Structural Calculation & Design Report For The Façade Of

Water Suppy And Distribution, Dhaka

(Rev. 2)

20/11/2025

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DOCUMENT PREPARATION RECORDS

Date of Issue	Revision	Prepared by	Checked & verified by
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CHAPTER 1: INTRODUCTION

1.1 PROJECT INFORMATION

Table 1.1 – Project Information

Project:	Water Suppy and Distribution, Dhaka
Client:	VolumeZero Ltd.
Contractor:	Arman Engineering Ltd.
Report for:	Structural Calculation Report for Water Suppy and Distribution, Dhaka
Design Method:	Design and Analysis using FEM Based Computer Software and Manual Calculations using Static Principles and Design Codes
Items Included:	1. Glass 2. Structural Silicone 3. Structural Members 4. Connections & Anchorage 5. Brackets and Bolts
References:	Attached Drawing and standards

1.2 OBJECTIVES

The aim of this report is to analyze the façade structure whether this is structurally safe and thereby –

1. To calculate the wind load for component and cladding using BNBC 2020.
2. To calculate the load acting on the façade structure.
3. To verify the glass whether it is safe against wind load, i.e., bending stress and deflection.
4. To evaluate the framing members (mullion and transom) is structurally sound and safe.
5. To analyze and design the support, i.e., Bracket, Anchor bolt etc. for the frame.

1.3 SCOPE

The main goal of structural report is to evaluate the façade structure whether it's structurally safe against the load acting on the structure such as dead load and wind load. Therefore, only structural calculation is provided for various element, i.e., glass, vertical & horizontal members, bracket, bolts etc. related to the fabrication of façade.

Note: This document should be read in conjunction with the provided tender drawing.

CHAPTER 2: DESIGN CRITERIA

2.1 CODES AND STANDARDS

Table 2.2 – Building Codes

Sl. No.	Code / Standard Name	For	Description
01.	BNBC 2020	Wind / General	Bangladesh National Building Code 2020
02.	AA ADM – 2015	Aluminum	Aluminum Design Manual 2015
03.	AISC 360 – 05	Steel	Specification for Structural Steel Buildings
04.	ASTM E 1300 – 04	Glass	Standard Practice for Determining Load Resistance of Glass in Buildings
05.	AS 1288 – 2006	Glass	Australian Standard® Glass in buildings —Selection and installation
06.	ASTM C1401 – 02	Silicone	Standard Guide for Structural Sealant Glazing

2.2 MATERIALS SPECIFICATION

Table 2.3 – Properties of Glass

Properties		Values	Units	Reference
Modulus of Elasticity, E		71700	N/mm^2	
Density, ρ		2500	KG/m^3	
Poisson's Ratio, U		0.25	-	
Allowable surface stress	Fully Tempered	93.1	N/mm^2	*; ASTM E1300, X8.2*
	Heat Strengthened	46.6	N/mm^2	
	Annealed	23.3	N/mm^2	
Allowable edge stress	Fully Tempered	73.0	N/mm^2	*; ASTM E1300, X9.1*
	Heat Strengthened	36.5	N/mm^2	
	Annealed	20.0	N/mm^2	

X8. APPROXIMATE MAXIMUM SURFACE STRESS TO BE USED WITH INDEPENDENT STRESS ANALYSES

X8.1 The purpose of this appendix is to provide a conservative technique for estimating the maximum allowable surface stress associated with glass lites continuously supported along all edges of the lite. The maximum allowable stress (*allowable*) is a function of area (A), load duration in seconds (d), and probability of breakage (P_b).

X8.2 This maximum allowable surface stress can be used for the design of special glass shapes and loads not covered elsewhere in Practice E 1300. This includes trapezoids, circular, triangular, and other odd shapes. A conservative allowable surface stress value for a 3-s duration load is 23.3 MPa (3 380 psi) for annealed glass, 46.6 MPa (6 750 psi) for heat-strengthened glass, and 93.1 MPa (13 500 psi) for fully tempered glass.

X8.3 The maximum allowable surface stress in the glass lite should be calculated using rigorous engineering analysis, which takes into account large deflections, when required. This maximum calculated stress must be less than the maximum allowable stress.

X8.4 Maximum allowable surface stress is calculated using the following equation which has its basis in the same glass failure prediction that was used to develop the non-factored load charts in Section 6.

$$\sigma_{allowable} = \left(\frac{P_B}{[k\,(d/3)^{7/n} * A]}\right)^{1/7} \quad \text{(X8.1)}$$

where:

$\sigma_{allowable}$ = maximum allowable surface stress,
P_B = probability of breakage,
k = a surface flaw parameter,
d = the duration of the loading,
A = the glass surface area, and
n = 16 for annealed glass.

X8.5 The non-factored loads that are determined in this manner should be conservative with respect to the values presented in Section 6.

X8.6 Eq X8.1 is applicable where the probability of breakage (P_b) is less than 0.05. (Note that Section 6 references a P_b less than or equal to 0.008.)

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X9. APPROXIMATE MAXIMUM EDGE STRESS FOR GLASS

X9.1 The purpose of this appendix is to provide a conservative estimate for the maximum allowable edge stress (*allowable*) for glass lites associated with a maximum probability of breakage (P_b) less than or equal to 0.008 for a 3-s load duration.[8]

X9.2 This maximum allowable edge stress can be used for the design of glass shapes and support conditions where edge stress is significant. This includes applications where the glass is not supported on one or more edges. A conservative allowable edge stress value for a 3-s duration can be found in Table X9.1.

TABLE X9.1 Allowable Edge Stress

	Clean Cut Edges, MPa (psi)	Seamed Edges, MPa (psi)	Polished Edges, MPa (psi)
Annealed	16.6 (2400)	18.3 (2650)	20.0 (2900)
Heat-strengthened	N/A[A]	36.5 (5300)	36.5 (5300)
Tempered	N/A	73.0 (10 600)	73.0 (10 600)

[A] N/A–Not Applicable.

X9.3 The maximum edge stress in the glass lite should be calculated using rigorous engineering analysis, which takes into account large deflections, when required. This maximum calculated stress must be less than the maximum allowable stress.

[8] Walker, G. R., and Muir, L. M., "An Investigation of the Bending Strength of Glass Louvre Blades," *Proceedings of the 9th Australian Conference on the Mechanics of Structures and Materials*, Sydney, Australia, August, 1984.

Table 2.4 – Properties of Aluminum (Alloy 6063 T5)

Properties	Values		Reference
Modulus of Elasticity, E	70000 N/mm^2	10100 *ksi*	; *Table A.3.3M, ADM 2015*
Density, ρ	2710 KG/m^3	169 lb/ft^3	
Modulus of rigidity, G	26600 N/mm^2	3800 *ksi*	
Poisons ratio, U	0.33	-	
Yield strength, F_y	110 N/mm^2	16 *ksi*	
Ultimate strength, F_u	150 N/mm^2	22 *ksi*	

Table 2.5 – Properties of Aluminum (Alloy 6063 T6)

Properties	Values		Reference
Modulus of Elasticity, E	70000 N/mm^2	10100 *ksi*	; *Table 2, ASTM B429 – 02* ; *Table A.3.3M, ADM 2015*
Density, ρ	2710 KG/m^3	169 lb/ft^3	
Modulus of rigidity, G	26600 N/mm^2	3800 *ksi*	
Poisons ratio, U	0.33	-	
Yield strength, F_y	172 N/mm^2	25 *ksi*	
Ultimate strength, F_u	207 N/mm^2	30 *ksi*	

Table 2.6 – Properties of Aluminum (Alloy 6061 T6)

Properties	Values		Reference
Modulus of Elasticity, E	70000 N/mm^2	10100 *ksi*	; *Table 2, ASTM B429 – 02* ; *Table A.3.3M, ADM 2015*
Density, ρ	2710 KG/m^3	169 lb/ft^3	
Modulus of rigidity, G	26600 N/mm^2	3800 *ksi*	
Poisons ratio, U	0.33	-	
Yield strength, F_y	241 N/mm^2	35 *ksi*	
Ultimate strength, F_u	262 N/mm^2	38 *ksi*	

Table 2.7 – Properties of Steel (ASTM A36)

Properties	Values		Reference
Modulus of Elasticity, E	200000 N/mm^2	29000 *ksi*	; *Table 3, ASTM A36M*
Density, ρ	7850 KG/m^3	490 lb/ft^3	
Poisons ratio, U	0.3	-	
Yield strength, F_y	250 N/mm^2	36 *ksi*	
Ultimate strength, F_u	400 N/mm^2	58 *ksi*	

Table 2.8 – Properties of Steel (ASTM A500 Gr. B)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	200000 *N/mm*^{2}	29000 *ksi*	*; Table 3, ASTM A500M*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	317 *N/mm*^{2}	46 *ksi*	
Ultimate strength, F_u	400 *N/mm*^{2}	58 *ksi*	

Table 2.9 – Properties of Steel (ASTM A572 Gr. 50)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	200000 *N/mm*^{2}	29000 *ksi*	*; Table 3, ASTM A572M*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	345 *N/mm*^{2}	50 *ksi*	
Ultimate strength, F_u	450 *N/mm*^{2}	65 *ksi*	

Table 2.10 – Properties of Stainless Steel (Gr. 304)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	200000 *N/mm*^{2}	29000 *ksi*	*; Table 3, ASTM A240M*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	205 *N/mm*^{2}	30 *ksi*	
Ultimate strength, F_u	515 *N/mm*^{2}	75 *ksi*	

Table 2.11 – Properties of Bolt Grade (Class 5.8)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	200000 *N/mm*^{2}	29000 *ksi*	*; Table 3, ISO 898-1:2013(E)*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	400 *N/mm*^{2}	58 *ksi*	
Ultimate strength, F_u	500 *N/mm*^{2}	72.5 *ksi*	

Table 2.12 – Properties of Bolt Grade (Class 8.8)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	200000 *N/mm*^{2}	29000 *ksi*	*; Table 3, ISO 898-1:2013(E)*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	640 *N/mm*^{2}	92.8 *ksi*	
Ultimate strength, F_u	800 *N/mm*^{2}	116 *ksi*	

Table 2.13 – Properties of Bolt Grade (ASTM A325M)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	210000 *N/mm*^{2}	30000 *ksi*	*; Table 5, ASTM A325M*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	660 *N/mm*^{2}	95 *ksi*	
Ultimate strength, F_u	830 *N/mm*^{2}	120 *ksi*	

Table 2.14 – Properties of Bolt Grade (ASTM A307M)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	210000 *N/mm*^{2}	30000 *ksi*	*; Table 2, ASTM A307M*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	250 *N/mm*^{2}	36 *ksi*	
Ultimate strength, F_u	415 *N/mm*^{2}	60 *ksi*	

Table 2.15 – Properties of Bolt Grade (Gr. SS A4-70)

Properties	**Values**		**Reference**
Modulus of Elasticity, E	210000 *N/mm*^{2}	30000 *ksi*	*; Table 2, ISO 3506-1:2020(E)*
Density, ρ	7850 *KG/m*^{3}	490 *lb/ft*^{3}	
Poisons ratio, U	0.3	-	
Yield strength, F_y	450 *N/mm*^{2}	65 *ksi*	
Ultimate strength, F_u	700 *N/mm*^{2}	102 *ksi*	

2.3 DESIGN CONSIDERATION

1. Vertical members (Aluminum mullions, MS tube etc.), which are outside of the slab (spanning multiple floor) are considered as continuous member.
2. Vertical members (Aluminum mullions, MS tube etc.), which are inside of the slab (spanning floor to floor) are considered as discontinuous/single span member.
3. Supports of vertical members at the floor/slab level is considered as pin supported.
4. The connections of Horizontal members (Aluminum transom), are considered as pinned/shear connection. Hence the end moment will be released during analysis.
5. In case of steel insert where required, steel and aluminum are attached using self-drilling screw at transom level to ensure no slip between steel and aluminum. Aluminum and Steel is considered to be subjected to the load respected to their flexural rigidity as they will go through the equal amount of deflection.
6. Loads are applied to vertical and horizontal members using two-way slab theory, i.e., trapezoidal and triangular loads are considered.
7. The structural components are designed by following Limit State Design method. Therefore, the Strength and bending moment are checked for Ultimate Limit State (ULS) and Deflections are checked for Serviceability Limit State (SLS).
8. For continuous member, at least four floors/spans of vertical and horizontal members are modeled in the structural analysis program when analyzing the curtain wall system. From experience, nearly 90% of actual condition result can be obtained from four floors/spans model.

NOTE: Other design considerations and assumptions (when applicable) will be addressed in the relevant section.

2.4 IDEALIZATION OF CROSS-SECTION

Most of the aluminum extruded profile are irregular in shape. The analysis software is not currently supported the design of irregular cross-section. Therefore, the cross-section is needed to be idealized for software input and design. The irregular cross-section is idealized as follows –

- Closed rectangular liked hollow section is idealized as rectangular hollow section (RHS).
- The width and the depth of the section kept same.
- For an irregular element (flange/web), the equivalent thickness is taken as the area of the element divided by the width of section.
- The moment of inertia of idealized section is adjusted by using the property modifier.

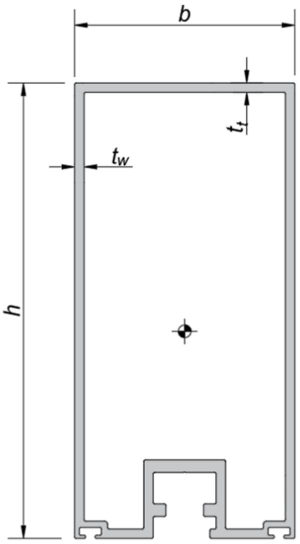


Figure 2.1 – Irregular section

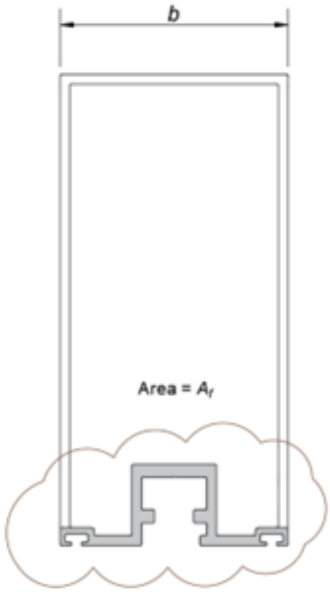


Figure 2.2 – Irregular flange

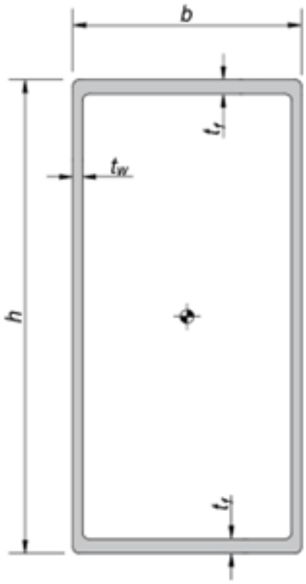


Figure 2.3 – Idealized section

For the above profile,

Area of irregular flange	A_f
Width of flange	b
Equivalent thickness of irregular flange	$t_e = A_f / b$
Regular (top) flange thickness	t_t
Average flange thickness	$t_f = (t_e + t_t) / 2$
Property modifier for Moment of inertia	$I_{33} = I_{original} / I_{idealized}$

2.5 LOAD COMBINATION

Table 2.16 – Load Combination

Combination	Description	For	Reference
1.4D 1.2D + 1.6L 1.2D + L ± 1.6W 0.9D ± 1.6W	Ultimate Limit State (ULS)	Strength checks for structure	*; Sec 2.7.3, BNBC 2020*
D ± 0.7W D + 0.5L ± 0.7W	Serviceability Limit State (SLS)	Deflection check	*; Sec 1.2.5, Note – f, BNBC 2020* *; Sec 2.7.5, BNBC 2020*

৩২৬৬ বাংলাদেশ গেজেট, অতিরিক্ত, ফেব্রুয়ারি ১১, ২০২১

2.7.3 Combinations of Load effects for Strength Design Method

When strength design method is used, structural members and foundations shall be designed to have strength not less than that required to resist the most unfavorable effect of the combinations of factored loads listed in the following Sections:

2.7.3.1 Basic combinations

1. $1.4(D + F)$
2. $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$
4. $1.2D + 1.6W + L + 0.5(L_r \text{ or } R)$
5. $1.2D + 1.0E + 1.0L$
6. $0.9D + 1.6W + 1.6H$
7. $0.9D + 1.0E + 1.6H$

Each relevant strength limit state shall be investigated. Effects of one or more loads not acting shall be investigated. The most unfavorable effect from both wind and earthquake loads shall be investigated, where appropriate, but they need not be considered to act simultaneously.

Exceptions:

1. The load factor on live load L in combinations (3), (4), and (5) is permitted to be reduced to 0.5 for all occupancies in which minimum specified uniformly distributed live load is less than or equal to 5.0 kN/m^2, with the exception of garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combinations (6) and (7) if the structural action due to H counteracts that due to W or E. Where lateral earth pressure provides resistance to structural actions from other

2.7.5 Load Combination for Serviceability

Serviceability limit states of buildings and structures shall be checked for the load combinations set forth in this Section as well as mentioned elsewhere in this Code. For serviceability limit states involving visually objectionable deformations, repairable cracking or other damage to interior finishes, and other short term effects, the suggested load combinations for checking vertical deflection due to gravity load is

1. $D + L$

For serviceability limit states involving creep, settlement, or similar long-term or permanent effects, the suggested load combination is:

2. $D + 0.5L$

The dead load effect, *D*, used in applying combinations 1 and 2 above may be that portion of dead load that occurs following attachment of nonstructural elements. In applying combination 2 above to account for long term creep effect, the immediate (e.g. elastic) deflection may be multiplied by a creep factor ranging from 1.5 to 2.0. Serviceability against gravity loads (vertical deflections) shall be checked against the limits set forth in Sec 1.2.5 Chapter 1 of this Part as well as mentioned elsewhere in this Code.

For serviceability limit state against lateral deflection of buildings and structures due to wind effect, the following combination shall be used:

3. $D + 0.5L + 0.7W$

Due to its transient nature, wind load need not be considered in analyzing the effects of creep or other long-term actions. Serviceability against wind load using load combination 3 above shall be checked in accordance with the limit set forth in Sec 1.5.6.2 Chapter 1 of this Part.

b. Interior partitions not exceeding 2 m in height and flexible, folding and portable partitions are not governed by the provisions of this Section.

c. For cantilever members, l shall be taken as twice the length of the cantilever.

d. For wood structural members having a moisture content of less than 16% at time of installation and used under dry conditions, the deflection resulting from $L + 0.5D$ is permitted to be substituted for the deflection resulting from $L + D$.

e. The above deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to assure adequate drainage shall be investigated for ponding. See Sec 1.6.5 for rain and ponding requirements.

f. The wind load is permitted to be taken as 0.7 times the "component and cladding" loads for the purpose of determining deflection limits herein.

g. Deflection due to dead load shall include both instantaneous and long term effects.

h. For aluminum structural members or aluminum panels used in skylights and sloped glazing framing, roofs or walls of sunroom additions or patio covers, not supporting edge of glass or aluminum sandwich panels, the total load deflection shall not exceed $l/60$. For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed $l/175$ for each glass lite or $l/60$ for the entire length of the member, whichever is more stringent. For aluminum sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed $l/120$.

2.6 DEFLECTION CRITERIA

Table 2.17 – Deflection Criteria

Element	Loading	Deflection Limit	Reference
Structural members (Mullion & Transom)	Wind Load	L/175 up to L = 4.1m (L/240) + 6.35 mm for L > 4.1m Where, L is the length between support.	*; AAMA TIR-A11-04* *; Sec 1.2.5, Note – h, BNBC 2020*
	Dead Load	L/300 or 3 mm, whichever is less Where, L is the maximum span length.	
Glass	Wind Load	B/60 at center Where, B is the shortest length of glass. L/175 at edge Where, L is the largest length of glass	*; AS 1288:2006* *; ASTM E1300*
Steel Frame	Combined Load	L/240 Where, L is the length between support	

1.0 SCOPE

The intent of this document is to provide suggested maximum deflection limits for building cladding framing system support members at design wind loads. This document specifically relates to building cladding components which support glass or other similar brittle materials.

2.0 BACKGROUND

Deflections of framing members are limited in order to:

- Provide adequate support for the materials being retained by the framing members;
- Maintain weatherability of the installed product;
- Prevent damage to adjacent construction;
- Provide a "psychologically acceptable" comfort level for occupants.

Some architectural specifications limit deflection to span/175 or 19 mm (3/4 in), whichever is less. Span/175 is believed to have come from the glass industry, as a limit for support of insulating glass units, and the 19 mm (3/4 in) limit referred to the maximum supporting member deflection allowed for each individual lite, not for the full length of framing members supporting multiple lites.

A partial list of current building codes and standards addressing deflection limits on cladding members supporting glazing follows:

2.1 British Standard 6262:1982, "British Standard Code of Practice for Glazing for Buildings," (formerly CP152), states: "For glass to be considered as four edge fully supported, the deflection of each edge of the glass should be limited to glass span/125 for single glazing and glass span/175 for insulating glass units."

2.2 ASTM E 1300-94, "Standard Practice for Determining the Minimum Thickness and Type of Glass Required to Resist a Specified Load," assumes that the framing system in which the glass is to be installed is sufficiently stiff to limit the lateral deflections of the edges of the glass to not more than 1/175 of their lengths at design load.

2.3 1994 Uniform Building Code, Section 2404.2, "Framing," states: "The framing members for each individual glass pane shall be designed so the deflection perpendicular to the glass plane shall not exceed 1/175 of the glass edge length or 19 mm (3/4 in), whichever is less, when subjected to the larger of the positive or negative load..."

2.4 1994 Standard Building Code Section 2406.1, "Deflection," states: "Glass supports such as sash members, glazing stops or glazing clips shall be considered firm when deflection of the support at design load does not exceed 1/175 of the span."

3.0 RECOMMENDATIONS FOR ALLOWABLE DEFLECTION CRITERIA

As was previously stated, the 19 mm (3/4 in) limit referenced in the 1994 Uniform Building Code pertains specifically to individual glass lites, not to the overall span of a member supporting multiple lites. The 19 mm (3/4 in) framing deflection limitation is then only appropriate for single lite high applications. For members supporting multiple lites, a 19 mm (3/4 in) limit places unwarranted demands on taller framing systems which may result in increased sitelines (framing widths), depths or reinforcing requirements.

Following is an "Allowable Deflection Comparison" chart which depicts the span/deflection relationship based on L/175 and L/240 + 6.35 mm (1/4 in). "L" denotes clear span, i.e., length of member between reaction points. This chart was prepared to create a more conservative upper limit on deflection for spans greater than 4110 mm (13 ft 6 in).

The L/175 and the L/240 + 6.35 mm (1/4 in) gradients intersect at a span of approximately 4100 mm (13 ft 6 in) with a deflection of 23.5 mm (0.925 in). Therefore, the following guideline is suggested:

At design windloads, deflections of building cladding framing members for spans up to 4110 mm (13 ft 6 in) shall be limited to L/175. For spans greater than 4110 mm (13 ft 6 in), but less than 12 m (40 ft), deflections at design windloads shall be limited to the more conservative value of L/240 + 6.35 mm (1/4 in). "L" denotes clear span, i.e., length of member between reaction points. Spans exceeding 12 m (40 ft) may require additional constraints and should be analyzed by the responsible design professional on a case-by-case basis.

Other factors exist which could require a deflection limit less than that allowed by the above framing formulae. The following is a partial list of those factors:

3.1 The anticipated movement of the framing members must not exceed the movement capabilities of adjoining sealants.

3.2 The anticipated movement of the framing members may need to be further limited to accommodate the properties and location of interior finishes (e.g. plaster, drywall, etc.)

3.3 The movement of the framing members must not cause disengagement of applied snap covers or trim.

3.4 The design of the framing members must accommodate differential movement in adjacent framing members such as might occur at jambs, parapets, unusual geometries and other similar conditions.

3.3.3 Serviceability limit states

Glass shall be designed for the serviceability limit states by controlling or limiting deflection.

The maximum deflection for all glass under serviceability limit state actions shall be limited to—

(a) span/60 for two-, three- or four- edge supported panels; or

(b) height/30 (or cantilever length/30) for cantilevered panels such as cantilevered structural glass balustrade.

Glass designed in accordance with Section 4 and other relevant sections, as appropriate, is deemed to comply with the requirements of this Clause.

A3 For the purpose of this Clause, the serviceability loading for wind loading shall be based on a 25-year return period.

3.4 LAMINATED GLASS AND INSULATING GLASS UNITS

3.4.1 Laminated glass

The following applies:

A2 (a) For short-term and medium term load durations, the actual total minimum glass thickness, given in Table 4.1, shall be used.

NOTES:

1 Table 4.1 is applicable to both symmetrical and non-symmetrical laminates.

2 Wind is considered to be a short-term load duration.

3 Access-imposed actions on roof lights and actions on balustrades are considered to be of medium-term load duration.

4 Dead, hydrostatic and some components of live load are considered to be of long-term load duration.

(b) For long-term load durations, the strength of each sheet shall be checked where the proportion of the total load to be resisted by each sheet is k_{sheet}, taken as the larger of the following:

$$k_{\text{sheet}} = \left[\frac{t^3_{\text{sheet}}}{\sum_i t_i^3} \right]$$

or

$$k_{\text{sheet}} = \left[\frac{t^2_{\text{sheet}}}{\sum_i t_i^2} \right]$$

where

k_{sheet} = load-sharing factor of sheet being checked

t_{sheet} = thickness of sheet being checked. Unless known, minimum glass thickness, as per Clause 3.6, shall be used

t_i = thickness of each sheet of glass within the assembly. Unless known, minimum glass thickness, as per Clause 3.6, shall be used

i = total number of sheets within the assembly

NOTE: For laminated glass with two sheets of equal thickness, $k_{\text{sheet}} = 0.5$.

CHAPTER 3: THEORETICAL BACKGROUND

3.1 BUCKLING CONSTANTS

For the design of **Aluminum member,**

The buckling constants B, D, and C are calculated as shown in the following table -

Table 3.18 – Buckling Constants

Type of stress and member	Intercept	Slope	Intersection
Member Buckling	$B_c = F_{cy}\left[1+\left(\frac{F_{cy}}{2250k}\right)^{1/2}\right]$	$D_c = \frac{B_c}{10}\left(\frac{B_c}{E}\right)^{1/2}$	$C_c = 0.41\frac{B_c}{D_c}$
Uniform Compression in Flat Elements	$B_p = F_{cy}\left[1+\left(\frac{F_{cy}}{1500k}\right)^{1/3}\right]$	$D_p = \frac{B_p}{10}\left(\frac{B_p}{E}\right)^{1/2}$	$C_p = 0.41\frac{B_p}{D_p}$
Uniform Compression in Curved Elements	$B_t = F_{cy}\left[1+\left(\frac{F_{cy}}{50000k}\right)^{1/5}\right]$	$D_t = \frac{B_t}{4.5}\left(\frac{B_t}{E}\right)^{1/3}$	$* C_t = 0.70\left(\frac{E}{F_{cy}}\right)^{1/2}$
Flexural Compression in Flat Elements	$B_{br} = 1.3F_{cy}\left[1+\left(\frac{F_{cy}}{340k}\right)^{1/3}\right]$	$D_{br} = \frac{B_{br}}{20}\left(\frac{6B_{br}}{E}\right)^{1/2}$	$C_{br} = \frac{2B_{br}}{3D_{br}}$
Flexural Compression in Curved Elements	$B_{tb} = 1.5F_{cy}\left[1+\left(\frac{F_{cy}}{50000k}\right)^{1/5}\right]$	$D_{tb} = \frac{B_t}{2.7}\left(\frac{B_{tb}}{E}\right)^{1/3}$	$C_{tb} = \left(\frac{B_{tb}-B_t}{D_{tb}-D_t}\right)^2$

** C_t in this Table is taken from AA 2020 for the purpose of simplifying the calculation. k = 1.0 ksi (6.895 MPa)*

3.2 STRENGTH OF ELEMENTS FOR LOCAL BUCKLING

The nominal strengths for compression and flexure of a section are dependent on the slenderness and stress capacity of individual elements of the section. In consideration of local buckling, each element of the section is categorized into loading conditions of Uniform Compression (UC) or Flexural Compression (FC), and its slenderness and stress capacity are calculated correspondingly.

Table 3.19 – Limiting Width-Thickness Ratios of Elements for Stress Capacity

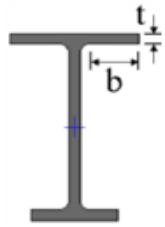
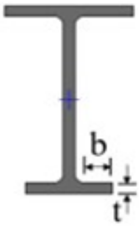
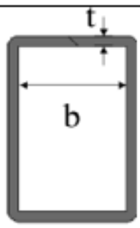
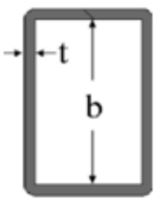
Example	Width-Thickness Ratio, (λ)	Compression		Flexure			
				Major		Minor	
		Support	Stress	Support	Stress	Support	Stress
	$^{b}/_{t}$	One Edge	UC	One Edge	UC	One Edge	FC
	$^{b}/_{t}$	Two Edges	UC	Two Edges	FC	One Edge	FC
	$^{b}/_{t}$	Two Edges	UC	Two Edges	UC	Two Edges	FC
	$^{b}/_{t}$	Two Edges	UC	Two Edges	UC	Two Edges	FC

Table 3.20 – Stress Capacity of Individual Elements

Element Type		λ1	λ2	F_c (or F_b)		
				$\lambda \le \lambda_1$	$\lambda_1 < \lambda < \lambda_2$	$\lambda \ge \lambda_2$
Uniform Compression	Flat Element Supported on One Edge	$\frac{B_p - F_{cy}}{5.0D_p}$	$\frac{k_1 B_p}{5.0D_p}$	F_{cy}	$B_p - 5.0D_p \frac{b}{t}$	$\frac{k_2\sqrt{B_p E}}{5.0\frac{b}{t}}$
	Flat Element Supported on Both Edge	$\frac{B_p - F_{cy}}{1.6D_p}$	$\frac{k_1 B_p}{1.6D_p}$	F_{cy}	$B_p - 1.6D_p \frac{b}{t}$	$\frac{k_2\sqrt{B_p E}}{1.6\frac{b}{t}}$
Flexural Compression	Flat Element Supported on One Edge	$\frac{B_{br} - 1.5F_{cy}}{3.5D_{br}}$	$\frac{C_{br}}{3.5}$	$1.5F_{cy}$	$B_{br} - 3.5D_{br} \frac{b}{t}$	$\frac{\pi^2 E}{\left(3.5\frac{b}{t}\right)^2}$
	Flat Element Supported on Both Edge	$\frac{B_{br} - 1.5F_{cy}}{mD_{br}}$	$\frac{k_1 B_{br}}{mD_{br}}$	$1.5F_{cy}$	$B_{br} - mD_{br} \frac{b}{t}$	$\frac{k_2\sqrt{B_{br} E}}{m\frac{b}{t}}$

Note:

$m = 1.15 + [c_o / (2c_c)]$ ---- when $-1 < c_o / c_c < 1$

$m = 1.3 / [1 - (c_o / c_c)]$ ---- when $c_o / c_c \le -1$

$m = 0.65$ ---- when $c_o = c_c$

c_c = distance from elastic neutral axis to the element extreme fiber with the greatest compressive stress and has negative value.

c_o = distance from elastic neutral axis to the other extreme fiber and has positive value.

$k_1 = 0.35$ & $k_2 = 2.27$ for flat elements in compression with temper designations beginning with T5, T6, T7, T8, or T9

$k_1 = 0.5$ & $k_2 = 2.04$ for flat elements in flexure.

3.3 NOMINAL FLEXURE STRENGTH

The design flexural strength, $\varphi_b M_n$, is determined using the following resistance factor.

$$\varphi_b = 0.9 \text{ (LRFD)}$$

The nominal bending strength depends on the following criteria: the geometric shape of the cross section; the axis of bending; the slenderness of the section; and a slenderness parameter for lateral-torsional buckling. The nominal bending strength is the minimum value obtained considering the limit states of yielding, local buckling and lateral-torsional buckling.

3.3.1 YIELDING

For yielding, the flexural strength is taken as the -

$$M_{np} = \min(Z\,F_{cy}\,,\,1.5\,S_t\,F_{ty}\,,\,1.5\,S_c\,F_{ty})$$

where, Z is plastic section modulus, S_t and S_c are the elastic section moduli on the tension and compression sides of the neutral axis, respectively.

3.3.2 LOCAL BUCKLING

The Weighted Average Method described in Section F.3.1 of the AA 2015 is adopted to calculate the flexural strength for the limit state of local buckling. The stress condition and capacity of each element of the section are determined as described in Section 3.2 and Table 3.3 of this report. And the nominal flexural strength is computed as –

$$M_{lb} = F_c(I_f / C_{cf}) + F_b(I_w / C_{cw})$$

Where,

F_c = uniform compression stress of an element

F_b = flexural compression stress of an element

C_{cf} = distance from centerline of the element subjected to uniform compression to the section's elastic neutral axis

C_{cw} = distance from the extreme compression fiber of an element subjected to flexural compression to the section's elastic neutral axis

I_f = moment of inertia of the element subjected to uniform compression stress about the section's elastic neutral axis

I_w = moment of inertia of the element subjected to flexural compression stress about the section's elastic neutral axis

3.3.3 LATERAL TORSIONAL BUCKLING

For the limit state of lateral-torsional buckling, the flexural strength is computed as –

$$M_{nm,b} = M_{np}\,(1 - \lambda/C_c) + (\pi^2 E\lambda S_{xc}) / (C_c^{\,3}) \text{ ---- when } \lambda < C_c$$
$$M_{nm,b} = (\pi^2 E S_{xc}) / \lambda^2 \text{ ---- when } \lambda \geq C_c$$

where C_c is the intercept buckling constant for member buckling. And λ is computed for box section by the following Equation in which C_b is required and defined as the lateral-torsional buckling modification factor for non-uniform moment diagram and conservatively taken as 1.0.

$$\lambda = 2.3\,\sqrt{[(L_b\, S_{xc}) / (C_b\, \sqrt{(I_y\, J_y)})]}$$

$$J_y = [2t_1 t_2\,(a - t_2)^2\,(b - t_1)^2] / [at_2 + bt_1 - t_2^{\,2} - t_1^{\,2}]$$

Where, J_y is the torsional constant.

a = length of flange

b = length of web

t_1 = thickness of flange

t_2 = thickness of web

CHAPTER 4: DESIGN MOMENT CAPACITY OF PROFILES

4.1 M125X60X2.5

Table 4.21 – Section Properties

Length of web	a	125	*mm*
Length of flange	b	60	*mm*
Thickness of web	t_1	2.5	*mm*
Thickness of flange (avg.)	t_2	4.49	*mm*
Torsional Constant	a	2327814.4	mm^4
Area of cross-section	A	1284.3	mm^2
Moment of inertia about major axis	I_x	3558480.9	mm^4
Moment of inertia about minor axis	I_y	889366.9	mm^4
Extreme fiber Distance from N.A (minor axis)	Y	80	*mm*
Extreme fiber Distance from N.A (major axis)	X	33.5	*mm*
Elastic section modulus about major axis	$S_x = I_x / Y$	44481.0	mm^3
Elastic section modulus about minor axis	$S_y = I_y / X$	26548.3	mm^3

–

Lower region centroid distance from PNA	x	35.9	*mm*
Upper region centroid distance from PNA	y	58.4	*mm*
Plastic section modulus about major axis	$Z_x = 0.5\,A(x + y)$	60554.7	mm^3
Yield strength of Aluminum	F_y	172.4	*MPa*
Modulus of elasticity of aluminum	E	70000	*MPa*

4.1.1 MOMENT CAPACITY BY YIELDING

$$\text{Moment capacity, } M_{np} = min(\,ZF_y\,,\ 1.5\,F_yS_x\,)$$
$$= 10.44\ kN\text{-}m$$

4.1.2 MOMENT CAPACITY BY LOCAL BUCKLING

The weighted average method is utilized to compute the nominal flexure strength due to the limit state of local buckling –

For web elements under flexural compression –

For flange elements under uniform compression –

Total moment capacity, M_{nlb} = $M_{nlb,w} + M_{nlb,f}$
= 9.68 *kN-m*

4.1.3 MOMENT CAPACITY BY LATERAL TORSIONAL BUCKLING

The member is considered to be continuously braced by the glass panel. Therefore, lateral torsional buckling (LTB) not governs.

The nominal bending strength is the minimum value obtained considering the limit states of yielding, local buckling and lateral-torsional buckling. Therefore –

Nominal Moment Capacity, $M_n = min(M_{np} , M_{nlb} , M_{nmb})$ = 9.68 *kN-m*
So, the design moment capacity, φM_n = 8.71 *kN-m*

4.2 M145X67X2.5

Table 4.22 – Section Properties

Length of web	a	145	*mm*
Length of flange	b	67	*mm*
Thickness of web	t_1	2.5	*mm*
Thickness of flange (avg.)	t_2	4.49	*mm*
Torsional Constant	a	2327814.4	mm^4
Area of cross-section	A	1284.3	mm^2
Moment of inertia about major axis	I_x	3558480.9	mm^4
Moment of inertia about minor axis	I_y	889366.9	mm^4
Extreme fiber Distance from N.A (minor axis)	Y	80	*mm*
Extreme fiber Distance from N.A (major axis)	X	33.5	*mm*
Elastic section modulus about major axis	$S_x = I_x / Y$	44481.0	mm^3
Elastic section modulus about minor axis	$S_y = I_y / X$	26548.3	mm^3

–

Lower region centroid distance from PNA	x	35.9	*mm*
Upper region centroid distance from PNA	y	58.4	*mm*
Plastic section modulus about major axis	$Z_x = 0.5\,A(x + y)$	60554.7	mm^3
Yield strength of Aluminum	F_y	172.4	*MPa*
Modulus of elasticity of aluminum	E	70000	*MPa*

4.2.1 MOMENT CAPACITY BY YIELDING

Moment capacity, M_{np} = $min(ZF_y , 1.5\ F_y S_x)$
= 10.44 *kN-m*

4.2.2 MOMENT CAPACITY BY LOCAL BUCKLING

The weighted average method is utilized to compute the nominal flexure strength due to the limit state of local buckling –

For web elements under flexural compression –

For flange elements under uniform compression –

Total moment capacity, M_{nlb} = $M_{nlb,w} + M_{nlb,f}$
= 9.68 *kN-m*

4.2.3 MOMENT CAPACITY BY LATERAL TORSIONAL BUCKLING

The member is considered to be continuously braced by the glass panel. Therefore, lateral torsional buckling (LTB) not governs.

The nominal bending strength is the minimum value obtained considering the limit states of yielding, local buckling and lateral-torsional buckling. Therefore –

Nominal Moment Capacity, $M_n = min(M_{np} , M_{nlb} , M_{nmb})$ = 9.68 *kN-m*
So, the design moment capacity, φM_n = 8.71 *kN-m*

CHAPTER 5: WIND PRESSURE CALCULATION

5.1 WIND PRESSURE FOR 'MWFRS'

$p = qGC_p - q_i(GC_{pi})$ (kN/m^2)

Where,

$q = q_z$ for windward walls evaluated at height z above the ground

$q = q_h$ for leeward walls, side walls, and roofs, evaluated at height h

$q_i = q_h$ for windward walls, side walls, leeward walls, and roofs of enclosed buildings and for negative internal pressure evaluation in partially enclosed buildings.

G = Gust effect factor from Sec 2.4.8, BNBC 2020

C_p = External pressure coefficient from Figure 6.2.6, BNBC 2020

GC_{pi} = Internal pressure coefficient from Figure 6.2.5, BNBC 2020

Velocity pressure, q_z evaluated at height z shall be calculated by the following equations:

$q_z = 0.000613\, K_z\, K_{zt}\, K_d\, V^2\, I$ (kN/m^2)

Where,

K_z = Velocity pressure exposure coefficient defined in Sec 2.4.6.6, BNBC 2020

K_{zt} = Topographic factor defined in Sec 2.4.7.2, BNBC 2020

K_d = Wind directionality factor

V = Basic wind speed (m/s)

I = Importance factor

Table 5.23 – Wind load parameters

Parameters	**Values**	**References**
Building type	Enclosed, Flat Roof	
Building height (Above GL), H	52.0	
Width perpendicular to the wind direction, B	36.2	
Width Parallel to the wind direction, L	16.5	
Location	Dhaka	
Basic Wind Speed, V	65.7	*BNBC 2020, Table 6.2.8*
Exposure Category	A	[a]
Occupancy Category	III	*BNBC 2020, Table 6.1.1* [b]
Importance factor, I	1.0	*BNBC 2020, Table 6.2.9*
Wind Directionality factor, K_d	0.85	*BNBC 2020, Table 6.2.12*
Topographic factor, K_{zt}	1.0	[c]
Gust factor, G	0.85	*; Rigid structure*
Internal Pressure Coefficient, GC_{pi}	± 0.18	
Velocity Pressure, q_z	$2.1\ K_z\ K_{zt}$	

[a] Exposure Category:

Urban area

[b] Other structure

[c] Not in hilly reason

[c] Homogeneous topographies, not in hilly region. No significant effect of topography.

Table 5.24 – External Wall Pressure Coefficient

Surface	**L/B**	**C_p**
Windward Wall	All	0.8
Side Wall	All	- 0.7
Leeward Wall	0.46	0.8

5.1.1 DESIGN WIND PRESSURE

at height h:

Velocity pressure coefficient, K_h	=	1.05	
Topography factor, K_{ht}	=	1.0	
Velocity pressure, q_h	=	2.5	kN/m^2
Internal pressure, P_{hi}	=	0.5	kN/m^2
Leeward pressure, P_{hl}	=	1.64	kN/m^2
Sidewall pressure, P_{hs}	=	2.67	kN/m^2

Table 5.25 – Wind pressure at different height z

5.1 WIND PRESSURE FOR COMPONENTS AND CLADDING (C&C)

$$p = q(GC_p) - q_i(GC_{pi})\ (kN/m^2)$$

Where,

$q = q_z$ for windward walls evaluated at height z above the ground

$q = q_h$ leeward walls, side walls, and roofs, evaluated at height h

$q_i = q_h$ for windward walls, side walls, leeward walls, and roofs of enclosed buildings and for negative internal pressure evaluation in partially enclosed buildings. For positive internal pressure evaluation, q_i may conservatively be evaluated at height h ($q_i = q_h$)

GC_p = External pressure coefficient from Figure 6.2.17, BNBC 2020

GC_{pi} = Internal pressure coefficient from Figure 6.2.5, BNBC 2020

Table 5.26 – GC_p for Wall Componets

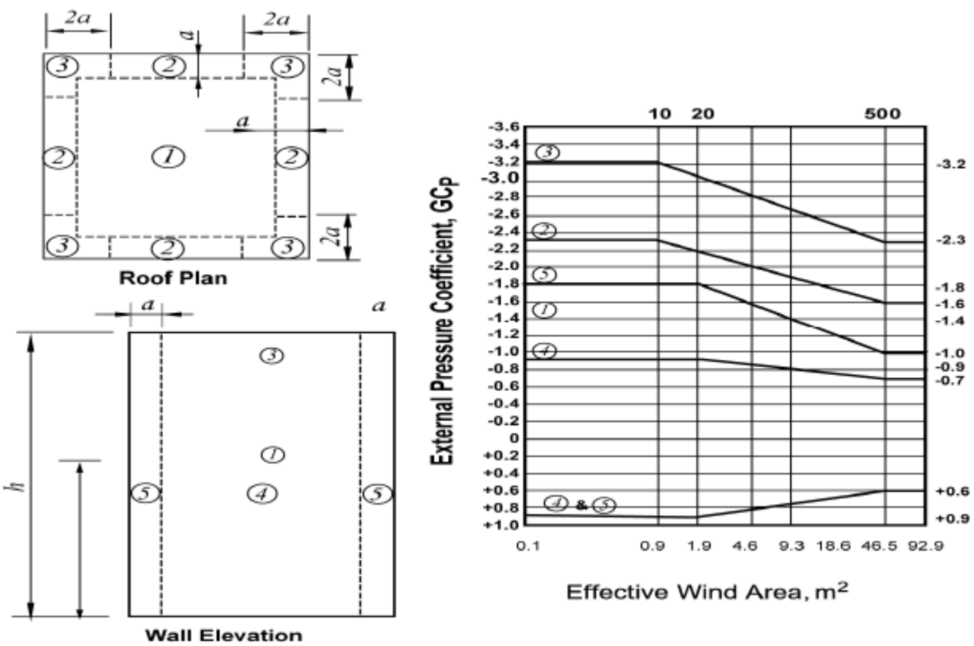
Eff. Area [1]	+ GC_p	- GC_p	
	Zone 4 & 5	Zone 4	Zone 5
≤ 5	0.81	0.84	1.56
10	0.74	0.80	1.38
20	0.68	0.75	1.21
30	0.64	0.73	1.11
40	0.60	0.70	1.00
≥ 46.5	0.60	0.70	1.00

Table 5.27 – GC_p for Roof Componets

- GC_p		
Zone 1	Zone 2	Zone 3
1.18	2.00	2.81
1.09	1.87	2.65
1.01	1.75	2.49
0.96	1.68	2.40
0.92	1.63	2.33
0.90	1.60	2.30

[1] Effective wind area as defined in Section 2.1.3, BNBC 2020. For component and cladding elements, the effective wind area is the span length multiplied by an effective width that need not be less than one-third the span length. i.e., A = max(hb, h × h/3)

Enclosed, Partially Enclosed Buildings: Walls & Roofs



Notes:

1. Vertical scale denotes GC_p to be used with appropriate q_z or q_h.

2. Horizontal scale denotes effective wind area A, in square feet (square meters).

3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.

4. Use q_z with positive values of GC_p and q_h with negative values of GC_p

5. Each component shall be designed for maximum positive and negative pressures.

6. Coefficients are for roofs with angle $\theta \leq 10°$. For other roof angles and geometry, use GC_p values from Figure 6.2.11 and attendant q_h based on exposure defined in Sec 2.4.6.

7. If a parapet equal to or higher than 0.9 m is provided around the perimeter of the roof with $\theta \leq 10°$ Zone 3 shall be treated as Zone 2.

8. Notation:

   a: 10 percent of least horizontal dimension, but not less than 0.9 m.

   h: Mean roof height, in meters, except that eave height shall be used for $\theta \leq 10°$.

   z: height above ground, in (meters).

   θ: Angle of plane of roof from horizontal, in degrees.

Figure 6.2.17 External pressure coefficients, GC_p for components and cladding – Method 2

Figure 5.4 – External pressure coefficient for C&C

Table 5.28 – C&C Wind Pressure for wall component

Zone 5 (Edge) width, a = Min^{m} of (10% of least horizontal dimension, 0.4h); but not less than 0.9 m.

Table 5.29 – C&C Wind Pressure for roof component

CHAPTER 6: [1] TYP. CONT. FACADE

6.1 VERIFICATION OF GLASS PANEL

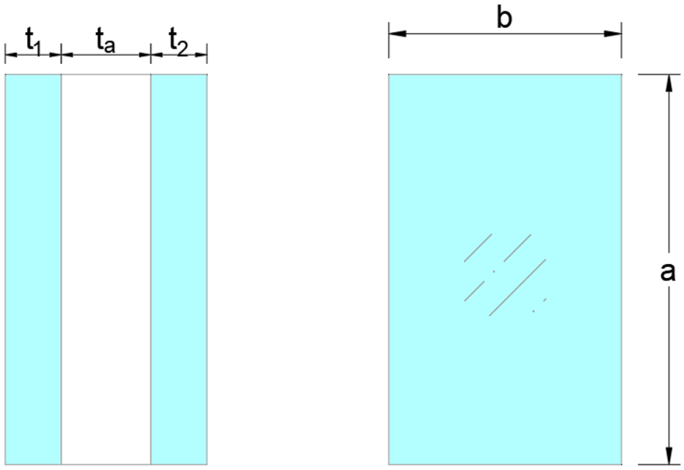


Figure 6.5 – DGU Glass (Section & Plan)

6.1.1 PANEL INFO

Glass Size	2700 x 900 *mm*
Glass Thickness	8.0 + 12 + 8.0 *mm*
Glass Type	DGU, FT + FT

6.1.2 DATA ANALYSIS

Glass length, a	=	2700 *mm*	
Glass width, b	=	900 *mm*	
Effective wind area for glass, A_{eff}	=	2.43 m^2	
Therefore, Max. wind suction/pressure, P_z	=	2.5 *kPa*	*; from wind load table*
Thickness of outer panel, t_1	=	8.0 *mm*	
Thickness of air/gas gap, t_a	=	12 *mm*	
Thickness of inner panel, t_2	=	8.0 *mm*	
Total glass thickness, $t_g = t_1 + t_2$	=	16.0 *mm*	*; without air/gas gap*
Modulus of Elasticity, E	=	71700 *MPa*	
Support Type	=	Four Edges	

6.1.3 CHECK FOR STRENGTH

For Outer Panel:

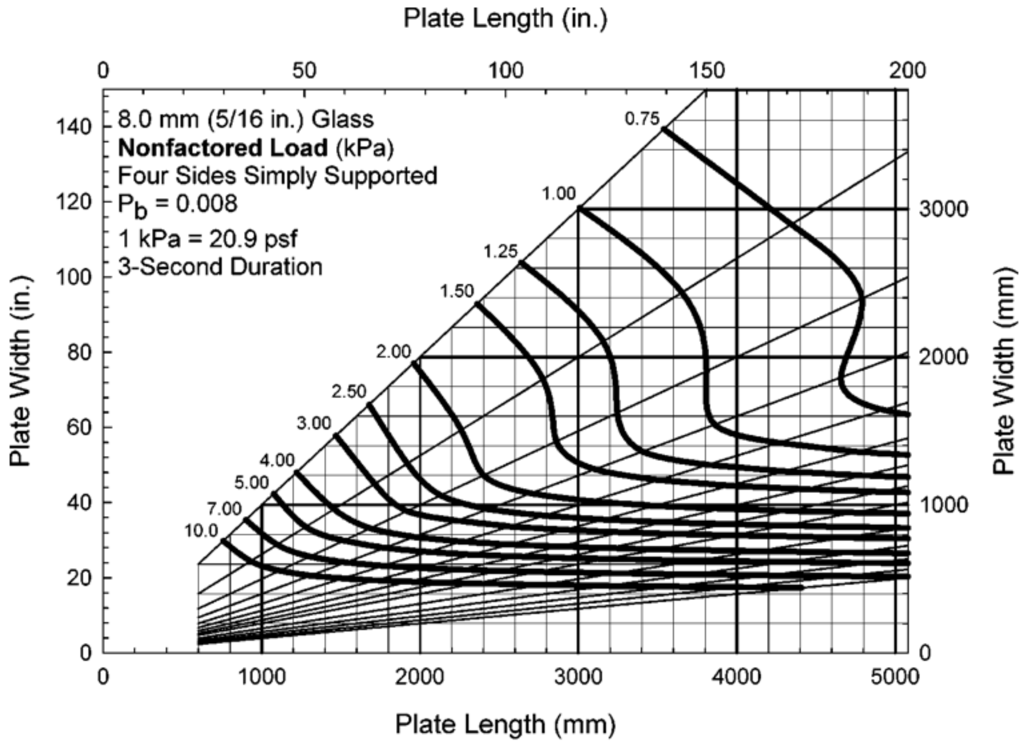


Figure 6.6 – Non-factored Load Chart

Max non factored load, NFL_1	=	2.5 *kPa*	*; from above chart*
Type of glass	=	FT	*; FT = Full Tempered*
Glass type factor, GTF_1	=	3.6	*; ASTM E1300, Table 2*
Load Share factor, LS_1	=	2.0	*; ASTM E1300, Table 5*
Load resisting capacity, $LR_1 = NFL_1 \times GTF_1 \times LS_1$	=	3.6 *kPa*	

For Inner Panel:

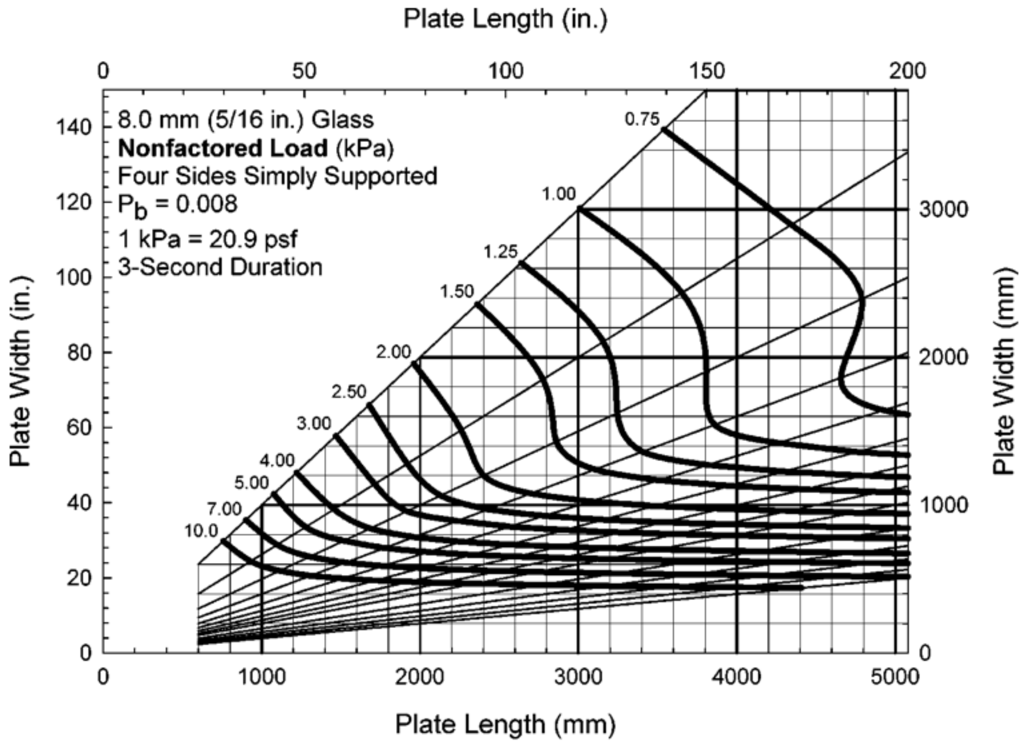


Figure 6.7 – Non-factored Load Chart

Max non factored load, NFL_2	=	2.5 *kPa*	*; from above chart*
Type of glass	=	FT	*; FT = Full Tempered*
Glass type factor, GTF_2	=	3.6	*; ASTM E1300, Table 2*
Load Share factor, LS_2	=	2.0	*; ASTM E1300, Table 5*
Load resisting capacity, $LR_2 = NFL_2 \times GTF_2 \times LS_2$	=	3.6 *kPa*	

Therefore,

Load resisting capacity of the glass, $LR = min(LR_1, LR_2)$	=	3.6 m^2	
Load resistance ratio = P_z/LR	=	0.54	**OK**

6.1.4 CHECK FOR DEFLECTION

$r_0 = 0.553 - 3.83(a/b) + 1.11(a/b)^2 - 0.0969(a/b)^3$ = 2.3

$r_1 = -2.29 + 5.83(a/b) - 2.17(a/b)^2 + 0.2067(a/b)^3$ = 1.2

$r_2 = 1.485 - 1.908(a/b) + 0.815(a/b)^2 - 0.0822(a/b)^3$ = 3.6

For Outer Panel:

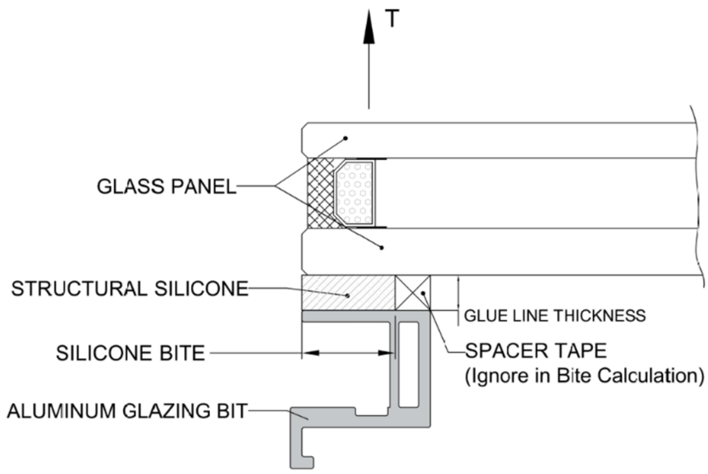
Service wind load, $q_1 = 0.7\ P_z/LS_1$ = $0.875\ kPa$
Outer panel minimum thickness, $t_{1,min}$ = $7.46\ mm$ *; ASTM E1300, Table 4*
$x_1 = ln\{ln[q_1(ab)^2 / Et_{1,min}{}^4]\}$ = 2.4
Deflection, $\delta_1 = t_{1,min} \times exp(r_0 + r_1 \times x_1 + r_2 \times x_1{}^2)$ = $16.2\ mm$

For Inner Panel:

Service wind load, $q_2 = 0.7\ P_z/LS_2$ = $0.875\ kPa$
Inner panel minimum thickness, $t_{2,min}$ = $7.46\ mm$ *; ASTM E1300, Table 4*
$x_2 = ln\{ln[q_2(ab)^2 / Et_{2,min}{}^4]\}$ = 2.4
Deflection, $\delta_2 = t_{2,min} \times exp(r_0 + r_1 \times x_2 + r_2 \times x_2{}^2)$ = $16.2\ mm$

Therefore,
Center of Glass deflection, $\delta = max(\delta_1, \delta_2)$ = $16.2\ m^2$
Allowable deflection, $\delta_a = b/90$ = $20.6\ mm$ *; AS 1288:2006*
Deflection ratio = 0.84 **OK**

6.1.5 VERIFICATION OF SILICONE BITE



Max. Design Wind/suction pressure, P_z = $2.5\ kN/m^2$
Effective load width, B = $900\ mm$
Design strength of Sealant, F_s = $140\ N/mm^2$ *; ASTM C1401 – 02*
Bite size/width required, $t_r = (P_z \times B) / (2\ F_s)$ = $12.4\ mm$
Bite size/width provided, t_p = $1.6\ mm$; $\geq t_r$ **OK**
Glue line thickness required, $e_r = t_r / 3$ = $3.2\ mm$; $\geq 6\ mm$
Glue line thickness provided, e_p = $6.0\ mm$; $\geq e_r$ **OK**

6.2 VERIFICATION OF GLASS PANEL

6.2.1 PANEL INFO

Glass Size	2700 x 900 *mm*
Glass Thickness	12.0 *mm*
Glass Type	SGU, FT

6.2.2 DATA ANALYSIS

Glass length, a	=	2700 *mm*	
Glass width, b	=	900 *mm*	
Effective wind area for glass, A_{eff}	=	2.43 m^2	
Therefore, Max. wind suction/pressure, P_z	=	2.5 *kPa*	*; from wind load table*
Glass thickness, t_g	=	12.0 *mm*	
Modulus of Elasticity, *E*	=	71700 *MPa*	
Support Type	=	Four Edges	

6.2.3 CHECK FOR STRENGTH

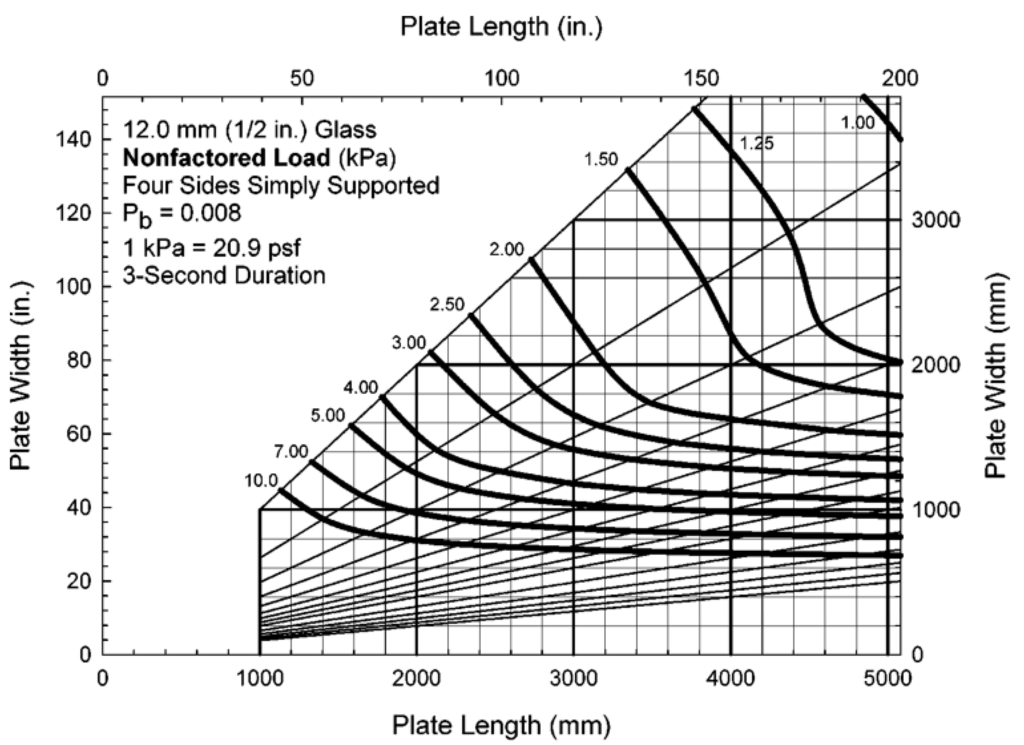


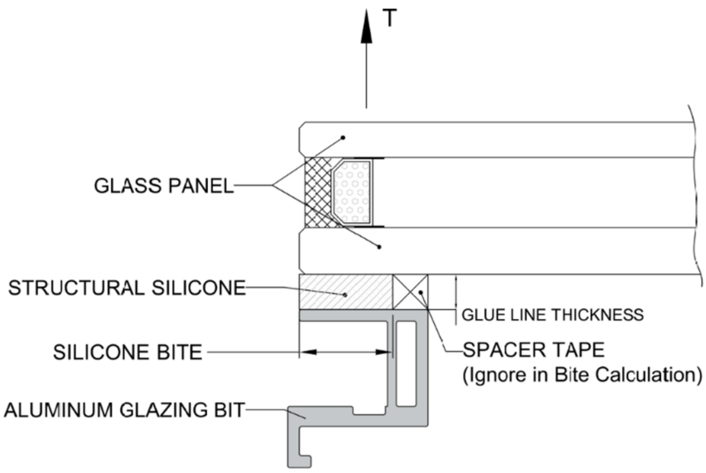
Figure 6.8 – Non-factored Load Chart

Max non factored load, *NFL*	=	2.5 *kPa*	*; from above chart*
Type of glass	=	FT	*; FT = Full Tempered*
Glass type factor, *GTF*	=	4.0	*; ASTM E1300, Table 2*
Load resisting capacity, *LR = NFL x GTF*	=	6.4 *kPa*	
Load resistance ratio = P_z/LR	=	0.54	**OK**

6.2.4 CHECK FOR DEFLECTION

$r_0 = 0.553 - 3.83(a/b) + 1.11(a/b)^2 - 0.0969(a/b)^3$	=	2.5	
$r_1 = -2.29 + 5.83(a/b) - 2.17(a/b)^2 + 0.2067(a/b)^3$	=	1.6	
$r_2 = 1.485 - 1.908(a/b) + 0.815(a/b)^2 - 0.0822(a/b)^3$	=	2.6	
Minimum thickness, t_{min}	=	7.46 *mm*	*; ASTM E1300, Table 4*
Service wind load, $q = 0.7P_z$	=	1.75 *kPa*	
$x = ln\{ln[q(ab)^2 / Et_{min}^4]\}$	=	2.56	
Deflection, $\delta = t_{min} \times exp(r_0 + r_1 \times x + r_2 \times x^2)$	=	12.2 *mm*	
Allowable deflection, $\delta_a = b/60$	=	16.5 *mm*	*; AS 1288:2006*
Deflection ratio	=	0.74	**OK**

6.2.5 VERIFICATION OF SILICONE BITE



Max. Design Wind/suction pressure, P_z	=	2.5 kN/m^2		
Effective load width, *B*	=	900 *mm*		
Design strength of Sealant, F_s	=	140 N/mm^2	*; ASTM C1401 – 02*	
Bite size/width required, $t_r = (P_z \times B) / (2 F_s)$	=	13.2 *mm*		
Bite size/width provided, t_p	=	16.0 *mm*	$; \geq t_r$	**OK**
Glue line thickness required, $e_r = t_r / 3$	=	4.2 *mm*	$; \geq 6$ *mm*	
Glue line thickness provided, e_p	=	6.0 *mm*	$; \geq e_r$	**OK**

CHAPTER 7: [2] TYP. CONT. FACADE

7.1 VERIFICATION OF GLASS PANEL

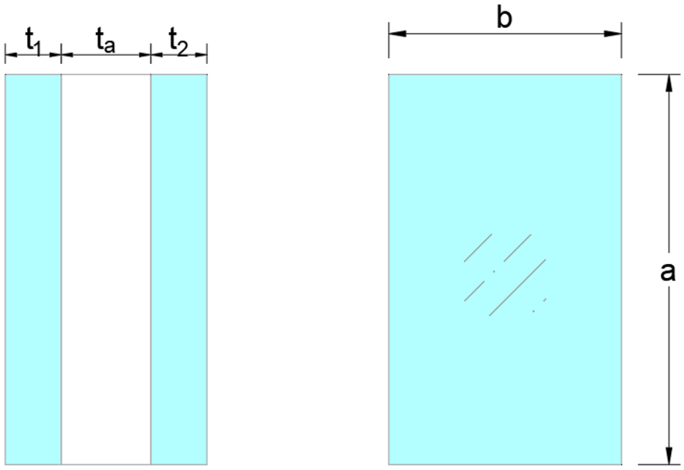


Figure 7.9 – DGU Glass (Section & Plan)

7.1.1 PANEL INFO

Glass Size	2700 x 900 *mm*
Glass Thickness	8.0 + 12 + 8.0 *mm*
Glass Type	DGU, FT + FT

7.1.2 DATA ANALYSIS

Glass length, a	=	2700 *mm*	
Glass width, b	=	900 *mm*	
Effective wind area for glass, A_{eff}	=	2.43 m^2	
Therefore, Max. wind suction/pressure, P_z	=	2.5 *kPa*	*; from wind load table*
Thickness of outer panel, t_1	=	8.0 *mm*	
Thickness of air/gas gap, t_a	=	12 *mm*	
Thickness of inner panel, t_2	=	8.0 *mm*	
Total glass thickness, $t_g = t_1 + t_2$	=	16.0 *mm*	*; without air/gas gap*
Modulus of Elasticity, *E*	=	71700 *MPa*	
Support Type	=	Four Edges	

7.1.3 CHECK FOR STRENGTH

For Outer Panel:

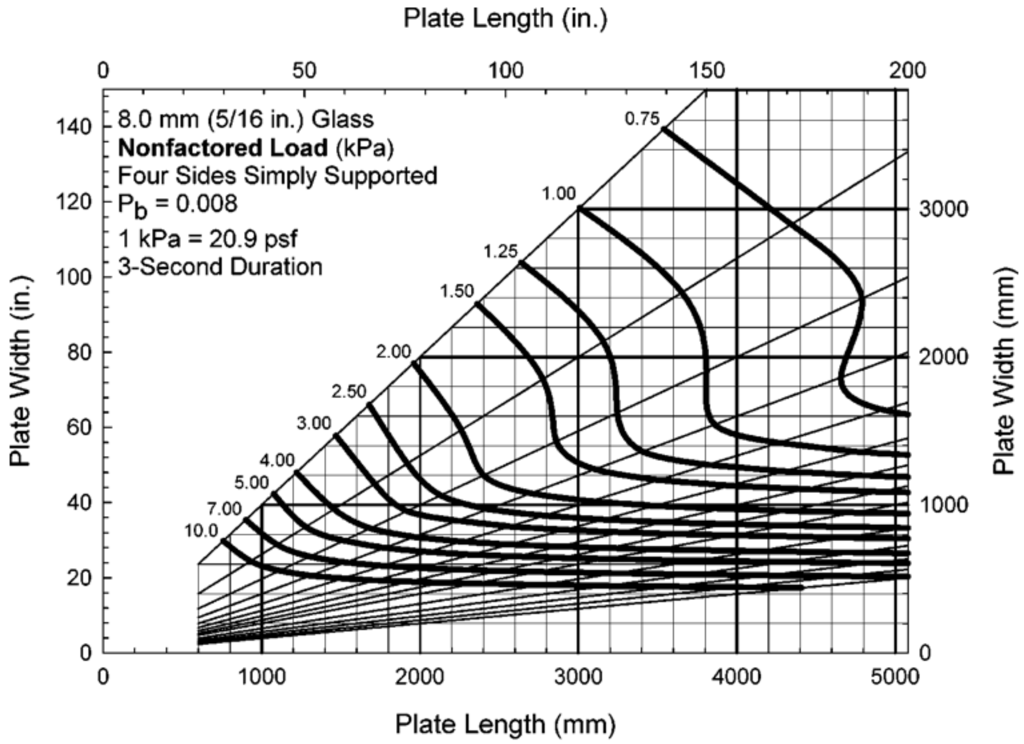


Figure 7.10 – Non-factored Load Chart

Max non factored load, NFL_1	=	2.5 *kPa*	*; from above chart*
Type of glass	=	FT	*; FT = Full Tempered*
Glass type factor, GTF_1	=	3.6	*; ASTM E1300, Table 2*
Load Share factor, LS_1	=	2.0	*; ASTM E1300, Table 5*
Load resisting capacity, $LR_1 = NFL_1 \times GTF_1 \times LS_1$	=	3.6 *kPa*	

For Inner Panel:

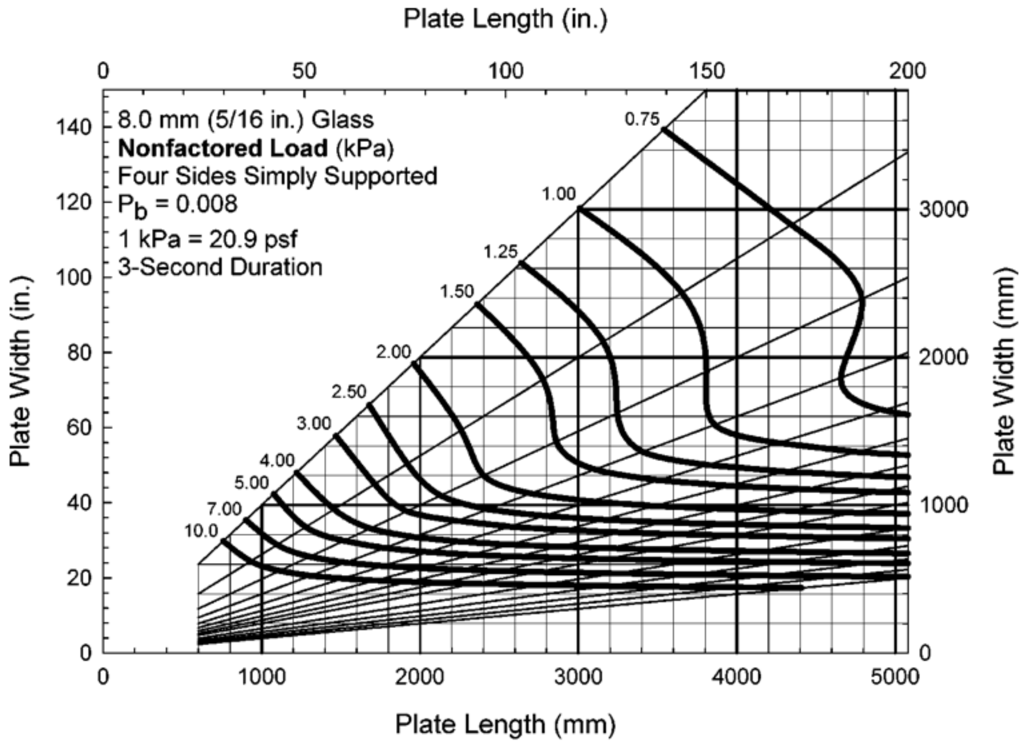


Figure 7.11 – Non-factored Load Chart

Max non factored load, NFL_2	=	2.5 *kPa*	*; from above chart*
Type of glass	=	FT	*; FT = Full Tempered*
Glass type factor, GTF_2	=	3.6	*; ASTM E1300, Table 2*
Load Share factor, LS_2	=	2.0	*; ASTM E1300, Table 5*
Load resisting capacity, $LR_2 = NFL_2 \times GTF_2 \times LS_2$	=	3.6 *kPa*	

Therefore,

Load resisting capacity of the glass, $LR = min(LR_1, LR_2)$	=	3.6 m^2	
Load resistance ratio = P_z/LR	=	0.54	**OK**

7.1.4 CHECK FOR DEFLECTION

$r_0 = 0.553 - 3.83(a/b) + 1.11(a/b)^2 - 0.0969(a/b)^3$ = 2.3

$r_1 = -2.29 + 5.83(a/b) - 2.17(a/b)^2 + 0.2067(a/b)^3$ = 1.2

$r_2 = 1.485 - 1.908(a/b) + 0.815(a/b)^2 - 0.0822(a/b)^3$ = 3.6

For Outer Panel:

Service wind load, $q_1 = 0.7\ P_z/LS_1$	=	0.875 *kPa*	
Outer panel minimum thickness, $t_{1,min}$	=	7.46 *mm*	*; ASTM E1300, Table 4*
$x_1 = ln\{ln[q_1(ab)^2 / Et_{1,min}{}^4]\}$	=	2.4	
Deflection, $\delta_1 = t_{1,min} \times exp(r_0 + r_1 \times x_1 + r_2 \times x_1{}^2)$	=	16.2 *mm*	

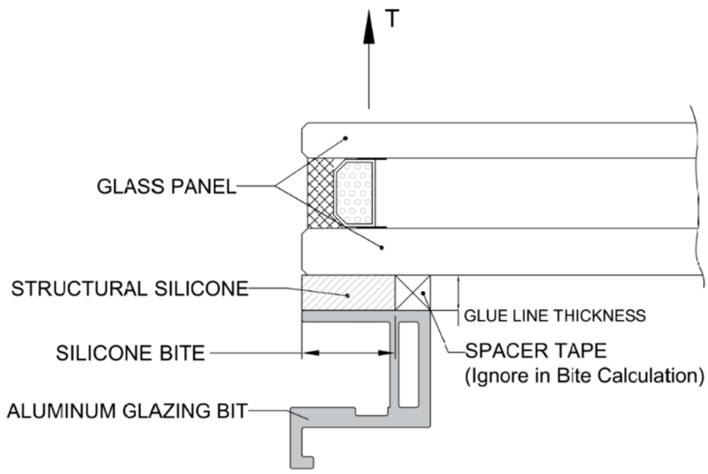
For Inner Panel:

Service wind load, $q_2 = 0.7\ P_z/LS_2$	=	0.875 *kPa*	
Inner panel minimum thickness, $t_{2,min}$	=	7.46 *mm*	*; ASTM E1300, Table 4*
$x_2 = ln\{ln[q_2(ab)^2 / Et_{2,min}{}^4]\}$	=	2.4	
Deflection, $\delta_2 = t_{2,min} \times exp(r_0 + r_1 \times x_2 + r_2 \times x_2{}^2)$	=	16.2 *mm*	

Therefore,

Center of Glass deflection, $\delta = max(\delta_1, \delta_2)$	=	16.2 m^2	
Allowable deflection, $\delta_a = b/90$	=	20.6 *mm*	*; AS 1288:2006*
Deflection ratio	=	0.84	**OK**

7.1.5 VERIFICATION OF SILICONE BITE



Max. Design Wind/suction pressure, P_z	=	2.5 kN/m^2		
Effective load width, B	=	900 *mm*		
Design strength of Sealant, F_s	=	140 N/mm^2	*; ASTM C1401 – 02*	
Bite size/width required, $t_r = (P_z \times B) / (2\ F_s)$	=	12.4 *mm*		
Bite size/width provided, t_p	=	1.6 *mm*	$; \geq t_r$	**OK**
Glue line thickness required, $e_r = t_r / 3$	=	3.2 *mm*	$; \geq 6\ mm$	
Glue line thickness provided, e_p	=	6.0 *mm*	$; \geq e_r$	**OK**

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