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## Load Testing on Laminated Glass Stair Tread Samples ASTM E 72 - 2005

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Report No.: 10-03-C0023  
5 Pages, 12 Figures, 1 Appendix

Proposal No.: 09-003-7914

Date: February 03, 2010

## 1.0 INTRODUCTION

At the request of NGI Designer Glass Inc. (NGI), Exova performed Load Testing on Laminated Glass Stair Tread samples, in accordance with ESTM E 72 – 2005, Sections 11 and 13, with the exception that the tests were not performed on three identical samples.

NGI submitted three (3) glass stair tread samples for testing. The as received samples were allocated with the following Exova Sample Numbers:

<u>Exova Sample #</u>	<u>Sample Description</u>
10-03-C0023-1	Tri-laminated 32 mm thick clear glass panels, consisting of three 10 mm layers of clear soda lime glass with two 0.045 ultra clear "Safety-Plus II" polyurethane inter-layers, with all panel edges polished
10-03-C0023-2	Tri-laminated 39 mm thick clear glass panels, consisting of three 12 mm layers of clear soda lime glass with two 0.045 ultra clear "Safety-Plus II" polyurethane inter-layers, all panel edges polished, top and centre layers tempered, bottom layer annealed
10-03-C0023-3	Tri-laminated 32 mm thick clear glass panels, consisting of three 10 mm layers of clear soda lime glass with two 0.045 ultra clear "Safety-Plus II" polyurethane inter-layers, with all panel edges polished

## 2.0 OBJECTIVES

The objective of the proposed program is to assess the compliance of the laminate glass stair tread samples with ESTM E 72 – 2005 load requirements.

## 3.0 INSTRUMENTATION

The following instruments were used to measure load and displacement values:

25 kip Load cell	MII # B12067
MTS 407 signal conditioner	MII # B06086
5 kip Load cell	MII # B06935
MTS 407 signal conditioner	MII # B06081
Displacement transducer	S/N 15893
MTS 407 signal conditioner	MII # B06079
Displacement transducer	S/N 15897
MTS 407 signal conditioner	MII # B06082
Spider 8 DAQ	MII # A14020

## 4.0 TEST PROCEDURE

The tests were performed in accordance with ESTM E 72 – 2005, Sections 11 and 13. The details of the test procedure are described below.

#### 4.1 Transverse Load (Distributed Load)

The test was performed in accordance with Section 11 from ESTM E 72 – 2005.

Each sample was seated on two steel rollers and metal plates, placed with rollers axis at 2.5 inches from the samples short edges. The two roller supports were seated on the test bed. A servo hydraulic actuator equipped with a 5Kip load cell was configured to apply the distributed load to the sample through a crossbeam and another two rollers placed at quarter distance from each support and equally spaced from centre. The actuator and crossbeam were configured to apply the load at mid span between roller supports (mid sample span between short edges).

Two displacement transducers were configured near to each longitudinal edge of the specimen (one inch from edge) and at mid span, on order to measure and record the deformation of the sample under distributed load.

The photos of the test set-up are presented in Figures 1 to 5.

The distributed compression load was applied on the tempered surface up to 150 lbs/sg-ft, in accordance with Ontario Building Code and National Building Code requirements (100 lbs/sq-ft. multiplied with 1.5 safety factor). The surface of each sample was calculated as 3.29 sq-ft. The maximum distributed load applied was 487.5 lbs including loading fixture of 32 lbs. The distributed load was slowly applied at a constant rate of 20 lbs/sec until the required load was achieved and then removed at the same rate. The data load and displacement were continuously recorded in order to determine the deflection of each sample under flexural load.

At the completion of the Concentrated Load Test (Section 13 from ASTM E 72 – 2005), each sample was re-tested for distributed load ultimate strength, when each sample was tested to failure, using the same set-up and test conditions as described above, with only difference that a 25Kip load cell was used due to higher load expectations.

The photo of the ultimate strength test set-up is presented in Figure 6.

#### 4.2 Concentrated Load

The concentrated load test was performed on all samples after the Transverse Load testing at 150 lbs/sq-ft was completed.

Each sample was seated with the whole surface on a flat wood levelled support. The required compression load of 1,000 lbs was applied on the tempered surface using a servo-hydraulic actuator and a steel bar with one inch diameter and contact edge rounded to 0.05 inches radius. A displacement transducer was configured to measure the sample deflection (indentation) at the load application location, installed on a three-legged support and placed on top of the sample (with the legs placed on undisturbed areas of the upper face of each specimen).

The photos of the test set-up are presented in Figures 7 to 9.

The compression load was slowly applied at a constant rate of 20 lbs/sec until the required load of 1,000 lbs was achieved (ESTM E 72 – 2005) and then removed at the same rate. The data load and displacement were continuously recorded in order to determine the indentation.

## 5.0 RESULTS

The results for all the tests performed are presented below.

### 5.1 Transverse Load (Distributed Load)

The deflections of each sample at the required 150 lbs/sq-ft compression load and with load removed are presented in Table 1 below:

**Table 1: Transverse Proof Load Test Results**

Sample Number	Deflection at Proof Load (in)	Deflection with Load Removed (in)
10-03-C0023-1	0.0212	0
10-03-C0023-2	0.0129	0
10-03-C0023-3	0.0208	0

The distributed load was applied up to 487.5 lbs (corresponding to 150 lbs/sq-ft, for a surface area of 3.29 sq-ft). No failure occurred during the proof load application and the deflection returned to zero when the load was removed. In conclusion the samples were within the elastic range of the deformation when the proof load was applied.

The plotted load vs. displacement curves are presented in Appendix A, Figures 1A to 3A.

At the completion of the Concentrated Load Test, each sample was re-tested for Transverse Load with the exception that the load was applied until failure occurs.

The failure loads and deflections at failures are presented in Table 2 below.

**Table 2: Transverse Ultimate Strength Load Test Results**

Sample Number	Ultimate Strength Load (lbs)	Ultimate Strength Pressure (lbs/sq-ft)	Percentage of Required Proof Load (%)	Deflection at Ultimate Strength Load (in)
10-03-C0023-1	4,211	1,280	853	0.1848
10-03-C0023-2	7,085	2,153	1,435	0.1503
10-03-C0023-3	4,103	1,247	831	0.1819

Each sample failed at a percentage between 831 and 1,435 of the required proof load of 150 lbs/sq-ft including safety factor of 1.5, depending on glass thickness.

The photos of the failed samples are presented in Figures 10 to 12.

The plotted load vs. displacement curves are presented in Appendix A, Figures 4A to 6A.

