CITY OF
PORTLAND, OREGON
BUREAU OF DEVELOPMENT SERVICES
1900 SW 4th Ave, Suite 5000
Portland, OR 97201

MULTNOMAH COUNTY

STATUS CHECK	Commercial Building Permit	Application # 03-172515-DFS-01-CO
Status Date: September 16, 2005		IVR Number: 2497784

APPLICANT	BENSON TOWER LLC *ANDY KREBS*	Phone: (971) 275-3033/CELL
PROPERTY OWNER	THE BENSON TOWER LLC	Phone:
CONTRACTOR	BENSON TOWER LLC *ANDY KREBS*	Phone:

PROJECT INFORMATION

Description of Work: DFS 9/16/05 - WINDOWS

Street Address: 1500 SW 11TH AVE

Occupancy Group	Construction Type	Sub Type	Work Proposed
R1 S3	I-FR	Apartments/Condos (3 or more un	New Construction

This report shows those reviews which have been assigned as of September 16, 2005 at 10:31 am. Technical reviews may trigger additional review assignments.

Review Type/Process	Mandatory	Status	Action Date	Reviewer	Phone
2nd Screen App Set-Up	X	Approved	9/16/05	Spencer, Tracy	503-823-7313
Intake - DSC	X	Intake	9/16/05	Spencer, Tracy	503-823-7313
Assign Plan and File Location		Open		DOCUMENT SERVICES	503-823-7357
Assign Reviews - CO		Open		DOCUMENT SERVICES	503-823-7357
Corrections Received - CO		Open			
Process Manager		In Progress		Litin,Melissa	503-823-3033
Point of Contact		Open			
Plans checked out to Applicant		Open			
Life Safety Review	X	Open		Howell,Ben	503-823-4539
Structural Review	X	Open		Thomas,Eric ✓	503-823-7653
Send Letter of Intent to expire		Open		Litin,Melissa	503-823-3033
Pre-Issuance Check	X	Open		Litin,Melissa	503-823-3033

PAID
SEP - 2005
CITY OF PORTLAND

CITY OF PORTLAND, OREGON – BUREAU OF DEVELOPMENT SERVICES

1900 SW Fourth Avenue, Suite 5000 • Portland, Oregon 97201 • www.bds.ci.portland.or.us

MULTNOMAH COUNTY

STRUCTURAL CHECKSHEET

Application # : 03-172515-DFS-01-CO
Review Date : September 28, 2005

Commercial Building Permit

To:	APPLICANT	ANDY KREBS BENSON TOWER LLC PO BOX 12127 PORTLAND, OREGON 97212	Cell: Fax:	971-275-3033 503-274-8604
From:	STRUCTURAL ENGINEER	ERIC THOMAS	Phone:	503-823-7653
cc:	OWNER	THE BENSON TOWER LLC 2154 NE BROADWAY ST #200 PORTLAND, OR 97232-1561		

PROJECT INFORMATION

Street Address: 1500 SW 11TH AVE

Description of Work: DFS 9/16/05 - WINDOWS

Based on the plans and specifications submitted, the following items appear to be missing or not in conformance with the Oregon Structural Specialty Code and / or other city, state, or federal requirements.

Item #	Location on plans	Code Section	Clarification / Correction Required
1.			It appears that the mullions, heads and sills use "crimped in polyamide thermal break" as shown on several drawings (i.e. 7.1). The section properties for the window members appear to assume that the two separate extrusions act compositely, with load transferred between them by the polyamide thermal break. Please submit structural calculations/data as appropriate to justify the use of this material.

INSTRUCTIONS

To respond to this checksheet, come to Document Services (1900 SW Fourth Ave., 2nd floor) between 7:30 a.m. and 3:00 p.m. and update all four sets of the originally submitted drawings. To update the drawings, you may either replace the original sheets with new sheets, or edit the originally submitted sheets when corrections are of a minor nature and when approved by the Bureau of Development Services. (Specific instructions for updating plans are posted in Document Services.)

Please complete the attached Checksheet Response Form and include it with your re-submittal. Notify Document Services Staff that you are submitting corrections for **structural review**. To ensure that the plan reviewer receives notification, verify that the computer has been updated to show that the corrections were received.

If you have specific questions concerning this Checksheet, please call me at 503-823-7653. To check the status of your project, call (503) 823-7000 and select option 4. Your Plan Review Status will be faxed to you, so please be ready to provide a fax number. If you don't have a fax number, you may check the status of your permit on the internet by going to www.cgis.ci.portland.or.us/maps/bds. Enter your permit number on the "Application Number" tab and then click on the green "Go" button. To see your permit details, left-click on the permit you want to view. Alternatively, you may also dial (503) 823-7357 to request a Plan Review Status or visit Document Services.

You may receive separate Checksheets from other City agencies that will require separate responses.

Layton Consulting Ltd.
Registered Engineering Professionals
British Columbia • Alberta
Washington • Oregon • California • Arizona

FACSIMILE TRANSMITTAL SHEET

TO: Eric Thomas	FROM: Leonard Pianalto, M.Sc., P.Eng.
COMPANY: City of Portland, Oregon Bureau of Development Services 1900 SW Fourth Avenue, Suite 5000 Portland, Oregon 97201	DATE: November 16, 2005
FAX NUMBER: 503 823 7692	TOTAL NO. OF PAGES INCLUDING COVER: 1+17
PHONE NUMBER: 503 823 7653	LCL PROJECT NUMBER: 116-2883
RE: Application # 03-172515-DFS-01-CO Benson Tower	STARLINE REFERENCE NUMBER: H3002

☐ URGENT ☐ FOR REVIEW ☐ PLEASE COMMENT ☐ PLEASE REPLY ☐ PLEASE RECYCLE

NOTES/COMMENTS:

Eric,

Please find our letter which presents test data for the Starline 9000 Window system as requested in your 3rd Structural Checksheet.

Please call if you have any questions re require further clarification

Sincerely,
LAYTON CONSULTING LTD.

Leonard Pianalto, M.Sc., P.Eng

CC Wayne Millard - Starline Windows (fax 604 882 6890)

Layton Consulting Ltd.
Registered Engineering Professionals
Washington • Oregon • California

REGISTERED PROFESSIONAL ENGINEER
OREGON
Sept. 19, 1998
MARK S. LAYTON
EXPIRES: 31/Dec/06

City of Portland, Oregon – Bureau of Development Services
1900 SW Fourth Avenue, Suite 5000
Portland, Oregon 97201

Attention: Eric Thomas

November 16, 2005

RE: **Application # 03-172515-DFS-01-CO**
3rd Structural Checksheet
Benson Tower

STRUCTURAL REVIEW LETTER REPORT:
Evaluation of Thermal Break – Starline Windows 9000 Series

This letter is written as a response to the "Request for Clarification", made by Eric Thomas of the City of Portland Oregon (the City), following a structural review of the Starline window system, proposed for the Benson Tower project at 1500 SW 11th Ave. The reviewer's concern centers on the behavior of the crimped-in polyamide thermal break (see enclosed – page A1-A2).

Mechanically locked thermal barriers are defined as follows:

> *An aluminum composite framing member, consisting of individual interior and exterior extruded aluminum sections separated by a pre-formed thermal barrier. First, both the interior and exterior aluminum extrusions are knurled. The structural thermal barrier material is then inserted into the knurled extruded cavity of the both the interior and exterior portions and after rolling (crimping) the mechanical locking process is complete. [AAMA TIR-A8-04]*

The Starline 9000 Aluminum window system incorporates the insulbar ® - Structural Thermal Barrier System (see enclosed product information - pages A3-A4).

Review of Full Scale Window Test:

Full scale testing of the sample window (W1F) was conducted at an independent laboratory, Interetek ETL Semko, on November 3 and November 16, 2005 in accordance with State Of Oregon 1998 Structural Specialty Code – Section 2013 (see enclosed test reports – pages A5-A8 and photos – pages A9-A12). Window W1F was selected as the largest (i.e. worst case) un-reinforced window as per our letters to the City dated October 13, 2005.

The testing has demonstrated that the in-situ performance of the window system was consistent with the design. The predicted deflection under the design wind load was 0.594 in (see enclosed – page A13) and the maximum measured deflection during the test was 0.563 in. Alternatively,

the theoretical moment of inertia (MOI) was calculated from the traditional second moment of the area approach and found to be 3.497 in^4. The measured MOI "back calculated" using trapezoidal wind areas was 3.69 in^4.

The tested MOI was 5.5% over the calculated MOI. This was not unexpected as the calculated value was based on the aluminum components of the vertical mullion only and did not account for contributions from the glazing, horizontal mullions, and sealants.

The measured permanent deflection at mid span was 0.046 in (0.04% of the span). This has indicated that no yielding or relative sliding of the components occurred under full wind load.

The window was also tested at 1.5 times the design pressure. The average permanent set was 0.28% of the span which meets the Commercial (C) and Heavy Commercial (HC) classifications as defined in AMMA 101 (maximum 0.3% of the span). Intertek further reported that following the testing, the windows were inspected and found to show no signs of failure or permanent deformation of any part of the window system that would cause any operational malfunction.

The test results have demonstrated that the two separate extruded aluminum components act compositely. Furthermore, it has been shown that load transfer has occurred through the mechanically crimped thermal break (shear flow and tension) and has allowed development of the full moment of inertia.

Application of Test Results to Reinforced Condition:

Window W3J represented the worst case reinforced window.

As steel is 2.9 times stiffer than aluminum, the steel reinforcing will take the majority of the load. Our calculations have demonstrated that the aluminum components in the reinforced window carries 93% of the flexural load and 87% of the shear flow when compared to window W1F, as discussed in the previous section. Therefore, the demand on the aluminum-polyamide composite is lower in the worst case reinforced window than in the un-reinforced case (see enclosed – page A14-A15).

Conclusion:

We are satisfied that the use of the Insulbar ® mechanically locked thermal barrier systems in the Starline 9000 series window meets the requirements of the Code (UBC 1997 and State of Oregon Structural Specialty Code 1998 Edition). The test results have demonstrated the composite action of the aluminum and crimped in polyamide thermal break: deflection under design pressure was 5% less than expected and as reported by Intertek "there was no failure or permanent deformation of any part of the window system" under 1.5 times the design pressure.

Sincerely,
LAYTON CONSULTING LTD.

Leonard Pianalto, M.Sc., P.Eng.

Reviewed by:

Mark S. Layton, PE

A1

CITY OF PORTLAND, OREGON – BUREAU OF DEVELOPMENT SERVICES

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MULTNOMAH COUNTY

3rd STRUCTURAL CHECKSHEET

Application # : 03-172515-DFS-01-CO
Review Date : November 9, 2005

Commercial Building Permit

To:	APPLICANT	ANDY KREBS BENSON TOWER LLC PO BOX 548 PORTLAND, OR 97207-0548	Cellular: Fax: e-Mail:	971-275-3033 503-274-8604 andy@bensontower.com
From:	STRUCTURAL ENGINEER	ERIC THOMAS	Phone:	503-823-7653
cc:	OWNER	THE BENSON TOWER LLC 2154 NE BROADWAY ST #200 PORTLAND, OR 97232-1561		

PROJECT INFORMATION

Street Address: 1500 SW 11TH AVE

Description of Work: DFS 9/16/05 - WINDOWS

NOTE: Comments from the 1st and 2nd Structural Checksheets dated September 28, 2005 and October 12, 2005 that need further clarification/correction have been provided below for reference only. This recheck is based on a response submitted to BDS on November 8, 2005.

Based on the plans and specifications submitted, the following items appear to be missing or not in conformance with the Oregon Structural Specialty Code and / or other city, state, or federal requirements.

Item #	Location on plans	Code Section	Clarification / Correction Required
1.			November 8, 2005 Please address the following items related to the submitted window test results and accompanying letter from the structural engineer for the windows: a) The test result summary letter indicates that the tests were conducted in accordance with ASTM E330. However, the letter indicates that the test pressure was 38 psf, which is exactly equal to the design pressure—not increased by a factor of 1.5 as required by ASTM E330. It appears that the test needs to be re-conducted and the specimen loaded to the appropriate pressure. b) The design pressure for the corner condition is 47 psf, and this value does not appear to have been addressed in the either the test or submitted comparison calculation. Please address the larger design pressure. **Continued,**

Continued,

3rd STRUCTURAL CHECKSHEET

Application # 03-172515-DFS-01-CO
Review Date November 9, 2005

A2

Continued from previous page,

1. (cont.)			**Continued from previous page,** **October 12, 2005 (For Reference Only)** The submitted manufacturer's promotional information does not address the structural performance of the mullion composite action due to the presence of the "crimped in polyamide thermal break." Representative testing must be performed under the direction of an Oregon registered structural engineer. An Oregon engineer stamped summary report must be submitted that justifies the various types of mullions and various loading/span conditions that exist on the project. If multiple tests are required, please indicate which test is used to justify the various conditions on the project. **September 28, 2005 (For Reference Only)** It appears that the mullions, heads and sills use "crimped in polyamide thermal break" as shown on several drawings (i.e. 7.1) The section properties for the window members appear to assume that the two separate extrusions act compositely, with load transferred between them by the polyamide thermal break. Please submit structural calculations/data as appropriate to justify the use of this material.

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You may receive separate Checksheets from other City agencies that will require separate responses.

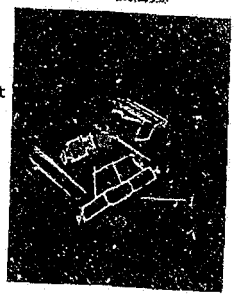
Insulbar® - Product Features

A3

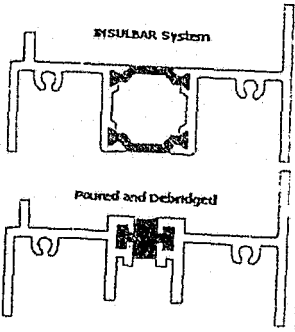
INSULBAR STRUCTURAL THERMAL BARRIERS

- Design Specifications
- Technical Information
- History of Insulbar
- Case Studies
- Certification Program
- Insertion Equipment
- Contact Us

INSULBAR® is a revolutionary insulating system for manufacturers of aluminum windows, doors and curtain walls. Proven in over 20 years of worldwide installation, Insulbar® Structural Thermal Barriers offer superior strength, maximum resistance to heat transfer and unexcelled flexibility.



Economical and Efficient - up to 50% better thermal insulation than PVC or Polyurethane!



The key to Insulbar's effectiveness is its unique composition of glass-reinforced nylon 6/6. Ensinger's proprietary extrusion process orients the glass fibers in three directions, countering stress in these d mensions for maximum structural integrity.

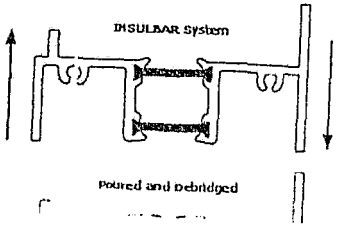
BETTER INSULATION!

An Insu bar system provides superior insulation through increased aluminum separation and air space. The material is extruded into a shape that effectively and economically joins two separate aluminum extrusions (the inner and outer aluminum profiles of the window, door or curtain wall).

Insulbar® includes a sealing wire that, under elevated temperature, activates to create a strong, permanent bond that seals out moisture and improves shear resistance.

INCREASED STRENGTH!

Since Insulbar's coefficient of thermal expansion is very close to that of aluminum, internal stresses are drastically reduced. The bond between Insulbar® and the aluminum extrusion retains its mechanical integrity through a

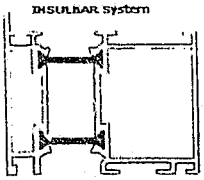


A4

wide range of temperature fluctuations.

The strength of the composite profile is increased due to Insulbar's composition and system geometry.

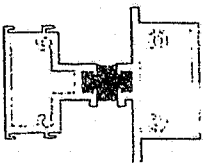
INSULBAR System



ALLOWS THINNER ALUMINUM WALLS!

Insulbar is a system with inherent strength, permitting the use of thinner aluminum walls even with similar hollow section construction. Manufacturers save on material costs and can offer reduced weight in finished assemblies.

Poured and Debridged



Insulbar® is the strongest structural thermal barrier available, delivering a better combination of insulation and strength than PVC or poured and debridged polyurethane!

Why buy Ensinger? Standard Profiles Compare P&D Site Index

ENSINGER
365 Meadowlands Blvd., Washington, PA 15301
Phone: 724-746-6050 Fax: 724-746-9209
insulbarsales@ensinger-ind.com

A5

Intertek ETL SEMKO

COPY

November 5, 2005

Starline Architectural Ltd.
19714 – 96th Avenue
Langley, BC
V1M 3B9

Attention: Mr. Remo Schulz

Dear Mr. Schulz,

Re: Aluminum Combination Window Test Results – Project No. 3086543

Intertek Testing Services NA Ltd. (Intertek) has performed physical testing on a 2514 mm (99.00") wide x 2740 mm (107.87") high Aluminum Combination window system, submitted to our laboratory by Starline Architectural Ltd. Testing was conducted on November 3, 2005. The test was conducted in accordance with ASTM E330-02 *"Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference."* Procedure A.

The window was tested for Uniform Load Deflection only. Load durations were 10 seconds. The span of the mullion tested was 2715 mm (106.89"). Deflections were measured at the mid-span and at the ends. The end deflections were averaged and subtracted from the mid-span deflection (to eliminate deflections caused by movement at the head and sill connections to the test frame). An elevation drawing indicating deflection gauge locations and a drawing of the cross-section of the mullion tested, both stamped "Intertek," are attached. The results of the test are indicated below:

Test Pressure	Deflection Measurements, mm (in.)			
	Positive		Negative	
Pa (psf)	Deflection	Perm. Set	Deflection	Perm. Set
1827 (38.0)	14.30 (0.563)	1.17 (0.046)	13.95 (0.549)	0.73 (0.029)

If you have any questions or concerns, please do not hesitate to call me at 604-520-3321, ex. 115.

INTERTEK TESTING SERVICES NA LTD.

Kazamir L. Falconbridge
Engineering Technologist – Building Products

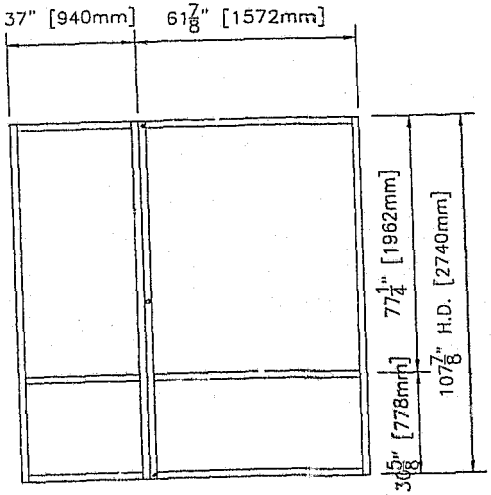
KLF/jm

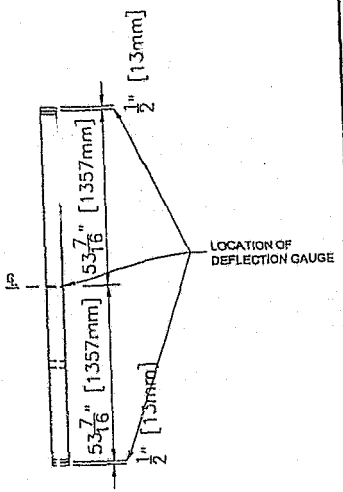
Attachment: 2 pages

Intertek Testing Services NA Ltd.
1500 Brigantine Drive, Coquitlam, BC V3K 7C1
Telephone: 604-520-3321 Fax: 604-524-9186 Web: www.intertek-etlsemko.com

(A6)

COPY





Intertek Testing Services
ETLSEMKO

DWG: 1 of 2

NOV 05 2005

PROJECT #: 3086543

REVIEWED BY:

STARLINE Architectural Windows Ltd.

9380 – 198 St
LANGLEY, BC V1M 3C8
Bus.(604) 882-0955
Fax.(604) 882-0990
WEBSITE
www.starlinewindows.com

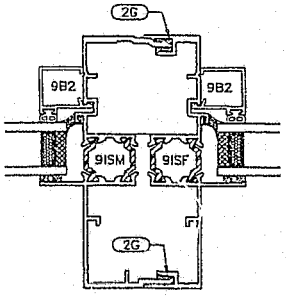
STARLINE WINDOWS INC.
14227 – N.E. 200 St.
WOODINVILLE, WA. 98072
Bus (425) 806-9585
Fax. (425) 806-6975
TOLL FREE 1-888-448-1605

PROJECT: BENSON TOWER	
DRAWN	PROJECT CODE No. H3002
DATE NOV/04/2005	DWG No. SK-1

A7

COPY

C1 180° COUPLER WITH FIXED LITES



HEEL DIMENSION(H.D.) | HEEL DIMENSION(H.D.)

C1 VERTICAL WINDOW COUPLER W/ FIXED LITES BOTH SIDES

(ARCH.REF.: N/A)

Intertek Testing Services
ETL SEMKO

DWG: 2 of 2

NOV 05 2005

PROJECT #: 3086543

REVIEWED BY:

STARLINE Architectural Windows Ltd.
9380 – 198 St.
LANGLEY, B.C. V1M 3C8
Bus.(604) 882-6855
Fax.(604) 888-6890
WEBSITE
www.starlinewindows.com

STARLINE WINDOWS INC.
14227 – N.E. 200 St.
WOODINVILLE, WA 98072
Bus (425) 806-0555
Fax (425) 806-0975
TOLL FREE 1-800-448-1805

PROJECT:	BENSON TOWER
DRAWN	PROJECT CODE No. H3002
DATE NOV/04/2005	DWG No. SK-2

Intertek ETL SEMKO

A8

November 15, 2005

Starline Architectural Ltd.
19714 – 96th Avenue
Langley, BC
V1M 3B9

Attention: Mr. Remo Schulz

Dear Mr. Schulz,

Re: Aluminum Combination Window Test Results – Project No. 3086543

Intertek Testing Services NA Ltd. (Intertek) has performed physical testing on a 2514 mm (99.00") wide x 2740 mm (107.87") high Aluminum Combination window system, submitted to our laboratory by Starline Architectural Ltd. Testing was conducted on November 14, 2005. The test was conducted in accordance with ASTM E330-02 *"Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference,"* Procedure A.

The window was tested for Uniform Load Structural only in both the positive and negative directions. The span of the mullion tested was 2715 mm (106.89"). Permanent deflections were measured at the mid-span and at the ends. The end deflections were averaged and subtracted from the mid-span deflection (to eliminate deflections caused by movement at the head and sill connections to the test frame). The results of the test are indicated below:

Test Pressure	Permanent Deformation			
	Positive		Negative	
Pa (psf)	mm	in.	mm	in.
2740 (57.0)	3.74	0.147	11.99	0.472

After the test loads were released, the window was inspected and there was no failure or permanent deformation of any part of the window system that would cause any operational malfunction. If you have any questions or concerns, please do not hesitate to call me at 604-520-3321, ext. 115.

INTERTEK TESTING SERVICES NA LTD.

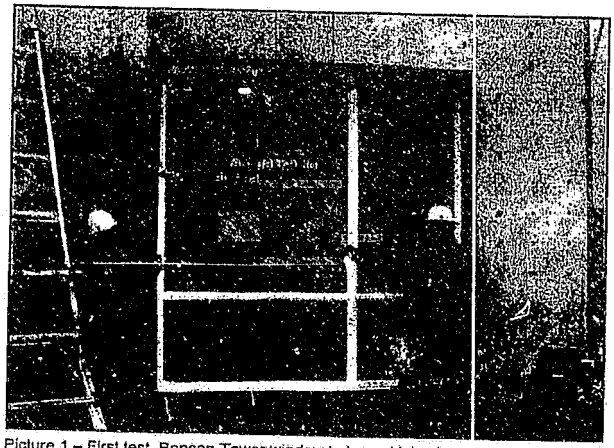
Kazamir L. Fakcombridge
Engineering Technologist – Building Products

KLF/jm

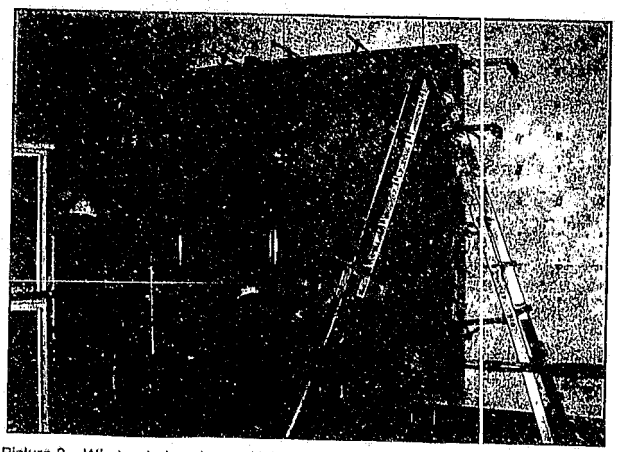
Intertek Testing Services NA Ltd.
1500 Sigurdha Drive, Coquitlam, BC V3K 7C1
Telephone: 604-520-3321 Fax: 604-524-6166 Web: www.intertek-etlsemko.com

Starline Architectural Windows 9000 Series deflection test
Test Facility: Fenestration Lab, Intertek Testing, Coquitlam, BC
Date of test: Thursday, November 3, 2005

A9



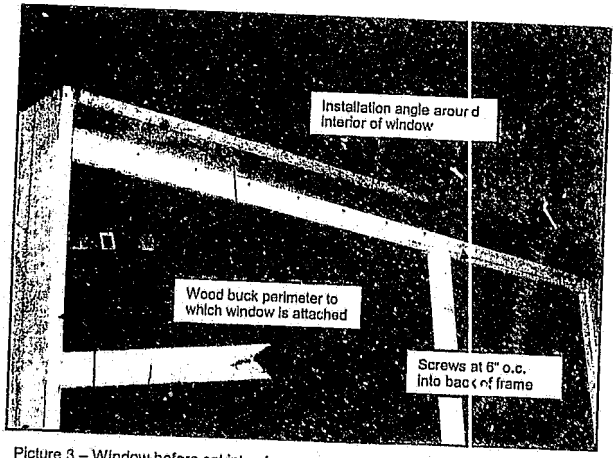
Picture 1 – First test, Benson Tower window being set into air pressure rack



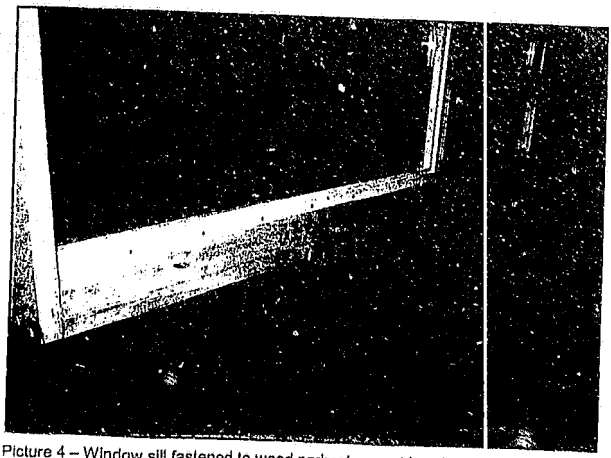
Picture 2 – Window being clamped into air pressure rack

Starline Architectural Windows 9000 Series deflection test
Test Facility: Fenestration Lab, Intertek Testing, Cocuitlam, BC
Date of test: Thursday, November 3, 2005

A10



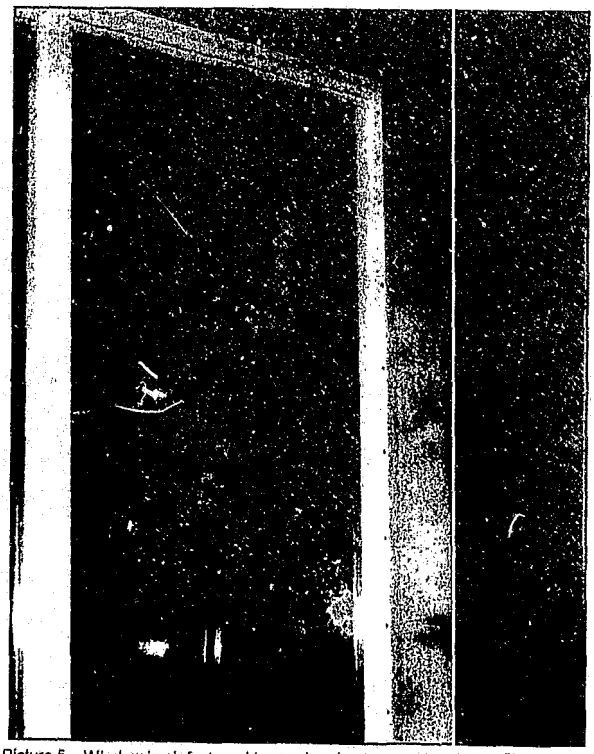
Picture 3 – Window before set into air pressure rack; fastening to wood buck



Picture 4 – Window sill fastened to wood perimeter as at head

Starline Architectural Windows 9000 Series deflection test
Test Facility: Fenestration Lab, Intertek Testing, Coquitlam, BC
Date of test: Thursday, November 3, 2005

A11

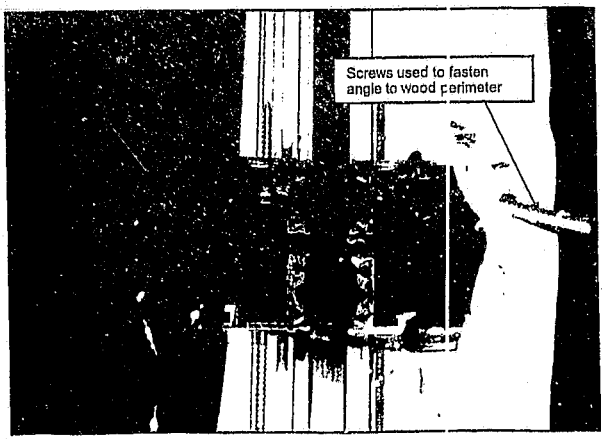


Picture 5 – Window jamb fastened to wood perimeter as at head and sill

Starline Architectural Windows 9000 Series deflection test
Test Facility: Fenestration Lab, Intertek Testing, Coquitlam, BC
Date of test: Thursday, November 3, 2005

A12

Picture 6 – deflection measuring gauge set against vertical coupler mullion



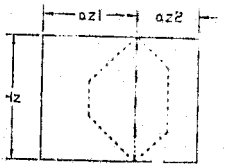
Picture 7 – vertical coupler after first test, verifying no steel was present

Layton Consulting Ltd.	Project: Benson Tower, Portland, Oregon				Client: Starline Arch. Windows
Registered Engineering Professionals 203B-10422 168th Street Surrey, BC	Item Checked: 9000 Series Mullion Analysis				Window Series: 9000 Series
British Columbia Alberta Washington Oregon California	Calc. by FH	Date 11/16/2005	Chk'd by LP	Date	Detail: A13	Date
Ref.	Calculations				Output	

Window W1F — Trapezoidal Mullion Check (Largest Un-reinforced Window)

::::::: BASIC INFORMATION:

Dimensions; Height of window; Hz= 107.88 in;
Side light #1; az1= 37.00 in;
Side light #2; az2 = 61.88 in;
Average tributary width; Wz=0.5*(az1+az2) =49.440 in;



Design wind load; p = 38.00 psf;

Section Properties; Moment of Inertia; Izx= 3.496 in^4;
Section Modulus; S = 1.550 in^3;
Modulus of elasticity; E = 10000000 psi;
Allowable stress; As = 16000 psi;

CALCULATE DEFLECTION OF TRAPEZOIDAL AREA1:

Mullion Height or span; L = Hz = 107.875 in;
Az1 = if(az1>L, L/2, az1/2) = 18.500 in;
Load; q = p*Az1 = 58.583 plf;
Reaction; RA1=RB1 = q*L*(1-Az1/L)/2 = 218.162 lbs;
Bending moment at mid-span; Mmax1= q*L^2/8-q*Az1^2/6 = 6822.934 lbs_in;
Deflection; vmax1 = 5*q*L^4*(1-8*Az1^2/(5*L^2)+16*Az1^4/(25*L^4)) /(384* E * Izx)= 0.235in;

CALCULATE DEFLECTION OF TRAPEZOIDAL AREA1:

Az2= if(az2>L, L/2, az2/2) = 30.940 in;
Load; q = p*Az2 = 97.977 plf;
Reaction; RA2=RB2 = q*L*(1-Az2/L)/2 = 314.076 lbs;
Bending moment at mid-span; Mmax2= q*L^2/8-q*Az2^2/6 = 10573.966 lbs_in;
Deflection; vmax2 = 5*q*L^4*(1-8*Az2^2/(5*L^2)+16*Az2^4/ 25*L^4))/(384* E * Izx)= 0.359in;

TOTAL

Reaction; RA =RB=RA1+RA2 = 532.238 lbs;
Bending moment at mid-span; Mmax = Mmax1+Mmax2 = 17396.900 lbs_in;
Deflection at Mid-span; vmax = vmax1+vmax2= 0.594 in;

SUMMARY

Allowable deflection; Δallow = L/175 = 0.616 in;
Check if vmax<Δallow; Check = if (vmax< Δallow, "Passes.", "Fails.") = "Passes.";
Bending stress; σ = Mmax/S = 11223.806 psi;
Check if (σ<As); Check = if (σ<As, "Passes.", "Fails.") = "Passes.";

SHEAR FLOW

Shear force; V= ΣA = 532.238 lbs;
Section Area of Top Portion; A = 0.761 in^2;
Distance from centroid of top portion to centroid of the whole section; y = 1.31 in;
Shear flow; q = V*A*y/Izx = 151.772 lb/in;
Total thickness of thermal break material; t = 2 mm; Total thickness of 4 pieces; Ttot = 4*t = 0.315 in;
Shear stress; τ = q/Ttot = 481.875 psi;

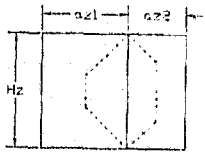
Layton Consulting Ltd.	Project: Benson Tower, Portland, Oregon			Client: Starline Arch. Windows
Registered Engineering Professionals 203B-10422 168th Street Surrey, BC	Item Checked: 9000 Series Mullion Analysis			Window Series: 9000 Series
British Columbia Alberta Washington Oregon California	Calc. by: FH	Date: 11/16/2005	Chck'd by: LP	Date:	Detail:	Date: A14
Ref.	Calculations				Output	

Window W3J

Trapezoidal Mullion Check (Largest Reinforced Window)

BASIC INFORMATION:

Dimensions;	Height of window;	Hz= 112.38 in;
	Side light #1;	az1= 69.00 in;
	Side light #2;	az2 = 56.00 in;
	Average tributary width;	Wz=0.5*(az1+az2) =62.500
Design wind load;	(Corner wind pressure)	p = 47.00 psf;
Section Properties;	Moment of Inertia (combined);	Izx= 6.211 in^4;
	Section Modulus (combined);	S = 2.769 in^3;
	Modulus of elasticity (aluminum);	Ea = 10000000 psi;
	Allowable stress of (aluminum);	Fya = 16000 psi;
	Modulus of elasticity of steel;	Es = 29000000 psi;
	Allowable stress of steel;	Fys = 0.66*50 ksi = 33 ksi;



CALCULATE DEFLECTION OF TRAPEZOIDAL AREA1:

Mullion Height or span;	L = Hz = 112.375 in;
	Az1 = If(az1>L, L/2, az1/2) = 34.500 in;
Load;	q = p*Az1 = 135.125 plf;
Reaction;	RA1=RB1 = q*L*(1-Az1/L)/2 = 438.452 lbs;
Bending moment at mid-span;	Mmax1= q*L^2/8-q*Az1^2/6 = 15540.980 lbs_in;
Deflection;	vmax1 = 5*q*L^4*(1-8*Az1^2/(5*L^2)+16*Az1^4 /(25*L^4)) /(384* E * Izx)= 0.322in;

CALCULATE DEFLECTION OF TRAPEZOIDAL AREA1:

	Az2= If(az2>L, L/2, az2/2) = 28.000 in;
Load;	q = p*Az2 = 109.667 plf;
Reaction;	RA2=RB2 = q*L*(1-Az2/L)/2 = 385.547 lbs;
Bending moment at mid-span;	Mmax2= q*L^2/8-q*Az2^2/6 = 13231.749 lbs_in;
Deflection;	vmax2 = 5*q*L^4*(1-8*Az2^2/(5*L^2)+16*Az2^4/(25*L^4))/(384* E * Izx)= 0.276in;

TOTAL

Reaction;	RA =RB=RA1+RA2 = 823.999 lbs;
Bending moment at mid-span;	Mmax = Mmax1+Mmax2 = 28772.729 lbs_in;
Deflection at Mid-span;	vmax = vmax1+vmax2= 0.598 in;

SUMMARY

Allowable deflection;	Δallow = L/175 = 0.642 in;
Check if vmax<Δallow;	Check = If (vmax< Δallow, "Passes.", "Fails.") = ' Passes.";
Bending stres. of aluminum;	σ = Mmax/S = 10391.018 psi; "%of W1F = 10391/11223 = 93%";
Check if (σ<Fya);	Check = If (σ<Fya, "Passes.", "Fails.") = "Pass es,";
Bending stress of steel;	σ = 2.9*Mmax*1 882 In/Izx = 25.283 ksi;
Check if (σ<Fys);	Check = If (σ<Fys, "Passes.", "Fails.") = "Passes.";

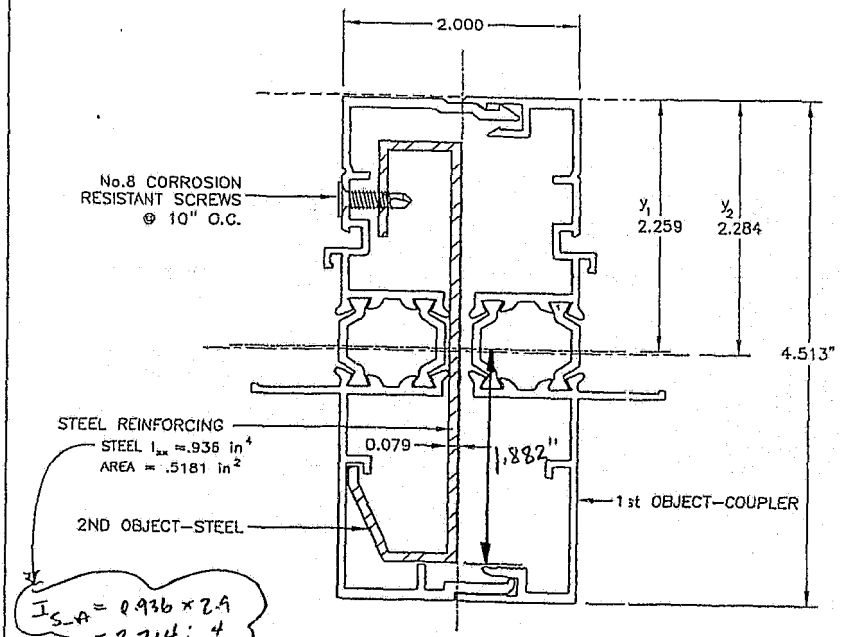
With Aluminum Components (Flexural)

SHEAR FLOW

Shear force;	V= RA = 823.999 lbs;
Section Area of Top Portion;	A = 0.761 in^2;
Distance from centroid of top portion to centroid of the whole section;	y = 1.31 in;
Shear flow;	q = V*A*y/Izx = 132.258 lb/in; "% of W1F = 132/152 = 87%".
Total thickness of thermal break material; t = 2 mm; Total thickness of 4 pieces;	t_{TO} = 4*t = 0.315 in;
Shear stress;	τ = q/t_{TOT} = 419.919 psi;

Shear Flow

A15



VERTICAL 180 DEGREE COUPLER WITH STEEL
MATERIAL: 6063–T5 ALUMINUM
DEFLECTION LIMIT: L/175

MOMENT OF INERTIA:	I_{xx} = 6.211 in^4
SECTION MODULUS:	S_{xx} = 2.769 in^3

DRAWING DETAILS: 9000 SERIES COUPLER (WITH STEEL REINFORCING)	LAYTON CONSULTING 203–10422 168TH STREET, SURREY, BC CANADA, V4N 1R9 TEL: 604–930–0612 FAX: 604–930–1103	DWG. BY E.S.
	SCALE: FULL SIZE DATE: AUGUST 2003	DWG. NO. 9000–1a