
By: JAK

Table of Contents

Note: This engineering document applies only to the pages and sections listed in the table of contents. Additional pages and sections not specifically listed were not reviewed by Stutzki Engineering, Inc.

1. Project Description

The purpose of this document is to outline the design/testing requirements for a glass guard/balustrade for SADEV SABCO products. This recommendation is based on the requirements of the International Building Code 2015 (IBC2015) and considers information in several reference documents (ASTM E2353, ASTM E935). Several configurations of glass and determines the “worst case” configuration, which was tested to prove the design.



SADEV®
ARCHITECTURAL GLASS SYSTEMS

2. Design Recommendations

The following glass configuration meets the design criteria of the International Building Code (2015, 2012). The following conditions are considered in this report:

1.) SABCO System Top Mounted where the bottom of the SABCO shoe is at ground level, and the top of the glass is 42” above ground level.
2.) Glass Composition:
    a. 3/8” Fully Tempered Glass with Polished Edges
    b. 0.06” Sentry Glass Interlayer
    c. 3/8” Fully Tempered Glass with Polished Edges
3.) Width of the Glass must be greater than 20 inches
4.) Glass Wedges inside the base shoe to be Spaced at 6” o.c.
5.) Fastening Bolts to be Spaced at a minimum 7-7/8” o.c. Bolts and anchorage to the building structure is not included in this report.

3. Codes and Standards

1) 2015 and 2012 International Building Code
2) ASCE7-10 Minimum Design Loads for Buildings and Other Structures
3) ASTM E2353-16 Standard Test Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades
4) ASTM E935-13 Standard Test Method for Performance of Permanent Metal Railing Systems and Rails for Buildings
5) AC439 ICC Evaluation Acceptance Criteria for Glass Railing And Balustrade Systems (Approved Feb 2014, Revised July 2015)
6) ASTM C1048 – 12e1 Standard Specification for Heat-Strengthened and Full Tempered Flat Glass
7) ASTM C1172-14 Standard Specification for Laminated Architectural Flat Glass
8) ASTM E1300-12 Standard Practice for Determining Load Resistance of Glass in Buildings

4. Loading

200 lbs Concentrated Load in any direction to produce the maximum load effect (IBC 1607.8.1.1, ASCE7 4.5.1)

50 lbs/ft in any direction along the top rail (IBC 1607.8.1, ASCE7 4.5.1)

50 lbs on a 12in x 12in area for panel fillers (ASCE7 4.5.1)

Loads above do not act concurrently (ASCE7 4.5.1).

5. Design Criteria

5.1. General Requirements

1.) A guard must be 42” above the walking surface per IBC 1015.3.
2.) Glass must be Heat Strengthened Laminated or Fully Tempered Laminated Glass (IBC 2407.1) fabricated per ASTM C1048 and ASTM C1172.
3.) Glass must be approved for hazardous locations (Safety Glazing per Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1) (IBC 2406.4.4, IBC 2407.1) and identified per the requirements of IBC 2406.1. This criteria is by the glass manufacturer.
4.) Glass can be installed without a top rail per IBC 2407.1.1 if it is laminated with two or more equal plies and it is approved by the building official. Approval by the building official is by others.

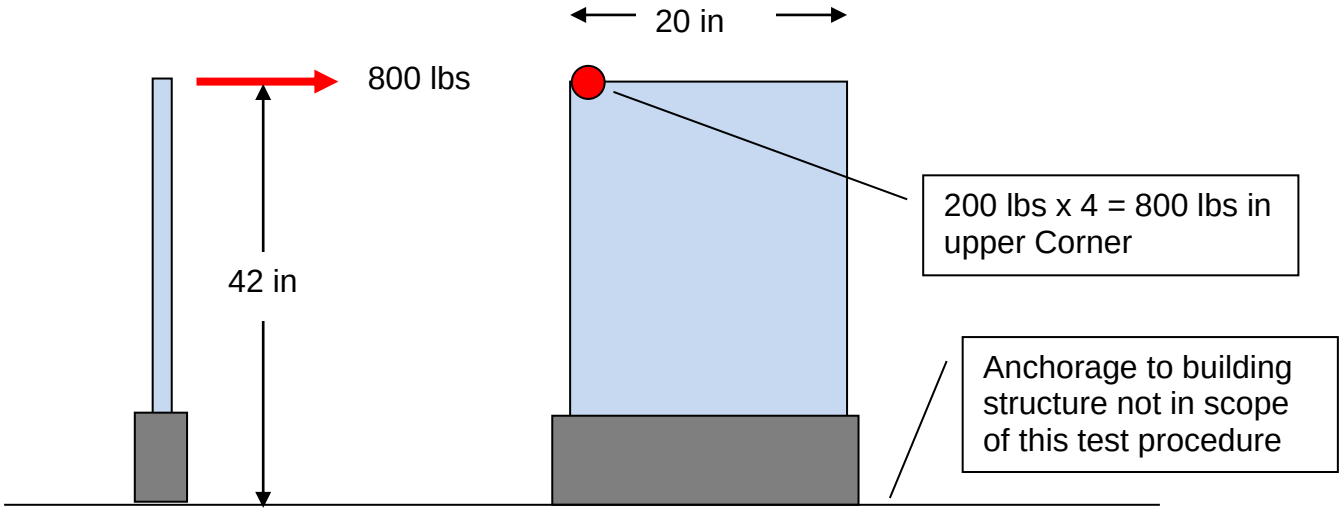
5.2. Strength for Guard Loads

The following is required for glass guards/balusters:

5.) Glass shall be tested with a design factor of 4.0 (IBC 2407.1.1) applied in at the “worst case” location and direction (ASCE7 4.5.1).
6.) The design factor must be applied mean peak load test results (AC439 3.4) of three separate test specimen (ASTM E2353).
7.) The load must be held for a minimum of 1 minute (ASTM E935, 11.2).
8.) Specimen must be conditioned to a temperature between 18deg C and 30 deg C for 4 hours prior to testing (ASTM E2353, 11.1).

6. Test Specimen

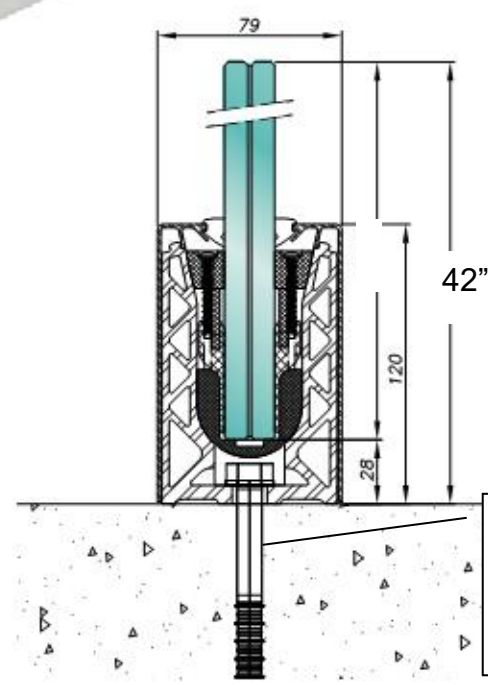
Three specimen were tested for each glass type and mounting condition. The smallest specimen with a 200lb concentrated load acting horizontally in the upper corner is determined to be the worst case based on analysis.



Top Mounted Configuration

SABCO® floor mounting

Avis Technique n°2/15-1673



Anchorage to building structure not in scope of this test procedure. Minimum spacing at 7-7/8” o.c.

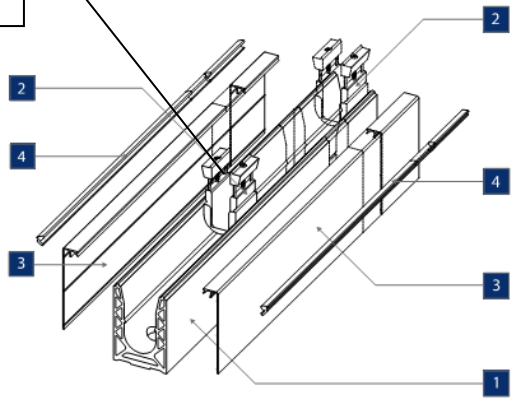
FLOOR MOUNTING KIT

The **SABCO** profile, floor mounting is available in a kit, you can also order other accessories separately *(see the following page)*.

In the kit:

1. Profile *(2 500 mm)*
2. Wedges *(one box)*
3. Low cladding *(2x 2 500 mm)*
4. Seals *(2x 2 500 mm)*

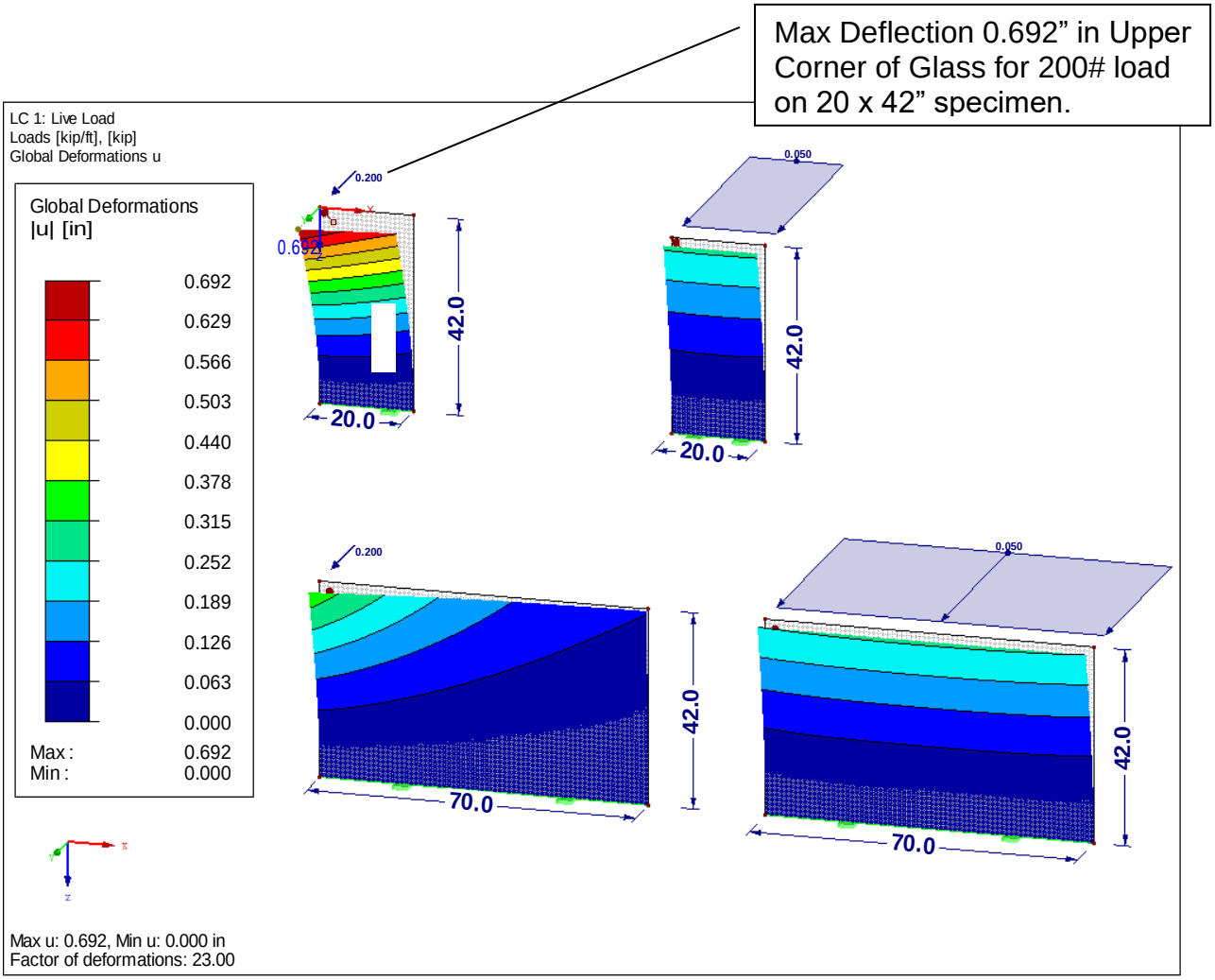
Wedges to be Spaced at 6” o.c..

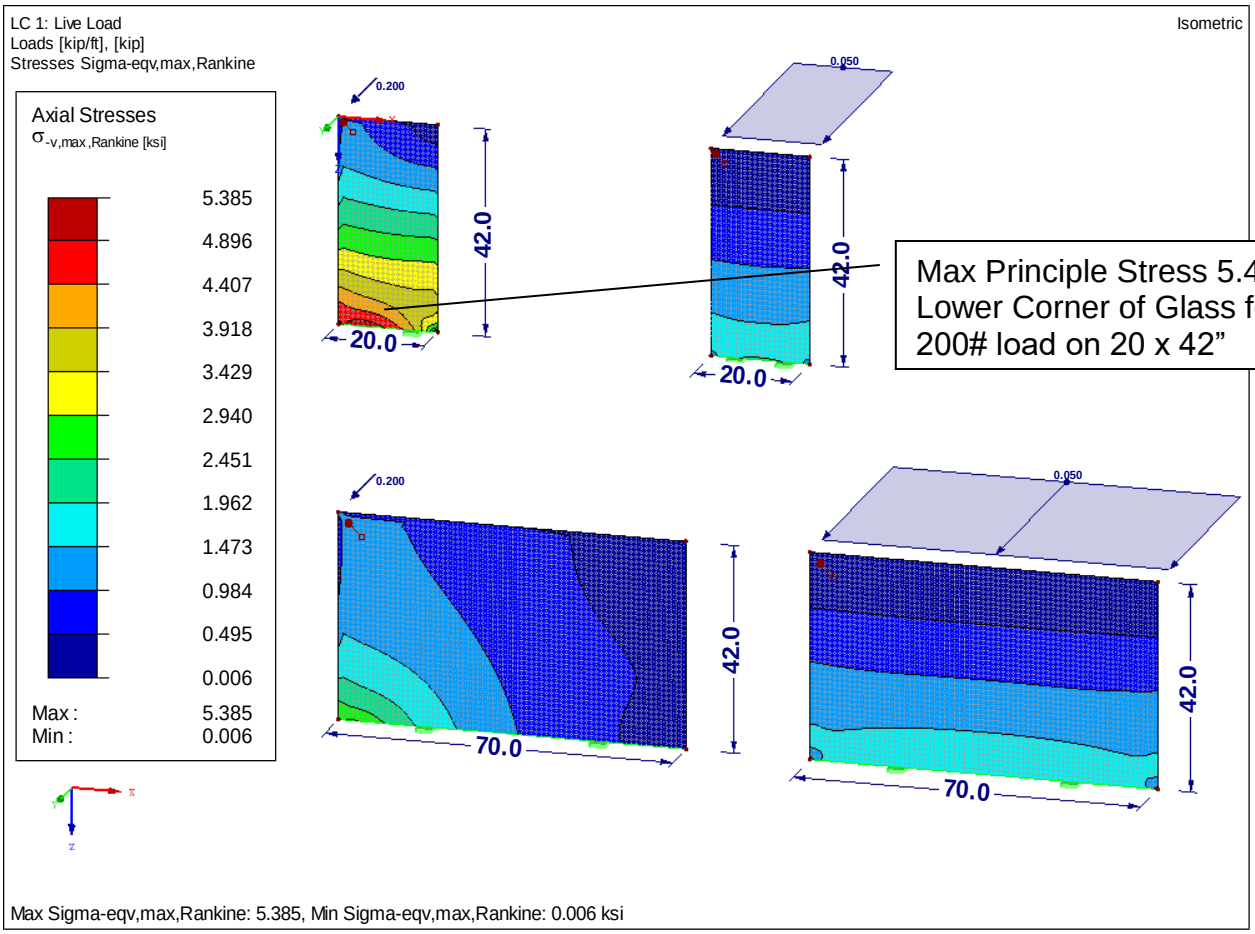


7. Supporting Design/Analysis

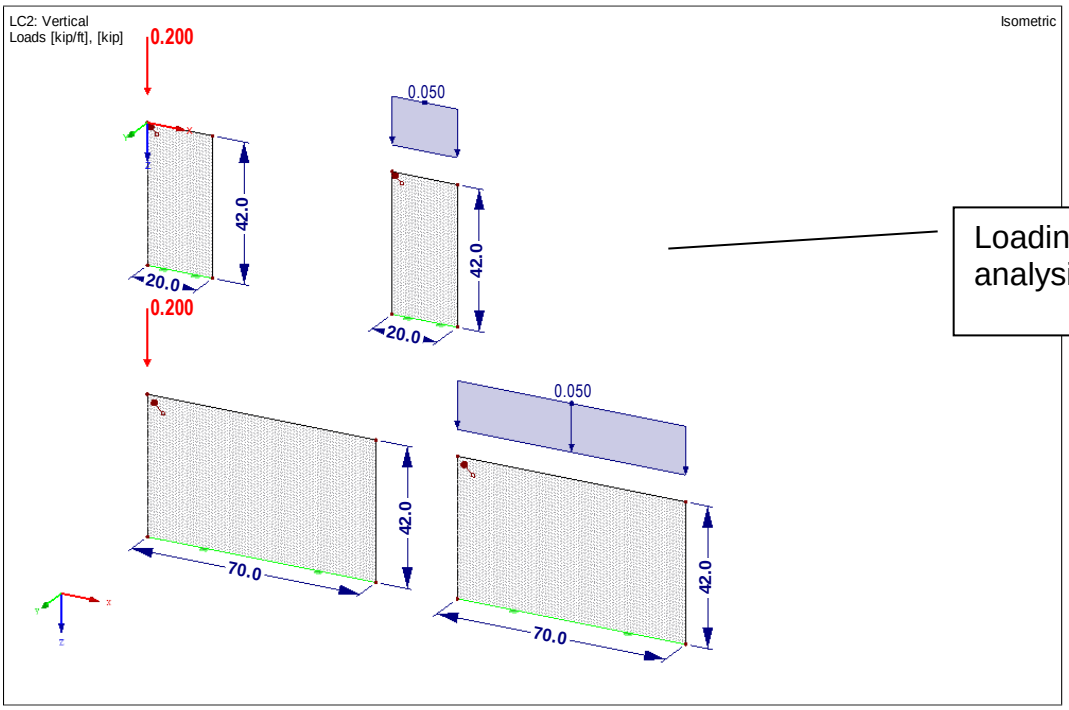
The following calculations demonstrate that the 200 lb load applied horizontally is the worst case loading condition for the balustrade system.

A shell model in FEA is used to determine that the 200 lb load acting horizontally is the controlling case on the 20" x 42" specimen. An effective thickness of 0.762" in was used in the model based on ASTM E1300 X11 to simulate 13/16" thick laminated glass. Other code required loading conditions were analyzed to prove a worst case loading condition. The FE results are below.

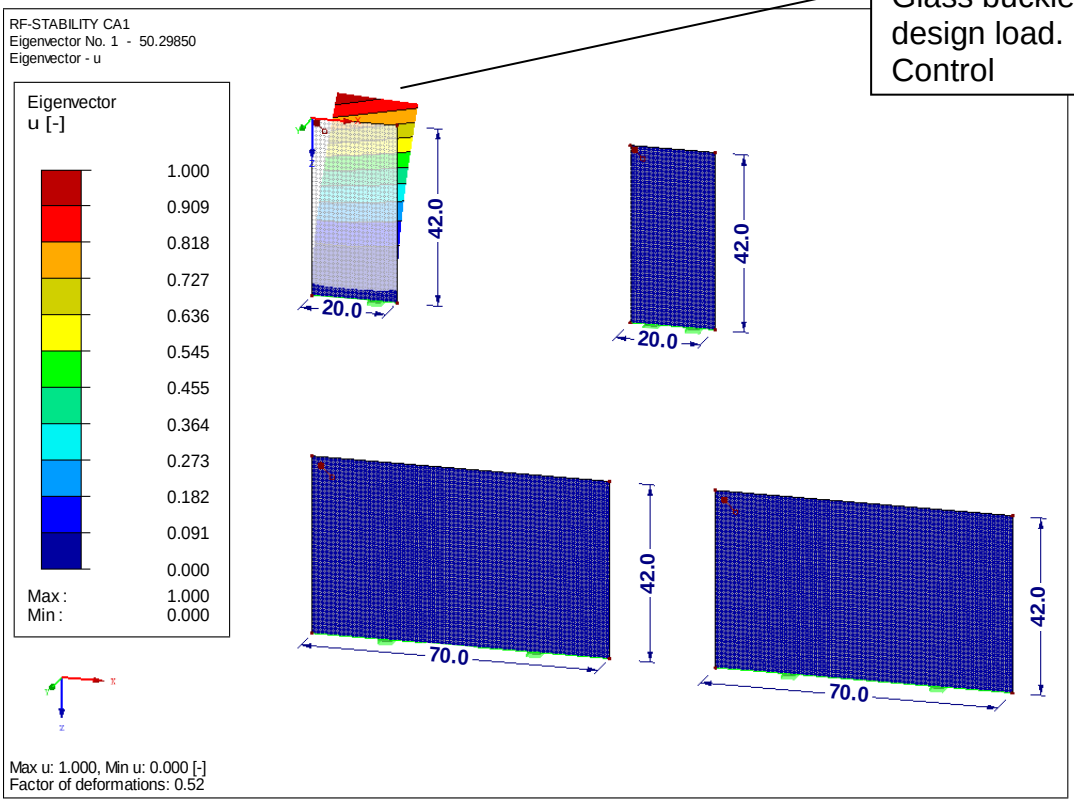



LC 1: Live Load
Loads [kip/ft], [kip]
Stresses Sigma-eqv,max,Rankine
Isometric
Axial Stresses
σ-v,max,Rankine [ksi]
5.385
4.896
4.407
3.918
3.429
2.940
2.451
1.962
1.473
0.984
0.495
0.006
Max : 5.385
Min : 0.006
0.200
0.050
42.0
20.0
70.0
Max Principle Stress 5.4 ksi in Lower Corner of Glass for 200# load on 20 x 42”
Max Sigma-eqv,max,Rankine: 5.385, Min Sigma-eqv,max,Rankine: 0.006 ksi

An eigenvalue analysis determined that vertical loads do not control the design.



Loading for Eigenvalue analysis.



Glass buckles at 50x the design load. Does not Control

X11. Method for Determining Effective Thickness of Laminated Glass for Analysis of Load Resistance

Based on E1300-09a Standard Practice for Determining Load Resistance of Glass in Buildings

	Metric		English	
Interlayer Thickness, h_v =	1.52	mm	0.060	in
Nominal Glass Thickness of Ply1 =	10	mm	3/8	in
Nominal Glass Thickness of Ply2 =	10	mm	3/8	in
Glass Ply 1 Minimum Thickness, h_1 =	9.02	mm	0.355	in
Glass Ply 2 Minimum Thickness, h_2 =	9.02	mm	0.355	in
Glass Young's Modulus, E =	71.7	GPa	1.040E+07	psi
Interlayer Storage Shear Modulus, G =	110	MPa	15954	psi
Length Scale, a =	1066.8	mm	42.00	in

Note: a is the smallest in-plane dimension of the glass plate

$$\Gamma = \frac{1}{1 + 9.6\frac{EI_s h_v}{Gh_s^2 a^2}} = 0.964 \quad \text{(Equation in metric units only)} \qquad \text{(X11.1)}$$

$$I_s = h_1 h_{s;2}^2 + h_2 h_{s;1}^2 = 501.0 \text{ mm}^3 \quad 0.031 \text{ in}^3 \qquad \text{(X11.2)}$$

$$h_{s;1} = \frac{h_s h_1}{h_1 + h_2} = 5.27 \text{ mm} \quad 0.207 \text{ in} \qquad \text{(X11.3)}$$

$$h_{s;2} = \frac{h_s h_2}{h_1 + h_2} = 5.27 \text{ mm} \quad 0.207 \text{ in} \qquad \text{(X11.4)}$$

$$h_s = 0.5\,(h_1 + h_2) + h_v = 10.54 \text{ mm} \quad 0.415 \text{ in} \qquad \text{(X11.5)}$$

Effective Thickness for Glass Laminate				
Deflection, $h_{ef;w}$ =	19.36	mm	0.762	in
Stress Lite1, $h_{1,e,\sigma}$ =	19.46	mm	0.766	in
Stress Lite2, $h_{2,e,\sigma}$ =	19.46	mm	0.766	in

$$h_{ef;w} = \sqrt[3]{h_1^3 + h_2^3 + 12\Gamma I_s} \qquad \text{(X11.6)}$$

$$h_{1;ef;\sigma} = \sqrt{\frac{h_{ef;w}^3}{h_1 + 2\Gamma I_{s;2}}} \qquad \text{(X11.7)}$$

$$h_{2;ef;\sigma} = \sqrt{\frac{h_{ef;w}^3}{h_2 + 2\Gamma I_{s;1}}} \qquad \text{(X11.8)}$$

Note: There is a typo in equations X11.7 & X11.8. $I_{s;2} = h_{s;2}$ & $I_{s;1} = h_{s;1}$

8. Test Report

QCT16-4148.01

Quast Consulting & Testing INC.

TEST REPORT

Project:

SADEV SABCO Glass Balustrade System

Rendered to:

SADEV Architectural Glass Systems
3201 Plank Road
Keokuk, IA 52632

Report No.:	QCT16-4148.01
Test Date:	03/15/2017
Through:	04/08/2017
Report Date:	04/11/2017

Project Summary:
Quast Consulting and Testing, Inc. was contracted by SADEV Architectural Glass Systems to perform load testing on a SADEV SABCO Glass Balustrade System. Testing was conducted at Quast Consulting and Testing laboratory located in Mosinee, Wisconsin. Test methods, specimen description and results are reported herein.

Test Methods:
Testing was conducted in accordance with:

ASTM E935-13	Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings
ASTM E2353-16 (Section 13.1)	Standard Test Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades

Test Specimen Description:
The glass panel was 20" wide x 40-15/16" wide x 13/16" tall comprising 3/8" TP, 0.030" Sentryglas laminate (x2), 3/8" TP. The glass was installed into a top-mount aluminum channel using 4 wedges spaced 6" on center. The TORX-T20 wedge fasteners were tightened to 3 N-m. The channel was attached to a rigid steel beam using three 1/2" x 2" long flat head bolts spaced 7-7/8" on center. See Photo #1.

QUAST CONSULTING AND TESTING, INC.
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www.qcandt.com

QCT16-4085.01

Quast Consulting & Testing INC.

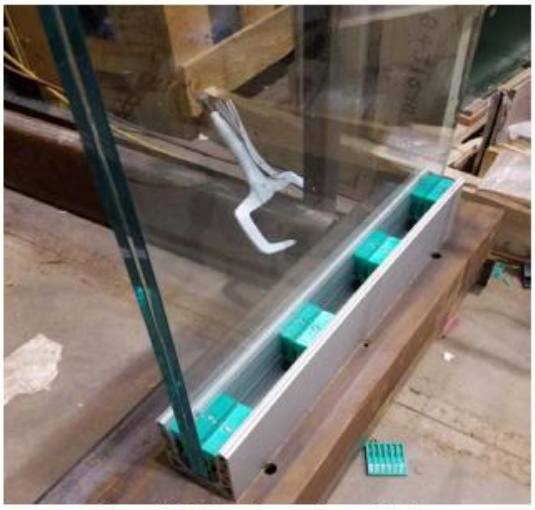

Photo #1: Specimen installation

Test Procedure:

The specimen was fitted with a steel sleeve to apply a concentrated load perpendicular to the glass. The point of load application and deflection measurement was centered approximately 1" from the top and side rail edges. The load was measured using a 2000 lbf full-bridge load cell and the deflection was measured using a SPD-25-3 string potentiometer. See Photo #2. The specimen was conditioned at approximately 19°C (66°F) before and during testing. A 200-lbf load was applied to the specimen for 60 seconds. Deflection was recorded during and after the load. An 800-lbf load was applied to the specimen for 60 seconds (maximum load was achieved in approximately 30 seconds). Deflection was recorded during and after the load. 3 Specimens were tested.

Photo #2: Test Setup

QCT16-4085.01

Quast Consulting & Testing INC.

Test Results:

Specimen #	200 lbf Load		800 lbf Load
	Maximum Deflection (in)	Residual Deflection (in)	
1	1.36	0.09	PASS
2	1.49	0.12	PASS
3	1.44	0.10	PASS

Summary:

Detailed drawings, data sheets, representative samples of test specimens, a copy of this report, or other pertinent project documentation will be retained by Quast Consulting and Testing, Inc. for a period of four years from the original test date. At the end of this retention period, such material may be discarded without notice and QCT's responsibility for servicing this report will end.

Results obtained are tested values and were secured by using the designated test methods. This report does not constitute certification of this product nor an opinion or endorsement by this laboratory. It is the exclusive property of the client so named herein and relates only to the specimens tested. This report may not be reproduced, except in full, without the written approval of Quast Consulting and Testing, Inc.

QUAST CONSULTING & TESTING, INC.

Arlen Fisher
Project Manager

QUAST CONSULTING & TESTING, INC.

Brian M. Sasman P.E.
Reviewer