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A Case study on the structural design of honey comb core metal panel

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Abstract: The here presented paper deals with the structural calculation for the honey comb core metal panels of the jk1 building located in doha, qatar. The wind pressure of 1.2 kpa [1] is considered for the assumed basic wind speed is 25m/s as per qatar construction standards [2]. The curtain walls consist of quadroclad™ façades qc25-25 panels [3] i.e., aluminium sandwich panel quadroclad qc25-25 which is a 25mm thick with a 23mm honeycomb core that is sandwiched by two outer facing skins of 1mm top and bottom aluminium thickness. Stresses and deflections are obtained from the numerical model [4] for the sandwich panels and the supporting members and are found safe according to different acceptance criterion [5-10]. The adequacy of bracket and anchors is also checked using abaqus nonlinear code [11] and hilti profis [12] software. Aluminum sandwich panel of 1540 x 3000 with an intermediate member is analyzed and verified.

Keywords: *Aluminium Sandwich Panels, Curtain Wall, Quadroclad, Structural Design*

1. Introduction:

The QuadroClad™ system is a unique, open-jointed cladding system based on the principles of rainscreen façades [3]. The supporting frame of the panels is in the form of a channel runner connecting the bracket and the Honey Comb panels. The geometric properties of the profile are given in Fig 4. The specifications used for the Aluminium and structural steel in the analysis are mentioned here.

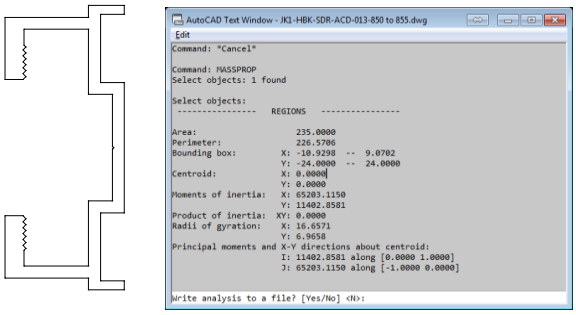


Figure 1: Geometrical properties for the Pre-Engineered profile for QC25-25

Aluminum 6063 T6 and 6061-T5 (as per BS8118 part 1 Table 4.1)
Mechanical properties of 6000 series Aluminum Alloy
Aluminium extrusions used 52i54 alloy to Structural Use of Aluminium BS 8118 Part 1: 1991 [7, 8]
Modulus of Elasticity E = 70000 MPa
Allowable stresses: Bending P_o = 160 MPa
Axial P_a = 175 MPa
Shear P_v = 95 Mpa
Density of Aluminium (KN/m^3) γ = 27

All structural steel shall have f_y nominal yield strength of as specified below and having similar chemical composition and mechanical properties to those specified in BS 4360 [13] for the specified grade of steel [14, 15].

Modulus of Elasticity E = 205000 MPa
Allowable stresses: Strength P_y = 275 Mpa (for t ≤ 16mm)
= 265 Mpa (for t ≤ 40mm)
Bearing P_{bs} = 185 MPa
Modulus of Elasticity E = 205000 N/mm^2
Poisson Ratio μ = 0.3
Density of Steel (KN/m^3) γ= 78
Shear Modulus G = E/ (2(1+ μ))
Coefficient of thermal expansion α = 12x10^{-6}/^{0}C

The adopted sections used for the curtain walls for the SAP 2000 numerical model are shown in Fig 5. The cross sectional area, Inertia in strong axis and weak axis is comparable to the one given by the QC25-25 pre-engineered profile.

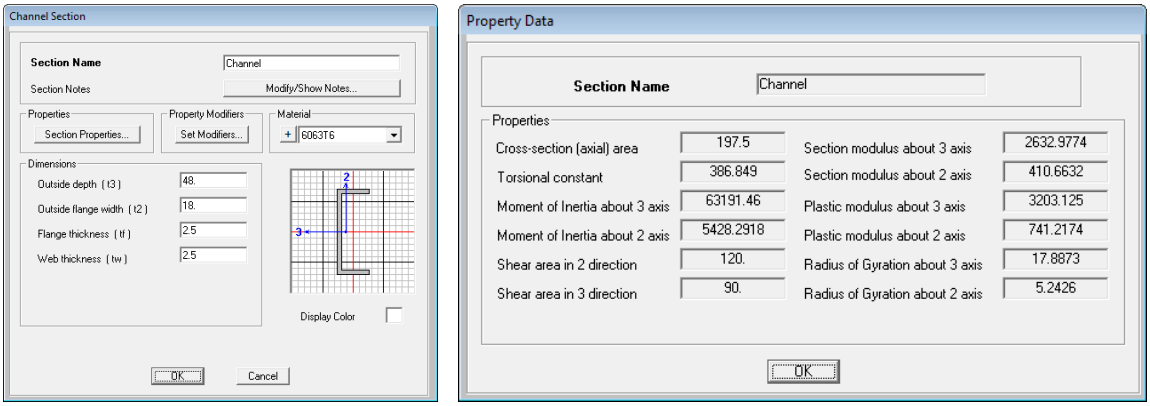


Figure 2: Aluminium channel with Sectional properties

For the ultimate limit state, Aluminum maximum bending stress considered is 160 MPa [7, 8] whereas for Steel it is 275 Mpa.

Serviceability Limit State: Aluminum sandwich panel permissible deflection under dead and wind load equals span/90 [16], Aluminum sandwich panel permissible deflection under dead and imposed load equals span/200 [16] and Aluminum elements deflection equals Span/175.

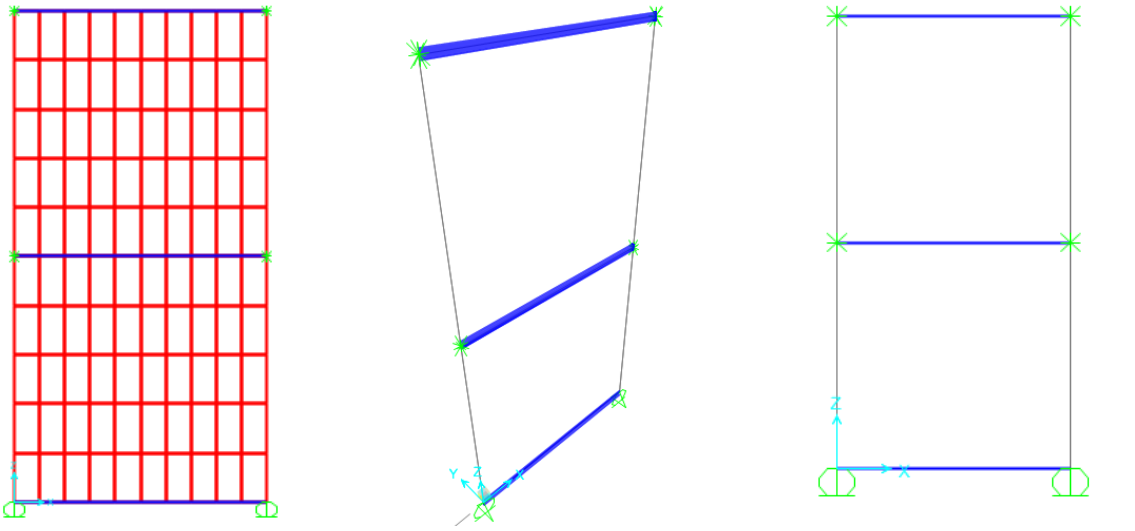
2. Loads and load combinations:

The Dead Load of Aluminium sandwich panel and Aluminium channel is calculated by the software SAP 2000 [4]. Regarding the wind, a wind load of 1.2 KN/m^2 as per British Standards [1, 17, 18]. Net wind pressure is considered to be the maximum value among all zones, i.e. 1.2 Kpa.

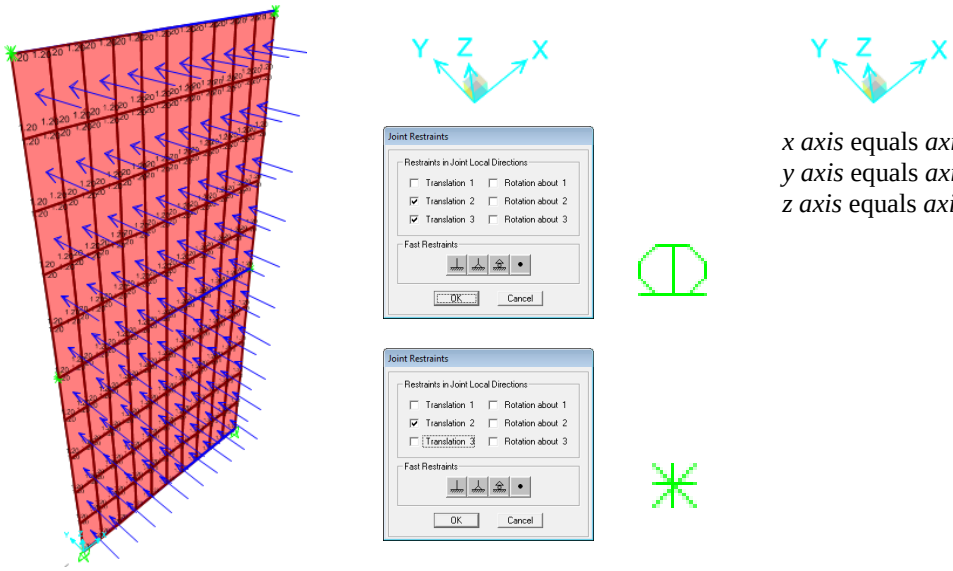
When designing Aluminium structures to British Standards, the relevant load factors are specified in BS 8118: Part 1: Clause 3.2.3 Factored loading [7], [8]. According to Clause 3.2.3 the overall load factor γ_f is calculated as: $\gamma_f = \gamma_{f1} \times \gamma_{f2}$., Where γ_{f1} and γ_{f2} are partial load factors and their values can be found in Tables 3.1 and 3.2 of BS 8118. For standard design situations with the imposed load or wind action giving the most severe loading action on the structure or component. In contrast to BS 8118, the load factors for designing Aluminium structures are given in the Eurocode 0, BS EN 1990 [19, 20] and its National Annex. Further it is seen that design loads generated with the procedure of Eurocode 0 generates higher values for the design actions for the ULSs [9]. The design load combinations in the present case are the various combinations of the load cases for which the model needs to be checked. Since, curtain walls consist of Aluminium material therefore, according to the BS 8118 code, they are assumed subjected to dead load (DL), and Wind load (WL), and the following load combinations may need to be considered, i.e., 1.2 DL and 1.2 DL ± 1.2 WL. Nevertheless, the connections are checked for load combinations with load factor 1.4.

3. Modeling of honeycomb typical panel:

The complete geometry with the assumptions for the typical Aluminium sandwich panel of the curtain wall is shown below. The structural calculation for the typical panel is presented here being the dimension of which will govern the design for the rest of the curtain wall honeycomb panels.



(a) Model meshing *(b) Frame Model* *(c) Frame releases and restraints*



(d) Wind Loading surface (1.2 kPa) *(e) Restraints condition* *(f) Axes*

Figure 3: Model meshing, (a) Model, (b) Frame Model 3D, (c) Frame releases and restraints, (d) Wind Loading surface (1.2kpa), (e) Restraints condition and (f) Axes

4. Checking aluminium honeycomb panel:

The Aluminum Sandwich panels are safe for both ultimate limit states and serviceability limit states

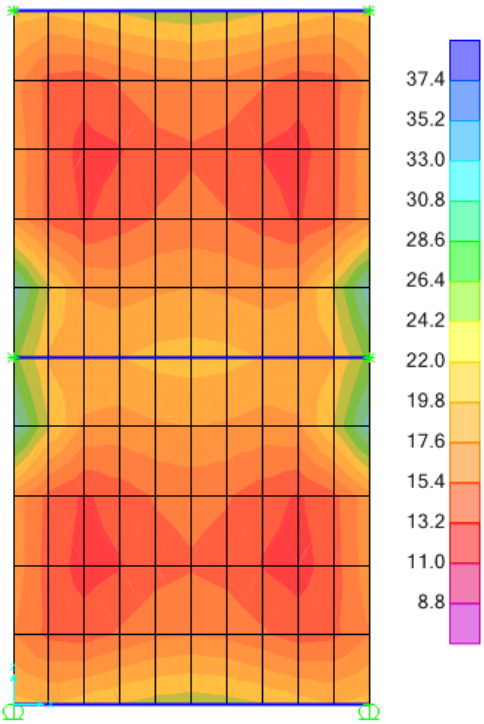


Figure 4: Stresses in Panel under ULS

Maximum Induced bending stress in the Honey comb under ULS is 36.4 Mpa < The allowable bending stress = 125 Mpa—

As 36.4 Mpa <125 MPa
Hence **SAFE**

Verifications

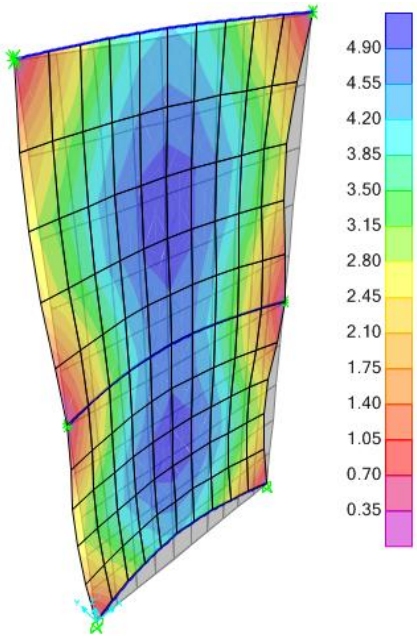


Figure 5: Deflection in Panel under SLS (DL + WL)

Acceptance criteria

Allowable Deflection under DL + WL =Span/90 = 1500/90 = 16.7 > 5.6 ***(GOVERNS)*** --- OK **SAFE**

Allowable Deflection under DL =Span/500 = 1500/500 = 3 mm > 0.2mm ---- **OK SAFE**

Verifications

5. Checking frame of curtain wall:

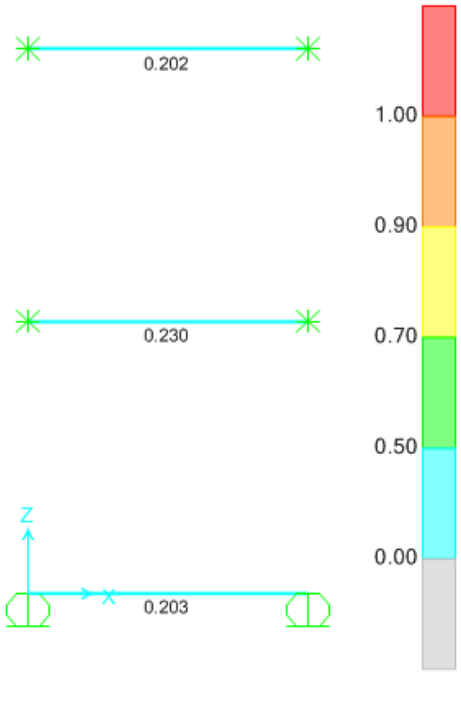


Figure 6: Demand to Capacity ratios of frame members (D/C < 1.0 OK), See SAP2000 report

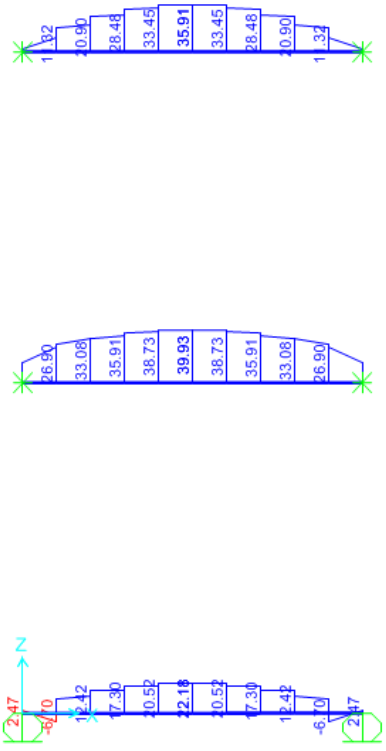


Figure 7: Stresses in Transoms (39.93MPa < 160Mpa OK)

Maximum Induced Stress in transoms under ULS is 39.93 Mpa < The allowable bending stress = 160 Mpa

Hence **SAFE**

Verifications

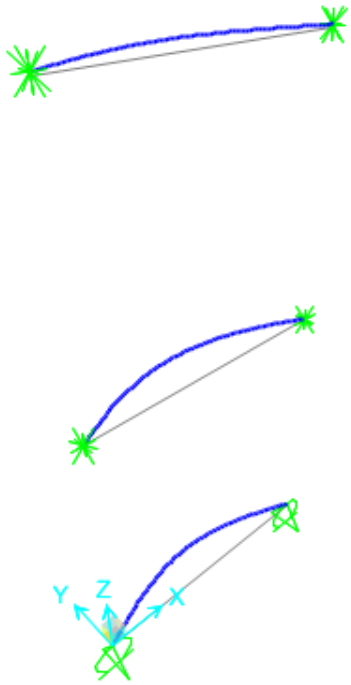


Figure 8:Deflection in Transoms under SLS

Maximum deflection in transom is 4.7 mm
Limiting value = Span/175 = 1500/175 = 8.6 mm
4.7mm < 8.6mm

Hence **SAFE**

Verifications

6. Reactions and brackets:

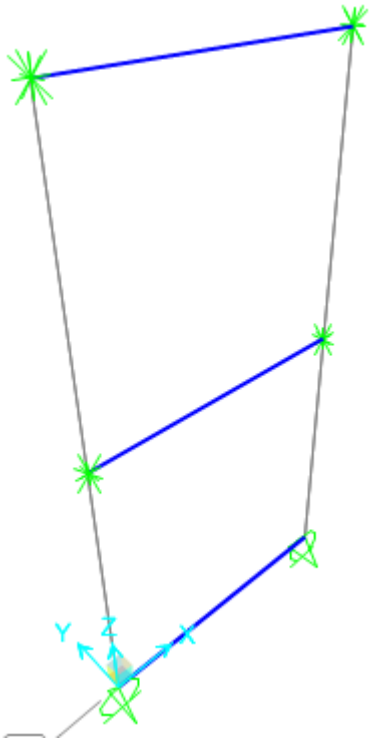


Figure 9: Supports of Panel

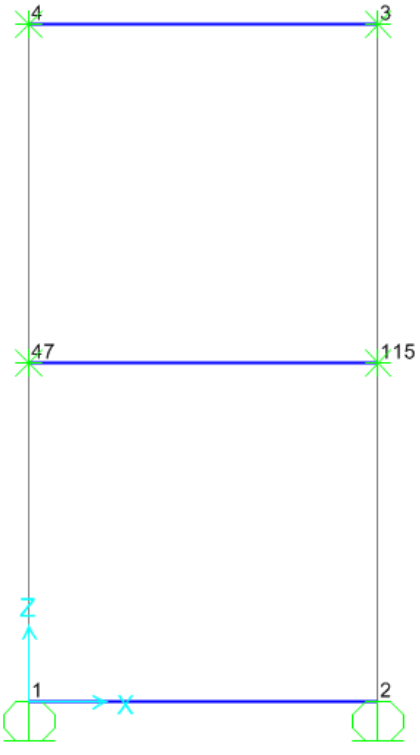


Figure 10: Nodes numbering

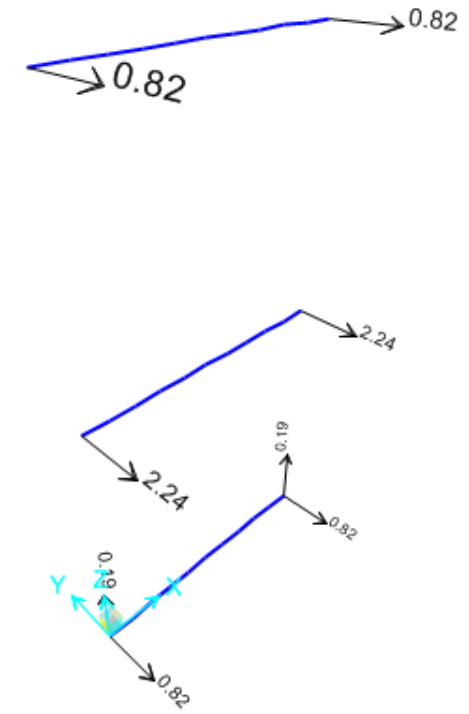


TABLE: Joint Reactions

Joint	Comb	F1	F2 (Y)	F3 (Z)
Text	Text	KN	KN	KN
1	ULS	0	-0.822	0.189
2	ULS	0	-0.822	0.189
3	ULS	0	-0.822	0
4	ULS	0	-0.822	0
47	ULS	0	-2.238	0
115	ULS	0	-2.238	0

.

Figure 11: Support reactions Support reactions

7. Check adequacy of connections:

Maximum induced reaction in shear is F_y = 2.34 KN and F_z = 0.19 KN

The resultant shear will be

$$V = \sqrt{F_y^{\,2} + F_z^{\,2}} = \sqrt{2.34^2 + 0.90^2} = 2.5\ KN$$

7.1. Bracket connection:

The maximum shear as per [21] that can be resisted by the stainless steel M6 bolt will be $P_s = p_s A_s$ where A_s is the shear area (A or A_t). p_s is the shear strength and for property class 70, it is 311 N/mm^2, Using Stainless Steel M6 bolts

Shear capacity $^{(1)}$ P_{sb} (KN) = 311x 21.2= 6.6KN > Applied shear (2.5 KN/2 for two bolts) --**OK**--

So **SAFE**

Hence use, Stainless Steel M6 bolts as Minimum

7.2. Stress Analysis for bracket in Abaqus:

In order to check the validity of bracket, a numerical model is developed in Abaqus nonlinear code [11, 22] for the adopted connections.

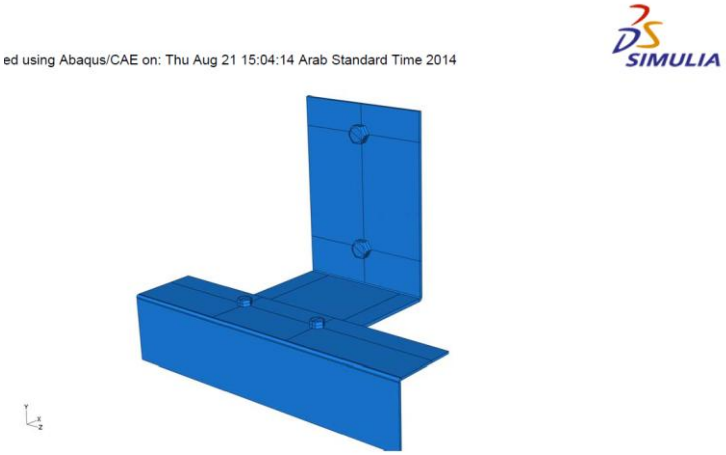


Figure 12: Numerical model for the bracket in Abaqus nonlinear code

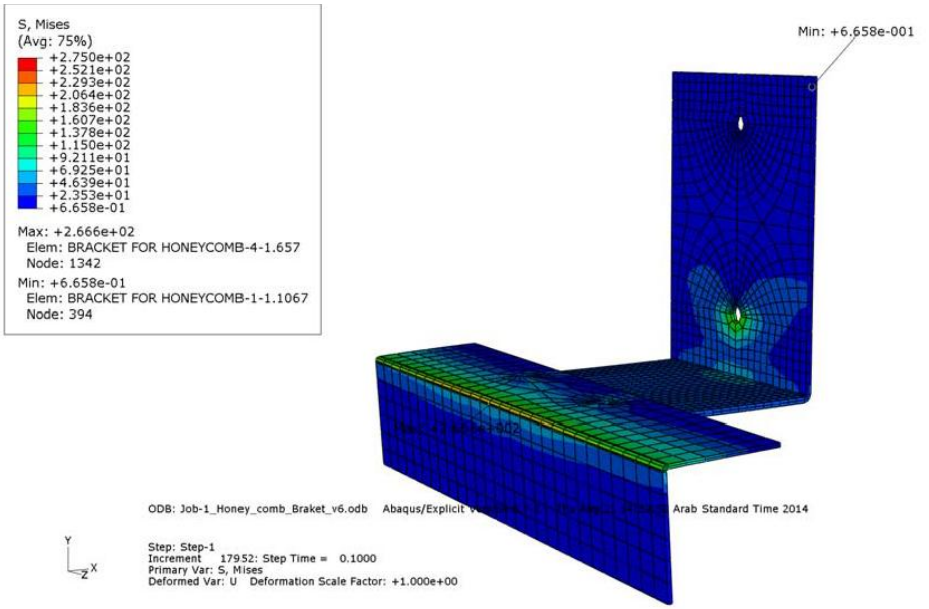


Figure 13: Induced stresses in the bracket

The induced stresses in the plate are less than the permissible. Hence Safe.

Maximum factored F_y = 2.34 KN and F_z = 0.19 KN with The resultant shear equal to 2.5KN, M_x = 2.5 x 0.033 = 0.0825 KNm, Stresses in the connected runner angle = MY/I, where I = 60 x $(2)^3/12$ = 40 mm^4, Stress = MY/I = 0.00825 x 10^6x1/40=206 Mpa < 275 Mpa ----Hence SAFE

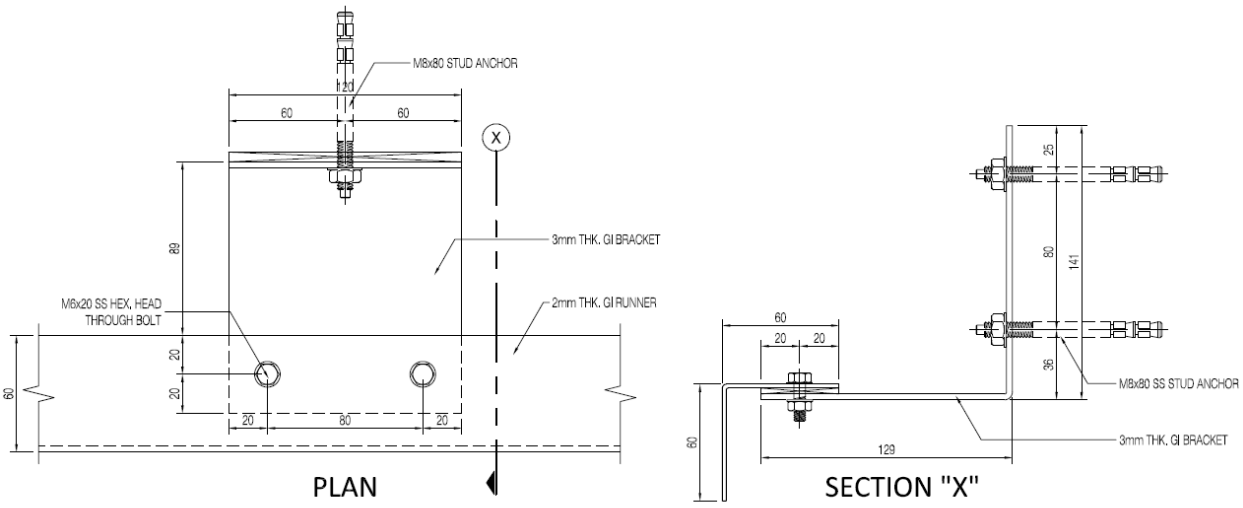


Figure 14: Plan and sectional view of a typical bracket

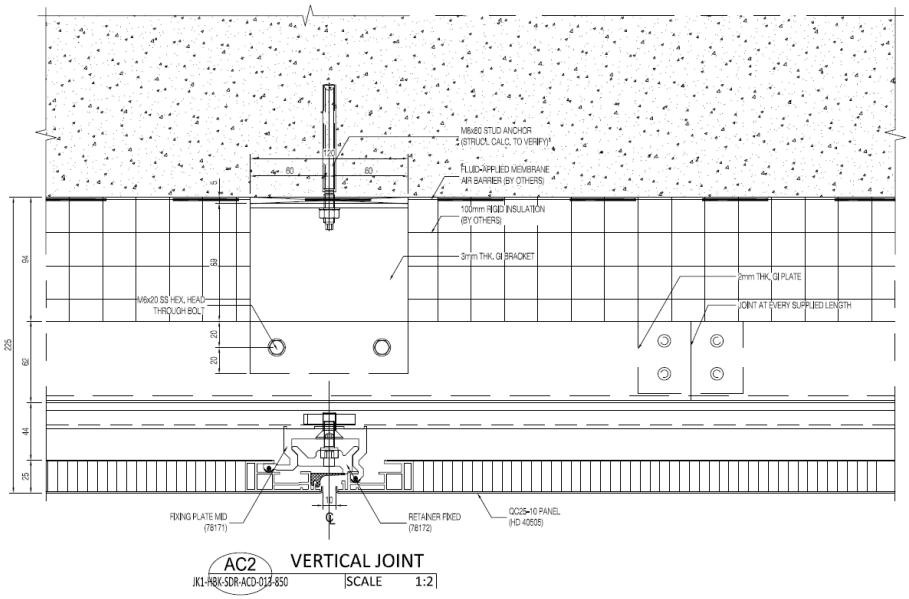


Figure 15: Plan view of the typical bracket connection with the wall

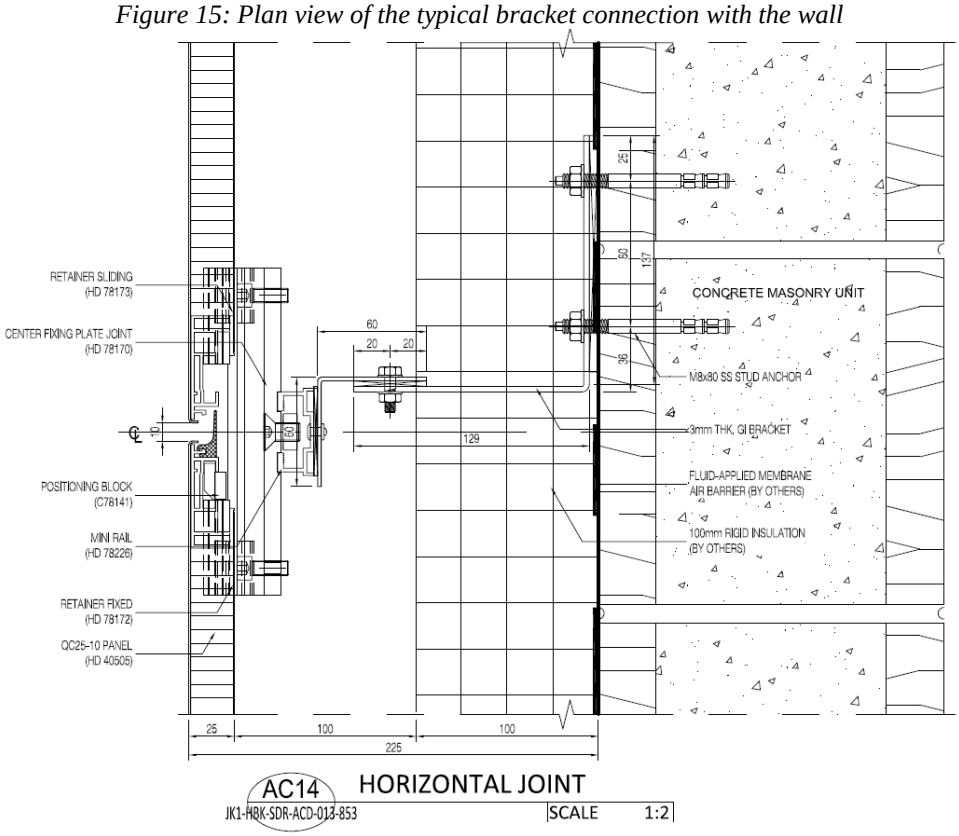


Figure 16: Sectional view of the typical connection

Under the applied action Hilti HIS-N insert with HIT-HY 200 injection mortar with 90 mm embedment h_ef, M8, Steel galvanized, Hammer drilled installation per ETA 12/0084 Or any other equivalent anchors are recommended

8. Conclusions:

The reports presented here shows the design of curtain wall where honey comb sandwich panels are used as glazing. The Aluminium Sandwich panel QuadroClad QC25-25 (1mm top and bottom Aluminium thickness with 23mm interlayer) satisfies both Strength and Serviceability criteria and therefore shall be used a minimum. The M6 Property class 70 stainless steel bolts (BS EN ISO 3506) satisfied the acceptance criteria and therefore are advised to be used as minimum. The Galvanized Iron (GI) sheet of S275 steel grade for bracket is found safe as per the acceptance criterion. Hilti SAFEset HIT-Z anchor with HIT-HY 200 injection mortar with 60 mm embedment h_ef, M8 OR any other equivalent, Steel

galvanized, Hammer drilled installation per ETA 12/0028 are recommended.

9. References:

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