APPLIED MATERIALS & ENGINEERING, INC.
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May 25, 2021 (Updated July 28, 2023 Project No. 1210339C

Mr. John Ruprecht
CLEAR VIEW GLASS RAILINGS COMPANY
737 Quentin Avenue South
Lakeland, MN 55043 Email: John@CVGRailings.com

Subject: ClearView Glass Railings

Dear Mr. Ruprecht:

This letter report summarizes our review and findings of the American Engineering Testing, Inc. (AET) reports dated October 15, 2020 and November 13, 2020 regarding Clear View's Hercules Glass panel testing.

The above reports are attached as an Appendix.

FINDINGS

AET determined that a 200 pounds (lbs) point load would be the required design load for this type of application, ie. glass handrails. This calculation is based on IBC (International Building Code) Section 1607.8.1.1.

I. October 15, 2020 Report

AET performed a dynamic test on a 60" x 40" glass panel. A pendulum load of 300 pounds was allowed to impact the panel at a height of 36" from the top of the panel. No damage was observed to the glass panel.

II. November 13, 2020 Report

AET performed static testing with a load of 800 pounds (this has a factory of safety of 4) vertical point load on a 60" x 40" glass panel. The tested panel withstood 800 lbs without failure.

AET also performed static testing with a load of 800 pounds horizontal (out-of-plane) load on the glass panel. The panel resisted a load of up to 820 pounds, loaded on its edge.

CONCLUSION

The calculations and tests performed by AET conform to the applicable industry standards and are valid for the stated application.

Please call if you have any questions regarding the above.

Sincerely,

APPLIED MATERIALS & ENGINEERING, INC.

Armen Tajirian, Ph.D., SE
Principal

Appendix

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AMERICAN ENGINEERING TESTING, INC.

October 15, 2020

Mr. John Ruprecht
Clear View Glass Railings
737 Quentin Avenue South
Lakeville, MN 55043

Re: Field test of Clear View Glass Railings "Hercules Glass" guardrail panel
AET Project #: 05-20608

Dear Mr. Ruprecht,

This letter reports tests performed on Clear View's Hercules Glass panel on April 21, 2020 by Clear View and your agents at 1141 120th Street in Roberts, Wisconsin. These tests were the first of a series of tests that included the dynamic loading test described below, and vertical and horizontal static tests. All tests were performed to provide test data that the panels meet International Building Code (IBC) requirements.

The panel tested was a 13mm thick tempered and laminated glass panel with the brand name Hercules Glass. It measured 13mm thick x 39.37" tall x 60" wide, and is supported by two metal "spigots", each located 12" inside a side edge of the panel (spaced 36" apart). The panel are secured in slots within the spigots, and the spigots are bolted to the supporting structure. The total height of the panel and spigots is 42".

The dynamic testing involved hanging 300# sandbags against the side of the panel at the panel's top edge. The sandbags were pulled back 33" and released, causing the sandbags to swing into the top of the panel, simulating a dynamic horizontal guardrail load – a person or object falling into the panel. The panel deflected approximately 4" and returned to its original shape, without experiencing any damage.

Don't hesitate to contact us with questions about this testing or any other aspects of this evaluation program.

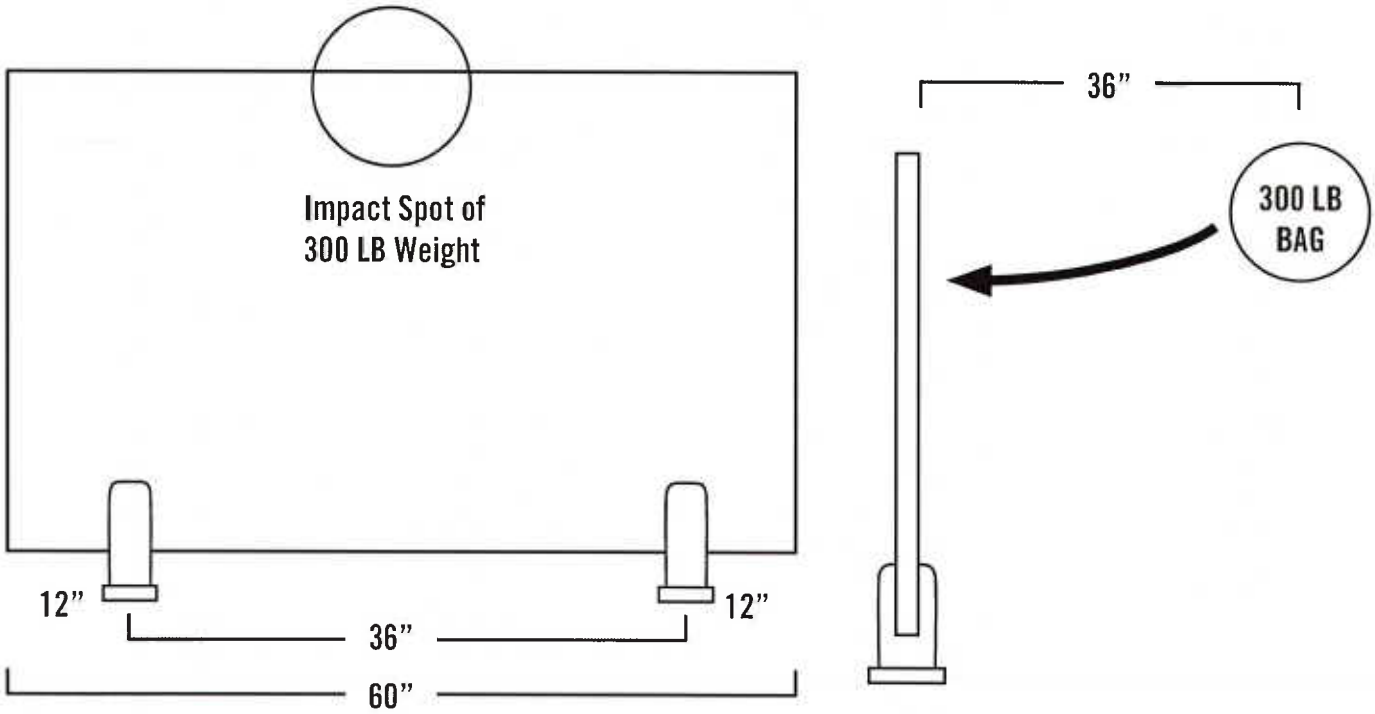
Sincerely,
American Engineering Testing, Inc.

Chris A Hartnett

Chris Hartnett, PE
Principal Engineer
MN Lic. No. 42371
Phone: 651-647-2750
chartnett@amengtest.com

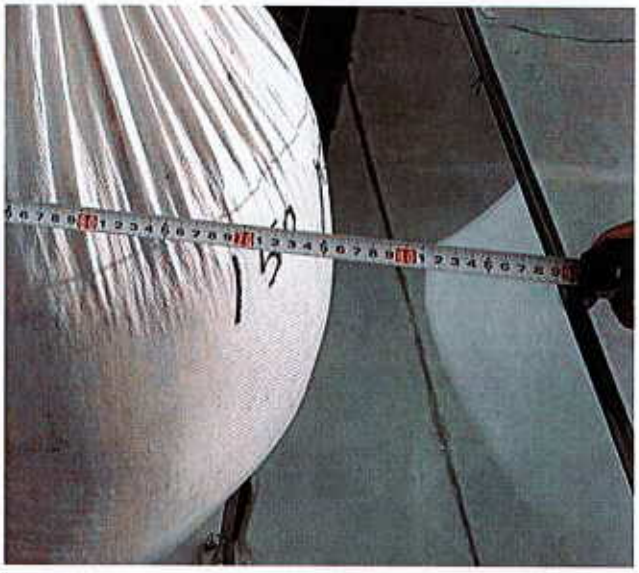
300 LB IMPACT TEST

This is an impact test of 60" x 39.37" x .53" thick CVGR Hercules tempered laminated glass panel mounted in two 316 solid core stainless steel spigots. Spigots are centered on glass 36" apart, 12" from end of glass. Plastic bags are weighted with 300 lbs of media, pulled back 36" from CVGR glass panel and then released to free fall to impact the top center of the CVGR panel. There is no damage or failure of the CVGR Hercules Glass panel or spigots from this 300 lb impact.



VIDEO STILLS ON REVERSE SIDE >

CVGR HERCULES GLASS 300 LB IMPACT TEST VIDEO STILLS



AMERICAN ENGINEERING TESTING, INC.

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· FORENSICS

November 13, 2020

Mr. John Ruprecht
Clear View Glass Railings
737 Quentin Avenue South
Lakeland, MN 55043

Re: Code Requirements & Static Test of Clear View Glass Railings "Hercules Glass" guardrail panel
AET Project #: 05-20608

Dear Mr. Ruprecht,

This letter reports building code requirements for guardrails; it also reports test methods and results for static tests performed on Clear View's Hercules Glass panel.

The International Building Code (IBC) and International Residential Code (IRC) are "model codes" created by the International Code Council, intended to be used by states and municipalities as they publish their own building codes. Section 1607.8 of the IBC requires that "handrails and guards shall be designed to resist a linear load of 50 plf." It also requires the system to resist a 200# concentrated load that produces the "maximum load effect" on any element within the system. The 2018 IRC Table R201.5 extends this requirement into residential construction. It is understood within the building design industry that laterial loads applied to the top of the panel create the maximum load effect; structural design assumes this loading condition.

Section 1607.8 of the IBC also refers to IBC section 2407 Glass in Handrails and Guards that adds a requirement for all-glass handrails and guards to "be laminated glass constructed of fully tempered or heat-strengthened glass"; this requirement was added in the 2015 IBC code cycle. Section 2407.1.1 adds the significant requirement: "a design factor of four shall be used for safety". This addition bumps up the linear load to 200 plf and the concentrated load to 800#..

Exterior glass guardrail panels are designed to resist two load types: wind loads, and "live" loads such as a person or object pushing on or striking the panel from the side or from above. Wind loading on a panel can vary greatly based on location, terrain (wooded vs open) and elevation above ground; these are governed by publication ASCE 7 (American Society of Civil Engineers) Minimum Design Loads for Buildings and Other Structures. Wind speeds of 115 psf are used to calculate wind pressures against the glass, which generally vary from 17 psf (2nd story in wooded area) to 35 psf (30 stories tall in open terrain). The wind speeds required to match the stresses created by the 800# point load are 192 mph for the 42" tall panel and 215 mph for the 36" tall panel; these are only seen in a Category 5 hurricane or a tornado. Therefore, the 800# horizontal point load requirement is the worst-case scenario for the panels. Calculation methods to arrive at these values include computer modeling using finite element analysis,

using criteria specific to Clear View's panels and support configuration.

Hercules Glass Testing

Testing was performed on the Hercules Glass panel by Clear View's glass supplier, to simulate the forces created by 800# horizontal and vertical point loads on the panel (loads are not required to be simultaneous). The vertical load test is fairly straightforward and is shown in photo 1. Note: the intent was to load the panel to failure; however, the testers ran out of sandbags at 2,520 pounds, without failure.

Photo 1: Panel loaded vertically with 2,520 pounds.

Given the difficulty of pushing an 800# load horizontally against the panel, a test rig was set up that supports the panel on its side and places sandbags vertically on the panel. The panel is supported 28" from the top of panel (creating a 28" cantilever), with a heavy counterweight holding down the bottom of the panel mounted in its spigots. Sandbags were placed at the top edge of the panel until failure. See Diagram 1 and photo 2. The panel failed after one minute with 820 pounds loaded on its edge, which is equivalent to 547 pounds for a 42" tall panel. Using a finite element computer model, it was determined that the stresses caused by the 547 pound point load are equivalent to those caused by a 147 mph wind.

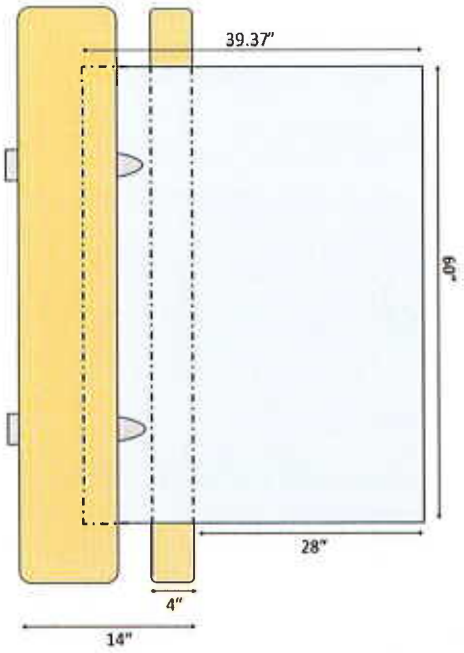

Diagram 1: Test rig lying on its side, looking from above, showing panel supported at 28" and at bottom of panel

Photo 2: Loading of panel with sandbags, simulating horizontal force

Due to the laminate construction of the panels (similar to a vehicle windshield), the panel broke into small pieces that were retained within the panel, preventing dangerous flying glass debris. See photo 3.

Photo 3: Panel after failure, showing all glass intact within laminate structure.

This test shows that the panel meets the intent to create a strong and safe barrier that can withstand reasonable loading (factor of safety of 2.5), and does not explode with dangerous glass shards during excessive loading.

Don't hesitate to contact us with questions about this testing or any other aspects of this evaluation program.

Sincerely,
American Engineering Testing, Inc.

Chris A Hartnett

Chris Hartnett, PE
Principal Engineer
MN Lic. No. 42371
Phone: 651-647-2750
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