

STRATA SOLUTIONS

# FINAL REPORT

**April 3, 2013**

# ORTHODONTIC CLINIC STRUCTURAL DESIGN




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April 3, 2013

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Dear Mr. Noel, Ms. Antle, and Ms. Pynn:

Please find enclosed the Final Design Report for the Orthodontic Clinic Structural Design Project, which Strata Solutions has developed for Morrison Hershfield.

This report presents detailed descriptions of all design aspects, including design requirements, assumptions, methodologies, sample calculations and results. Detailed design workings, S-Frame outputs, structural drawings and other related project documents are found in the appendices. In addition, a complete set of D size drawings have been produced. A detailed breakdown of material quantities and a final building cost estimate has been determined, as well as a breakdown of internal incurred costs. Concluding remarks and recommendations are given following the cost estimate, and include discussion on the challenges faced by the group and lessons learned during the design process.

If you have any questions regarding the content of the enclosed report, please feel free to contact Strata Solutions via the contact information provided above.

Regards,

Kathy Higgins

Colin Gibling

Mark Reynolds

Jacob Tucker

## Executive Summary

Strata Solutions was requested by Morrison Hershfield to provide the structural design of a three storey orthodontic clinic and retail/office building to be located in St. John's. Strata was responsible for design of the vertical resisting system of the building, along with the slab-on-grade, elevated slabs, joist, roof and foundation design. The team was required to provide the client with a full set of construction drawings with plan, elevation and details. A cost estimate broken down by material was also a requirement.

Strata began the project by developing a project plan and schedule to assure that the project would run smoothly. Members were assigned specific tasks and troubleshooting plans and design methodologies were put in place.

Design of the slab on grade was completed using CSA A23.3-04 and the welded wire mesh reinforcement guide. The elevated slabs, complete with composite steel decking and open web steel joists, were designed using the Canam guides. The roof design was also completed using the Canam guides for steel deck and open web steel joists.

Loading combinations were determined using the contributions due to snow, wind and dead and live loads. 27 loading combinations were required for the building. With the load combinations calculated, the S-Frame model could begin. The architectural drawings were utilized to frame the building.

The S-Frame model was utilized to accurately portray the load transfer between steel members. The resulting moments and shear forces in each member due to the load combinations were required for design. By using the integrated S-Steel software, the steel beams and columns could be selected.

S-Steel was used for the design of all steel members within the structure. Each member was designed by S-Steel for optimal utilization based on each applied load case. To limit the number of steel sections used in the structure, members were divided such that all members of a group were designed to be the same section based on which section provided optimal utilization for the entire group. An additional code check was performed on the structure with the new applied sections to ensure optimal utilization was present throughout the structure.

Vertical loads on the columns from S-Frame were used to design the spread footings and wall footings. Wall footings spanned the perimeter of the building as well as the

shear cores. Two different interior and exterior types of spread footings were designed to distribute the loads from the columns.

Cost estimates were completed using RS Means data from the St. John's area. Total steel weights were calculated automatically by S-Steel; concrete volumes were determined from structural drawings; joist and decking weights were based on Canam specifications. The cost to install each component of the structural system was detailed and used to estimate a final cost of $1,365,000.00 for the scope of work enclosed.

Strata learned that planning and sticking to schedule is the most important part of a successful project. Using all resources at the team's disposal, the structural design scope was completed on time and within budget.

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# 1 INTRODUCTION

The following report is a detailed account of Strata Solutions' involvement in the design of a three-story orthodontic clinic for Morrison Hershfield. It presents detailed descriptions of all design aspects, including design requirements, assumptions, methodologies, sample calculations and results. Major design sections include load calculations, S-FRAME modeling, roof design, slab-on-grade and elevated slab design, steel design and foundation design. As well, a detailed breakdown of material quantities and a final building cost estimate have been determined. This report was developed to provide the reader with a thorough understanding of the process followed by Strata through the project life cycle.

# 2 PROJECT DESCRIPTION

A proposed three-story commercial building is to be built on Hebron Way, located in the Stavanger Drive area of St. John's, NL. The first floor of the building has been designated as retail space, the second floor as commercial office space, and the third floor as an orthodontic clinic. Appendix A contains the architectural drawing set provided by Sheppard Case Architects. Figure 1 shows a 3D view of the exterior of the building.



**Figure 1: 3D rendering of the proposed orthodontic clinic (Source: Sheppard Case)**

The building has several distinct features, including a curved face on the front of the top level, terraces around the exterior of much of the second floor, and clay brick facing

around the exterior of the majority of the first floor. There are two concrete shear cores on the east and west sides of the building containing stairwells and an elevator core. These shear cores provide lateral resistance to the structural system. Above the second level terrace on the curved section of the building is a cantilevered overhang.

## 3 STATEMENT OF PROJECT REQUIREMENTS

Morrison Hershfield appointed Strata to provide design services for the majority of the structural aspects of the three-story building. This required the team to consider possible loading scenarios (wind loads, snow loads, live loads and dead loads), provide design calculations for the various building components (slab on grade, roof system, steel decking, open-web steel joists, beams, columns and foundations) and use the Structural Office software package (including S-FRAME and S-STEEL) to model the building.

Structural drawings were required by the client, and were produced using AutoCAD. The drawing package includes foundation and base plate layout, slab-on-grade plan, first floor, second floor and roof plans, building section views, connection details and general notes.

Strata was also responsible for producing material quantity takeoffs and a detailed cost estimates of the building's components, arriving at a final cost for the structural scope of work.

The team was not responsible for completing the concrete shear core design as it was considered outside of our scope of work.

## 4 PROJECT WORK PLAN

Strata developed a comprehensive project work plan that was used as a guide and source of reference throughout the project. This assured organization and effective time management when completing specific deliverables. A troubleshooting section provided the group with information and guidance for the issues that occasionally arose.

The project work plan included a MS Project schedule of all major tasks and their expected completion dates. This schedule was updated weekly to ensure activities were moving ahead as planned.

The project work plan ultimately ensured that all team members, the client, and the course instructors knew what was expected of Strata throughout the course of the project.

### 4.1 Schedule Compliance

The baseline schedule was driven by design. The original plan called for completion of all design activities by March 20th. The team planned to focus primarily on design until it was completed, with minimal effort put toward completion of other activities. This would allow sufficient time for completion of other deliverables (structural drawings, cost estimate, report, and presentation) once design had concluded.

In practice, each design activity relied on completion of all preceding design activities and it proved inefficient for all team members to work on a single design activity at one time. For this reason, most of the slack in the design schedule was used up. Much more effort was focused on working on drafting, cost estimating, and reporting alongside design. This allowed the team to work more effectively on concurrent tasks to reduce the risk of schedule overruns near the end of the project. For more detailed schedule information, refer to the baseline and final schedule in Appendix B.

## 5 DESIGN ASSUMPTIONS

Strata, by recommendation of the client, made several design assumptions to avoid challenges which were well beyond their scope of knowledge and to better focus attention on the standard principles of building design.

### 5.1 Cross Bracing to Provide Lateral Support

The orthodontic clinic architectural drawings included plans for a lateral support system by means of two solid concrete stairwell and elevator cores. Morrison Hershfield agreed that it would not be a part of Strata's scope of work to complete this. Instead, for modeling purposes, Strata would use sufficiently strong cross bracing members within the elevator and stairwell cores to assure that failure of these sections would not be an issue and that lateral loads were transferred properly.

### 5.2 Curved Third Story

The architectural rendering of the building, as seen in Figure 1, has a curved exterior. When determining the wind loads on the building, this face was treated as a straight faced section for simplicity.

### 5.3 Snow Drifting onto Terraces

When determining the snow drift loading on the second level terraces, the snow drift from the upper level was ignored due to the overhang of the third story. The accumulation of snow on terraces was instead determined as if snow were drifting against an obstruction or wall for conservative design.

### 5.4 Geotechnical Information

The client was unable to provide the team with a geotechnical report. Therefore, an assumed allowable bearing pressure of 200 kPa was used. As well, it is assumed that the water table is well below the frost line.

## 6 LOADS ON THE BUILDING SYSTEM

The structure is required to transfer all loads through its structural steel system and into its foundation. For the purposes of this project, Strata considered the various loads acting on the floors, roof and walls of the building based on the National Building Code of Canada (NBC) specifications. The detailed loading calculations can be found in Appendix C.

### 6.1 Dead Loads

#### *6.1.1 Steel Roof Deck*

The typical value for the dead loads on the steel roof deck was determined using Professor Amgad Hussain's Structural Building Systems Notes; see Table 1. These values took into account the roofing, insulation and steel deck for a total dead load of 0.55kPa.

**Table 1: Steel Deck Dead Load**

| Item | Load (kPa) |
|---|---|
| Roofing | 0.35 |
| Insulation | 0.10 |
| Steel Deck | 0.10 |
| **TOTAL** | **0.55** |

### *6.1.2 Wall Assembly*

Contributions from the various wall assemblies were also taken into account when determining the dead load of the building. The provided architectural drawings referenced 4 different wall assemblies to be utilized. Each wall's composition and weight contributions can be seen in Table 2. For wall assemblies W3, W4, W6 and W7, the dead loads were 0.47kPa, 7.15kPa, 0.66kPa and 0.86kPa respectively.

**Table 2: Wall Assemblies**

| Wall Assemblies and Compositions | Dead Loads (kPa) |
|---|---|
| **W3** | **0.47** |
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum board | 0.00 |
| 203mm metal studs + gypsum either side | 0.38 |
| 64mm rigid poly insulation | 0.09 |
| **W4** | **7.15** |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| Concrete foundation wall | 6.87 |
| **W6** | **0.66** |
| 152 mm metal studs | 0.38 |
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum board | 0.00 |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| **W7** | **0.86** |

| | |
|---|---|
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum board | 0.00 |
| 203mm metal studs | 0.38 |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| 92 mm metal studs | 0.19 |

## 6.2 Environmental Loads

### *6.2.1 Wind Loads*

The wind loads on the structure were determined using The National Building Code's Structural Commentary (Part 4 of Division B) in conjunction with Professor Amgad Hussein's ENGI 8705 - Structural Building Systems class notes. As mentioned in Section 5.2, the curved exterior of the third storey of the building was treated as a straight face for simplicity.

Figure I-1 of the Structural Commentary was used to classify the building and determine external wind loads. The height of the building was 14.88m and the characteristic width was determined to be 23.017m. Given that the height to width ratio was 0.646 (less than 4), the building was less than 120m tall (14.88m), and the building was assumed to not be susceptible to vibrations, the static procedure could be utilized.

From Section 4.1.7.1, Sentence 5, the exposure coefficient was determined to be 1.083 based on an exposed setting for the building. The height to shortest dimension ratio was calculated to be 0.814, less than 1; the structure could then be classified as a low-rise building.

Coefficients of internal suction, pressure, and the gust effect factor were determined from Paragraph 31. An importance factor of $I_w$= 1.0 and a wind pressure of 0.78kPa for St. John's was used.

Paragraphs 19 through 21, as well as 25 through 28 and Figure I-7 were used to determine appropriate $C_pC_g$ values based on Load Cases A and B. The governing wind load case was the uplift force which occurred when exterior wind forces were combined with internal pressure. See Table 3 and Table 4 for the summation of these forces on each face of the building.

**Table 3: Case A - Internal and External Worst Case Wind Loading**

| Case A | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E |
|---|---|---|---|---|---|---|---|---|
| Pressure (kPa) | 0.125 | 0.463 | -1.603 | -2.193 | -1.097 | -1.35 | -0.971 | -1.182 |

**Table 4: Case B - Internal and External Worst Case Wind Loading**

| Case B | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E | 5 | 5E | 6 | 6E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure (kPa) | -1.224 | -1.266 | -1.603 | -2.193 | -1.097 | -1.350 | -1.224 | -1.266 | .125 | 0.463 | -0.971 | -1.182 |

Internal Pressure and suction were determined using paragraph 31 of the structural commentary. Internal suction, pressure and gust effect coefficients were -0.45, 0.3 and 2.0 respectively, resulting in pressures of -0.76kPa and 0.507KPa.

$$p = I_w * q * C_e * C_p * C_g$$

$$p_{i1} = I_w * q * C_e * C_{pi1} * C_{gi} = -0.76\ kPa$$
$$p_{i2} = I_w * q * C_e * C_{pi2} * C_{g2} = 0.507\ kPa$$

The wind loads applied to the structure were based on a worst case scenario. The loading provided by Case B CpCg values with the addition of 0.507 kPa internal pressure was determined to provide the highest pressures to the majority of building faces.

### *6.2.2 Snow Loads*

Snow loads on the structure were also determined using The National Building Code's Structural Commentary (Part 4 of Division B) in conjunction with Professor Amgad Hussein's ENGI 8705 - Structural Building Systems class notes. Snow loads on the upper roof and the second level terraces were calculated. The proposed roof from the architectural team was flat, meaning no calculations for snow sliding from the roof to the lower second level terraces were required.

An importance factor of normal was determined to be suitable given the nature of the building. Loads due to snow and rain for St. John's were taken as 2.9KPa and 0.7KPa respectively from the NBCC Climatic Data table.

#### 6.2.2.1 Basic Snow Load

Beginning with the upper roof, the characteristic length was calculated to be 31.835m, therefore classifying this roof as small and giving a basic snow load factor of 0.8. From Figure G-1, the exposure factor, the shape factor and the slope factor were all 1.0. Given the information, the basic snow load on the upper roof was calculated to be 3.02kPa.

$$S = I_s * (S_S * (C_b * C_w * C_s * C_a) + S_r = \ 3.02\ kPa$$

#### 6.2.2.2 Drifting due to Mechanical Equipment

The roof contained three pieces of mechanical equipment, each of which were approximately 2.3 meters by 3.4 meters and assumed to be 1.5 meters tall; see Figure 2. The drifting of snow against the equipment was calculated.

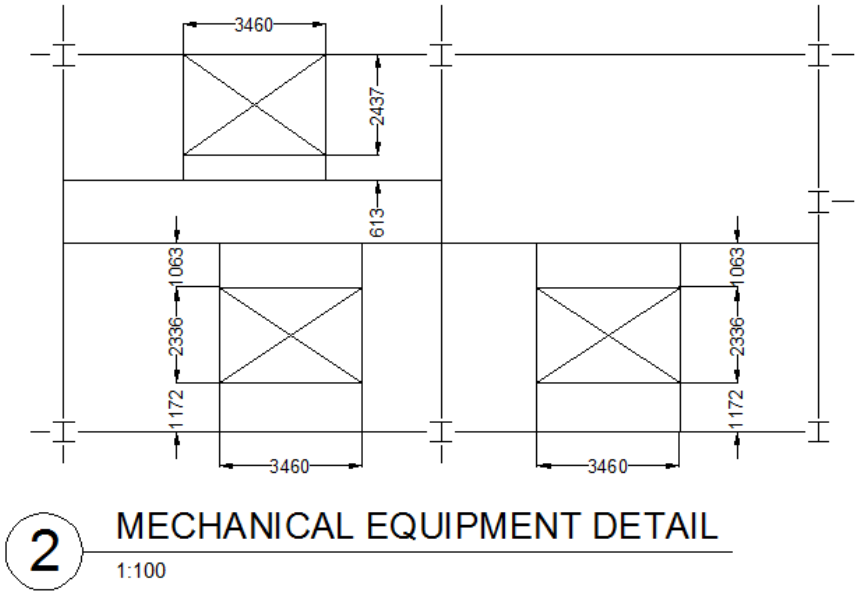


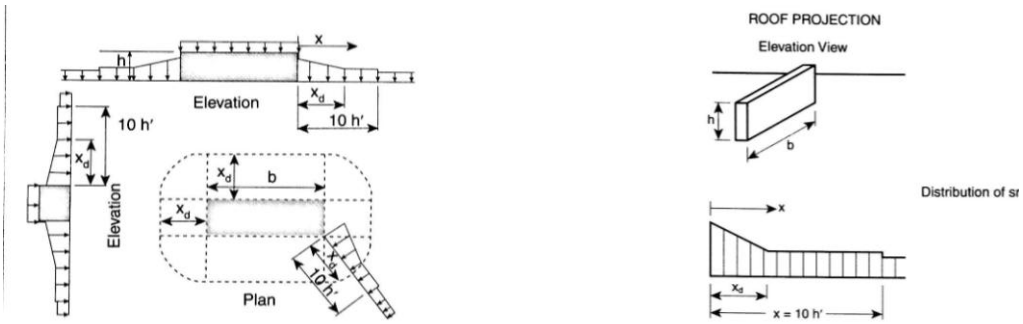

**Figure 2: Mechanical Equipment Detail**

Drifting on the upper roof due to the mechanical equipment was calculated using Figure G-8 of the commentary. A linearly varying load from the face of the equipment to a distance 3.048 m from equipment was determined to be 3.76 kPa to 3.02 kPa. Drift loads would only be considered in the North-South direction since the equipment width was less than 2.9 m in the East-West direction and could be ignored.

Length of varying drift load $x_d = 2 * h = 2 * 1.524m = 3.048m$

Shape factor at distance "0" from obstruction $C_a(0) = 0.67 * \frac{\gamma_s * h}{C_b * S_s} = 1.32$

Highest Drift Load $S = I_s * (S_S * (C_b * C_w * C_s * C_a(0)) + S_r = 3.763\ kPa$




$x_d$ = 2h but 3 m ≤ $x_d$ ≤ 9 m

$h' = h - \frac{C_b C_w S_s}{\gamma}$

$C_a(0) = 0.67\ \frac{\gamma h}{C_b S_s}$

when $C_a(0) < 0.8/C_b$, use $0.8/C_b$

when $C_a(0) > 2/C_b$, use $2/C_b$

| b, metres | x | Factors | | |
|---|---|---|---|---|
| | | $C_w$ | $C_s$ | $C_a$ |
| ≤ 3 $S_s/\gamma$ (2) | All | 1.0 (3) | f(α) (1) | 1.0 |
| > 3 $S_s/\gamma$ | 0 | 1.0 | f(α) (1) | $C_a(0)$ |
| > 3 $S_s/\gamma$ | 0 < x ≤ $x_d$ | 1.0 | f(α) (1) | $C_a(0) - \frac{(C_a(0) - 1)\ x}{x_d}$ |
| > 3 $S_s/\gamma$ | $x_d$ < x ≤ 10 h' | 1.0 | f(α) (1) | 1.0 |
| | > 10 h' | 1.0 (3) | f(α) (1) | 1.0 |

**Figure 3: Excerpts from Figure G-8 of Structural Commentary (Source: User's Guide-NBC 2010, Structural Commentaries (Part 4 of Division B))**

#### *6.2.2.3 Snow Drift on Terraces*

Snow drift on the second level terraces was determined. Since the third storey overhangs above the second floor terraces, it was assumed that no snow would drift from the top roof onto the terraces. Instead, the second-floor exterior wall was treated as an obstruction. Using Figure G-8; the height of the terrace was 3.337 m, $x_d$ was calculated at 6.674 m. The maximum Ca value, Ca (0), was determined to be 2.891, but upper and lower limits are placed on this coefficient, therefore a value of 2.5 was used. The minimum Ca value for the terrace was based on the terrace width 'w' and calculated to be 1.815, at the most outward point of the terrace. Given the calculations, the drift load on either terrace ranged linearly from 6.5 kPa to 4.911 kPa

Length of varying drift load $x_d = 2 * h = 6.674\ m$

Shape factor at distance "0" from obstruction $C_a(0) = 0.67 * \frac{\gamma_s * h}{C_b * S_s} = 2.891$

Shape factor at xd $C_a min = C_a(0) - \frac{(C_a(0) - 1.0) * w}{x_d} = 1.815$

Highest Load on Terraces $S = I_s * (S_S * \left(C_b * C_w * C_s * C_a(0)\right) + S_r = 6.5\ kPa$

Lowest Load on Terraces $S = I_s * (S_S * (C_b * C_w * C_s * C_a min) + S_r = 4.911\ kPa$

### 6.3 Loading Combinations

The load combinations applied to the structure were determined using The National Building Code (Part 4 of Division B) in conjunction with Professor Amgad Hussein's ENGI 8705 - Structural Building Systems class notes. For the structural analysis, load combinations 1, 2, 3, and 4 of Table 4.1.3.2.A were considered. Case 5 was ignored, as the client specified that seismic loading should not be considered.

**Table 5: Load Combination Cases**

| Case | Load Combination | |
|---|---|---|
| | Principal Loads | Companion Loads |
| 1 | 1.4**D** | |
| 2 | (1.25**D** or 0.9**D**) + 1.5**L** | 0.5**S** or 0.4**W** |
| 3 | (1.25**D** or 0.9**D**) + 1.5**S** | 0.5**L** or 0.4**W** |
| 4 | (1.25**D** or 0.9**D**) + 1.4**W** | 0.5**L** or 0.5**S** |
| 5 | 1.0**D** + 1.5**E** | 0.5**L** + 0.25**S** |

For each case, separate combinations were considered for each companion load. Whenever wind load was considered in a load combination (as either a principal or companion load) it was considered in each cardinal direction, thus four variations of each combination with were considered. For case 4 (where wind acts as a principal load), situations where the wind would provide an overturning force were also considered and thus the factor applied to the dead load was reduced from 1.25 to 0.9.

A total of 27 load combinations were used in the structural analysis, as shown in Table 6.

**Table 6: Load Combinations used in structural analysis**

| Comb. No. | Comb. Description |
|---|---|
| 1 | 1.4D |
| 2 | 1.25D + 1.5L + 0.5S |
| 3 | 1.25D + 1.5L + 0.4Wnorth |
| 4 | 1.25D + 1.5L + 0.4Wsouth |
| 5 | 1.25D + 1.5L + 0.4Weast |
| 6 | 1.25D + 1.5L + 0.4Wwest |
| 7 | 1.25D + 1.5S + 0.5L |
| 8 | 1.25D + 1.5S + 0.4Wnorth |
| 9 | 1.25D + 1.5S + 0.4Wsouth |
| 10 | 1.25D + 1.5S + 0.4Weast |
| 11 | 1.25D + 1.5S + 0.4Wwest |
| 12 | 1.25D + 1.4Wnorth + 0.5L |
| 13 | 1.25D + 1.4Wsouth + 0.5L |
| 14 | 1.25D + 1.4Weast + 0.5L |

| | |
|---|---|
| 15 | 1.25D + 1.4Wwest + 0.5L |
| 16 | 1.25D + 1.4Wnorth + 0.5S |
| 17 | 1.25D + 1.4Wsouth + 0.5S |
| 18 | 1.25D + 1.4Weast + 0.5S |
| 19 | 1.25D + 1.4Wwest + 0.5S |
| 20 | 0.9D + 1.4Wnorth + 0.5L |
| 21 | 0.9D + 1.4Wsouth + 0.5L |
| 22 | 0.9D + 1.4Weast + 0.5L |
| 23 | 0.9D + 1.4Wwest + 0.5L |
| 24 | 0.9D + 1.4Wnorth + 0.5S |
| 25 | 0.9D + 1.4Wsouth + 0.5S |
| 26 | 0.9D + 1.4Weast + 0.5S |
| 27 | 0.9D + 1.4Wwest + 0.5S |

# 7 DESIGN METHOLODOGIES

This section reviews the methodologies considered when completed all aspects of design of the building. Detailed design calculations can be found in Appendix D.

## 7.1 Slab on Grade design

A slab-on-grade (SOG) was designed for the first storey of the building. A 150 mm thick slab was chosen based on typical industry designs. The slab-on-grade was not responsible for carrying any of the loads from the upper stories since these loads would be transferred directly from the beams and columns to the spread and wall footings located below. It was assumed that the 200 kPa bearing strength of the soil directly underneath the slab was sufficiently stiff enough to carry any live or dead loads felt on the first floor. Given these conditions, the slab-on-grade was designed to resist shrinkage effects only; appropriate minimum reinforcement using welded wire reinforcement (WWR) chosen according to the Concrete Design Handbook and the Welded Wire Reinforcement Guide. The WWR provides the required strength and is easier to install.

Minimum area of steel was calculated to be 300 mm². Top and bottom reinforcing was specified with each row having a minimum steel area of 150 mm². Given a maximum spacing of 450 mm, a minimum area of steel of 22.8 mm² and 7 bars per 1 meter width,

a 150 mm concrete slab with 152x152 – MW25xMW25 welded wire mesh each way was chosen for design.

The ground beneath the SOG would require proper compaction to minimize undesirable settling patterns and cracking.

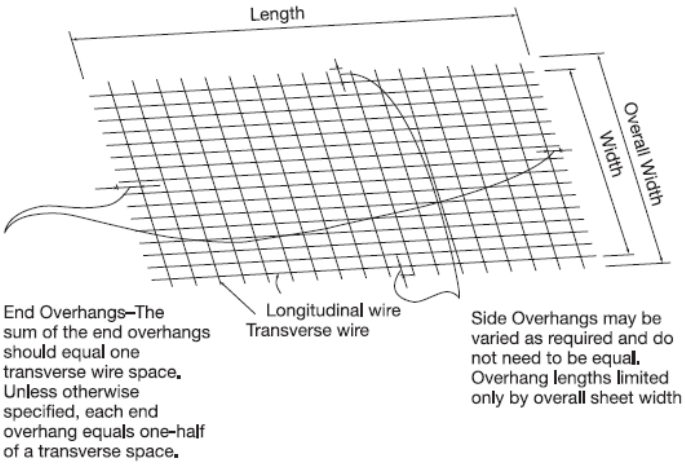



**Figure 4: Welded Wire Mesh Nomenclature (Source: Wire Reinforcement Institute)**

Strata referenced ACI 302.1R to determine a suitable contraction joint spacing distance; these cuts reduce the potential of cracking in the slab. Saw cut joints, most commonly made along the column lines, are intended to regulate localized cracking. Isolation/expansion joints are located around the perimeter of the slab as well as around the columns and assure that settlement or movement from these members does not adversely affect slab-on-grade quality. Joints spaced to create square patterns are preferred, although not always practical given the location of the columns lines. In instances where square sections are not possible, a long to short length ratio between 1.25 and 1.5 should not be exceeded. For purposes of this building, the team designed a saw cut spacing which adhered to the common ASI convention, between 24 and 36 times the slab thickness. This resulted in saw cut spacing ranging between 3600 mm and 5400 mm. With the various column spaces for the building, saw cuts along all column lines was sufficient, in addition to cuts midway between the longer 9210 mm spans throughout the interior of the slab; see Drawing 3 in Appendix A for clarity.

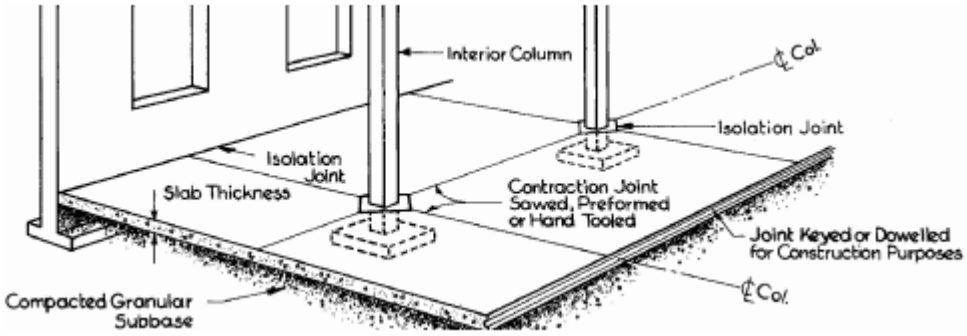



**Figure 5: Location and types of joint (Source: ACI 302.1R)**

AutoCAD drawings were completed for the slab on grade design.These drawings included a plan view of the slab compete with isolation joint and saw cut joint locations with respect to the column lines. Section views of the plan were also included in the package that showed the slab thickness, and details of the welded wire mesh and the joints.

## 7.2 Roof Design

### *7.2.1 Steel Decking*

Standard steel decking from Canam was recommended by Morrison Hershfield to be a suitable roofing material for the building. The steel deck would transfer the gravity loads on the building to the steel joists underneath. The steel deck would also act as a diaphragm, transferring the lateral loads to the structural members of the system. To ensure diaphragm action, proper connections between the deck and joists, as well as between the joists and girders, must be ensured. Canam would provide the specific model of decking required from the gravity loads provided to them by the structural engineer. For the purposes of the project, the team presented different loading combinations based on dead, live, and snow loads on the roof. It should be noted that the load contributions due to the mechanical equipment were not included in the steel decking design; instead, a frame was designed around the opening of the mechanical equipment to transfer these loads directly to the joists; see section 6.6.3.

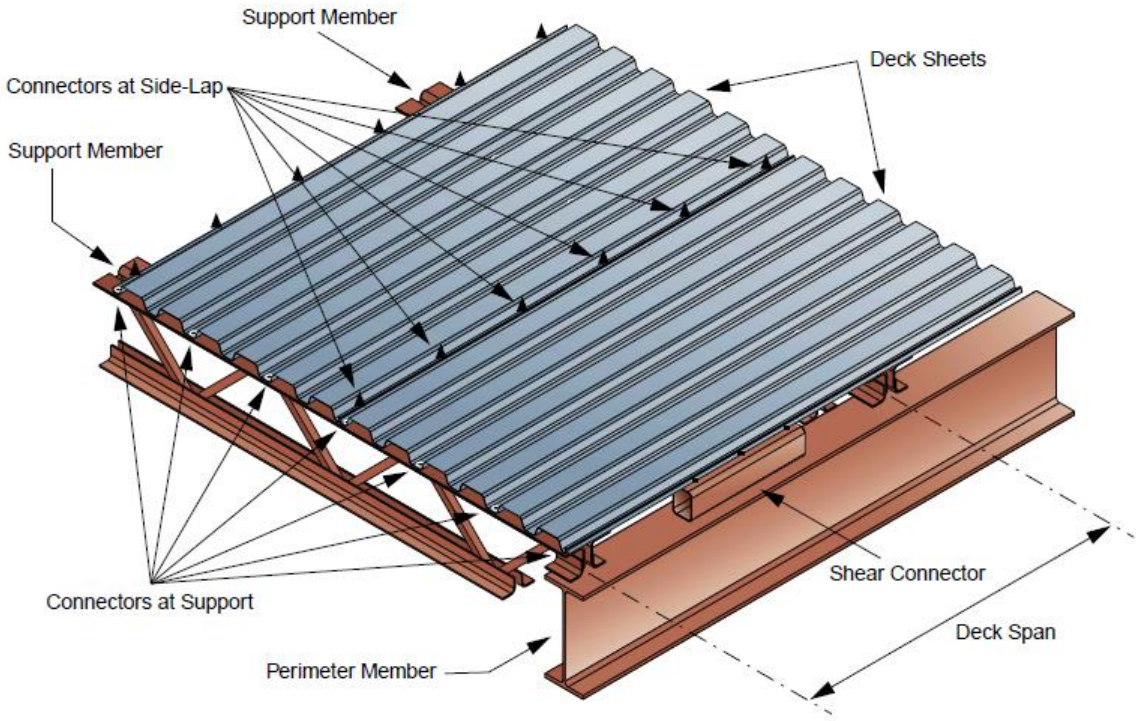
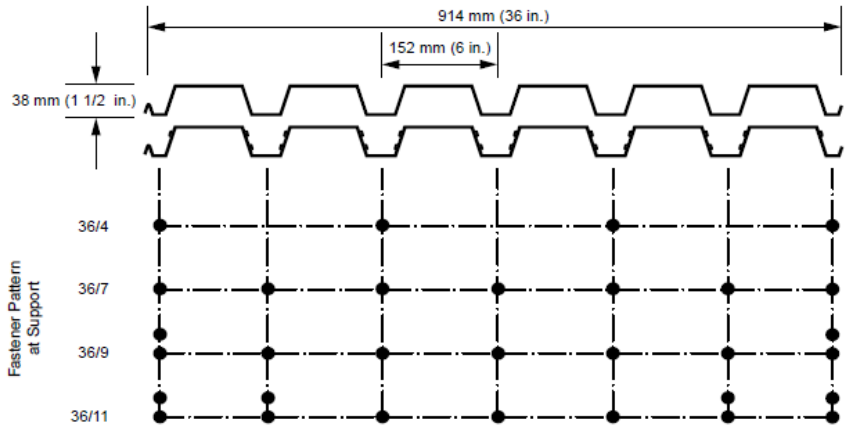



**Figure 6: Steel deck layout complete with Open-web steel joists (Source: Canam)**

Neglecting the roof equipment, the loads on the roof were applied in 1 meter strips. S-Frame was used to determine the maximum moment on each deck span and the equation $M=wl^2/8$ was used to find a value for the equivalent distributed load on the deck. The worst case service and factored loads were calculated to be 5.13 kPa and 6.55 kPa, respectively. Given a 1500 mm span and these loads, a type 18 P-3615 steel with a 1.21 mm thickness and 38 mm depth was deemed suitable. This deck was called up in the AutoCAD drawings pending final selection from Canam.

**P-3615 & P-3615 COMPOSITE**




**PHYSICAL PROPERTIES**

| Type | Nominal Thickness | Overall Depth | Weight | Gross Moment of Inertia |
|---|---|---|---|---|
| | mm (in.) | mm (in.) | kg/m² (lb./ft.²) | mm⁴/m (in.⁴/ft.) |
| 22 | 0.76 (0.030) | 37.4 (1.47) | 8.50 (1.74) | 228 227 (0.1671) |
| 20 | 0.91 (0.036) | 37.5 (1.48) | 10.07 (2.06) | 272 365 (0.1994) |
| 18 | 1.21 (0.048) | 37.8 (1.49) | 13.26 (2.72) | 364 468 (0.2669) |
| 16 | 1.52 (0.060) | 38.1 (1.50) | 16.34 (3.35) | 452 803 (0.3316) |

**Figure 7: Recommended deck size. (Source: Canam)**

### *7.2.2 Open-web Steel Joists*

The open-web steel joists (OWSJ) were also specified using the Canam guides. These structural components are used to transfer loads on the roof to the beam and column elements. Strata provided numerical values for a uniformly distributed load on the roof to be supported by the joists. Strata accounted for the dead loads due to the roof assembly, the OWSJ self weight, the 1.0 kPa live load and the worst case snow load of 3.76 kPa (area of the max drifting near equipment). Loads due to wind were checked, but were non-governing. The factored and unfactored governing design values for loads on the joist loading were 8.34 kN/m and 10.72 kN/m, respectively.

$$\begin{aligned} FACTORED\ LOAD &= 1.25D + 1.5S + 0.5L \\ &= 1.25(1.09) + 1.50(5.73) + 0.5(1.52) \\ &= 10.72\ kN/m \end{aligned}$$

Using the Canam selection table for a 10 m span, an appropriate joist with a depth of 750 mm, a mass per unit length of 18.3 kg/m and with 90% of the service load producing a deflection of L/360 was chosen; see Figure 8. Note that the final joist selection would be pending on final review and approval by a Canam structural engineer. This joist selection would not only provide the necessary support, it would also mount within the allowable 1455 mm of space provided in the architectural drawings.

| Span | Joist Depth | Factored load (kN/m) Service load (kN/m) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **4.5** 3.0 | **6.0** 4.0 | **7.5** 5.0 | **9.0** 6.0 | **10.5** 7.0 | **12.0** 8.0 | **13.5** 9.0 | **15.0** 10.0 | **16.5** 11.0 | **18.0** 12.0 | **19.5** 13.0 | **21.0** 14.0 | **22.5** 15.0 |
| (m) | (mm) | | | | | | | | | | | | | |
| 10 | 500 | 11.6 66 | 13.5 65 | 16.8 64 | 18.2 65 | 21.8 65 | 24.7 64 | 31.5 64 | 33.1 64 | 33.6 64 | 37.0 65 | 42.0 68 | 45.5 69 | 45.5 64 |
| | 550 | 10.5 70 | 13.3 68 | 13.9 68 | 15.6 65 | 18.4 65 | 20.2 63 | 24.6 65 | 28.3 65 | 28.3 64 | 30.0 64 | 33.3 64 | 36.1 67 | 38.4 64 |
| | 600 | 11.1 83 | 13.2 77 | 13.6 76 | 14.4 70 | 17.2 71 | 18.8 69 | 21.8 67 | 23.9 65 | 24.8 67 | 26.4 65 | 28.6 64 | 31.7 65 | 35.2 68 |
| | 650 | 11.8 132 | 13.4 112 | 13.7 89 | 14.2 83 | 16.0 78 | 17.8 76 | 20.7 74 | 22.7 72 | 23.2 72 | 25.3 73 | 27.0 69 | 28.9 70 | 31.8 72 |
| | 700 | 11.9 153 | 13.5 14 | 13.8 104 | 14.3 87 | 15.4 85 | 17.2 85 | 19.9 81 | 22.3 80 | 22.3 76 | 24.8 83 | 25.2 75 | 26.7 75 | 29.9 80 |
| | 750 | 12.1 177 | 13.6 133 | 14.0 120 | 14.4 100 | 15.7 95 | 16.8 98 | 18.3 90 | 19.9 90 | 21.6 87 | 23.1 88 | 25.0 88 | 26.5 89 | 28.3 87 |
| | 800 | 12.3 200 | 13.7 172 | 14.1 137 | 14.5 114 | 16.0 98 | 17.1 95 | 19.3 100 | 21.9 96 | 21.9 93 | 22.9 95 | 24.1 93 | 26.0 94 | 27.4 93 |

**Figure 8: Canam Table for 10 meter span Open Web Steel Joists**

## 7.3 Elevated Slab Design

The second and third stories of the building required the design of elevated slabs to carry the loads of each respective floor. These two elevated slabs were designed as a concrete slab poured in a composite steel deck complete with welded wire mesh reinforcement. Strata again used the Canam guides to determine a suitable deck and concrete depth and an appropriate welded wire mesh size to resist shrinkage effects.

### *7.3.1 Composite Steel decking*

Given the 1500 mm span and an assumed thickness of 100 mm, a 0.76 mm thick P-3615 composite deck was chosen from Canam. This selection was made based on the summation of the factored dead and live loads of 9.51 kPa; the factored resistance of the deck of 20 kPa, sufficiently large to resist this load.

The steel deck was assumed to provide necessary resistance against bending and deflection. Therefore the concrete was designed for temperature and cracking, so

minimum reinforcement was used. Minimum reinforcement would be 0.002 times the gross area of concrete; calculated as 200 mm² with a cover of 30 mm. From Table 7M of the Structural Welded Wire Reinforcement code, 152 mm welded reinforcement was used with 7 bars per 1 meter width of slab. The area of steel per bar required was 30.4 mm², therefore MW35 bars were used. In summary, the 100 mm concrete slab was reinforced with 152x152 MW-35xMW-35 welded wire mesh running in each direction.

#### *7.3.2 Open-Web Steel Joists*

The dead loads resisted by the open-web steel joists were transferred from the composite steel deck. The loads transferred were the weight of concrete and the self weight of the deck itself; with a combined value of 1.85 kPa taken from the composite steel deck tables provided by CANAM. The live load was taken as 4.8 kPa based on requirements for retail space. The dead and live loads were transferred to the joists over a tributary width of 1.524 m based on joist spacing. The governing service and factored load were 10.39 kN/m and 14.82 kN/m, respectively.

$$SERVICE\ LOADS = (2.82 + 0.25) + 7.32 = 10.39\ kN/m$$

$$FACTORED\ LOADS = 1.25 * (2.82 + 0.25) + 1.5 * (7.32) = 14.82\ kN/m$$

For a 10 m span, 750 mm depth joists were selected from the CANAM tables with a mass per unit length of 21.6 kg/m and with 87% of the service load producing a deflection of L/360: see Figure 8. A 700 mm deep joist, with a mass per unit length of 22.3 kg/m and with 76% of the service load producing a deflection of L/360, was chosen between gridlines A & B and H & J on the third storey of the building where architectural design limited the available room for the 750 mm joist.

### 7.4 Structural Modeling in S-Frame

The structural modeling of the building in S-Frame began by placing nodes along the major gridlines from the client-provided architectural drawings. These nodes would represent the beam-column intersection points. The team then connected the nodes to complete the framing for the beams and the columns.

#### *7.4.1 Lateral Load Resistance*

The concrete shear cores were not modeled. Instead, the shear cores were simulated by a series of beams and columns with cross-bracing in each bay. The cross-bracing was used to provide the necessary lateral support for the structure. In S-Frame, the cross-bracing was modeled using truss members as shown below. The steel members simulating the shear core were chosen to be sufficiently large so that wind loads would not cause issues with stability of the lateral load resisting system.

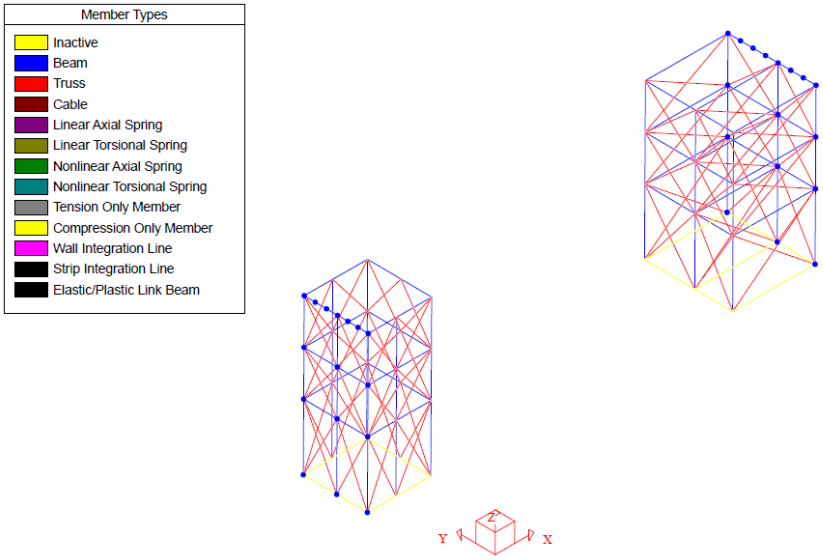



**Figure 9: Shear cores as modeled in S-Frame**

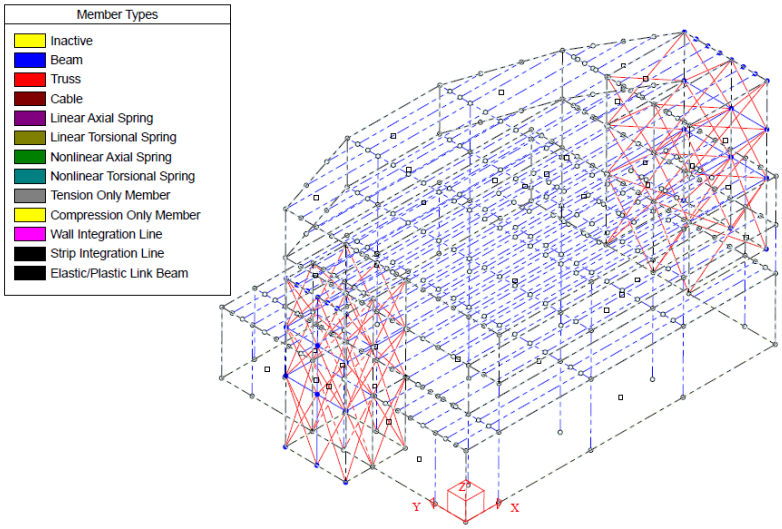



**Figure 10: Isometric view of building including simulated shear cores**

### *7.4.2 Connection Releases*

All members had end moments released to ensure no capacity for moment resistance came from the beam-column framing. This allowed the shear cores to provide all of the lateral stability required for the building. The only locations where releases were fixed were:

- The shear core;
- The cantilevered portion of the third floor. The main beams holding up the cantilevered portion were set to act continuously over the joints circled below:

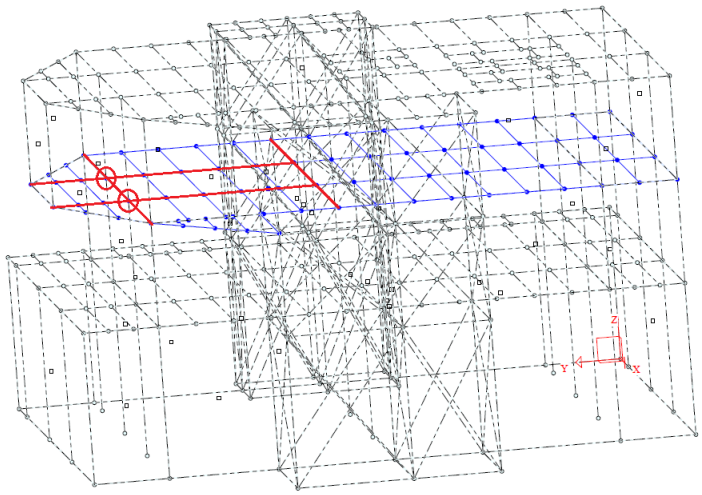



**Figure 11: Fixed releases for the cantilevered portion of the third floor. The same supports are fixed at the roof level.**

### *7.4.3 Open-web Steel Joists*

Open-web steel joists were not modeled. To accurately reflect the load transfer from roof decking to the joists and into girders, members were placed at the joist locations using the S-Frame “Add Floor Joist” tool. The girders were modeled using the “physical members” tool in S-Frame, which prevented them from being split into individual members at each point where they were intersected by joists.

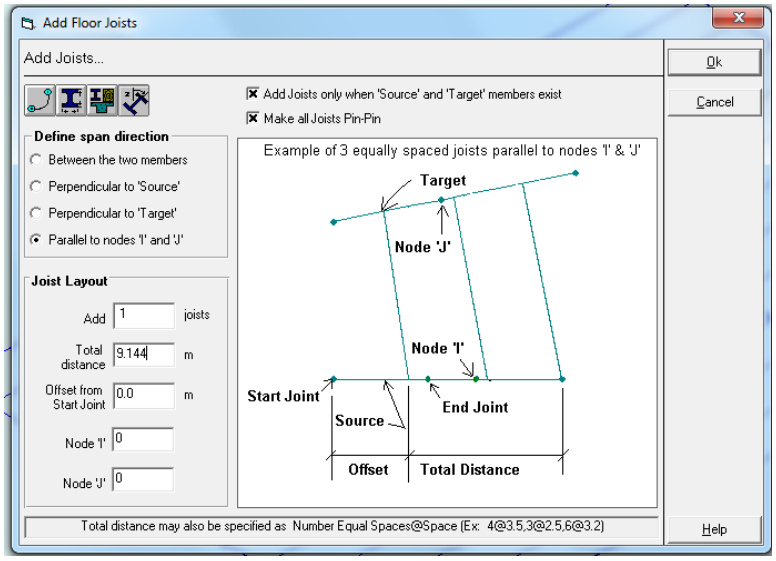



**Figure 12: S-Frame joist tool**

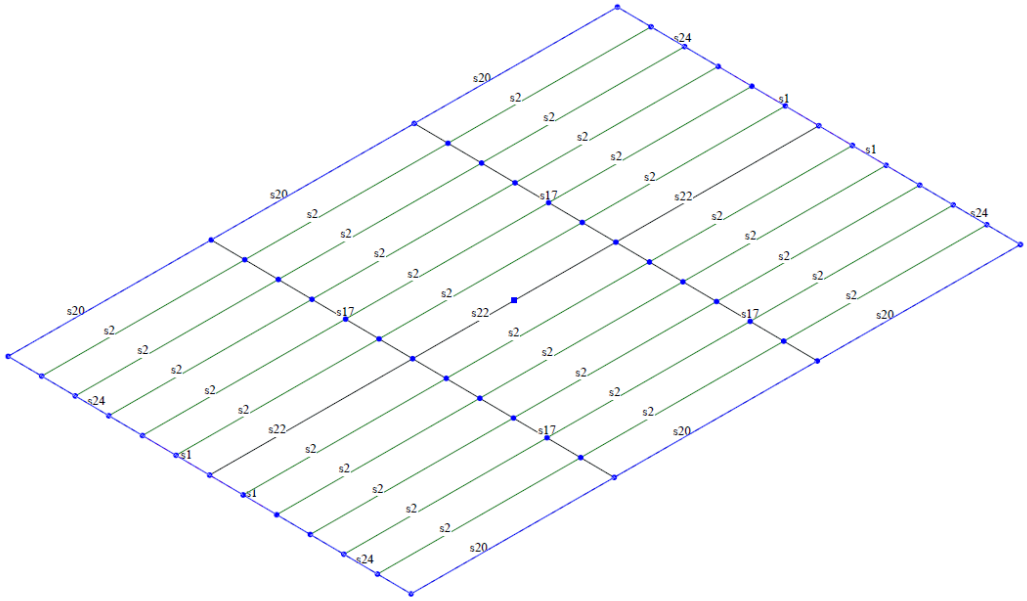



**Figure 13: Joists are represented by section s2 in the S-Frame model**

To accurately simulate the dead weight of the open-web steel joists, placeholder members were selected with a mass similar to that of the joists. The actual joists in the structural drawings were designed using CANAM tables as detailed in sections 7.2.2 and 7.3.2.

### *7.4.4 Infill Steel*

Locations for infill steel were determined by observation. In specific areas where the roof deck was supported by infill steel instead of joists, member locations were selected using deck span criteria. The locations for infill steel were reviewed and updated based on the results from S-Steel

### *7.4.5 Panels and Area Loads*

The team split the various faces and levels of the building into panels. Load transfer directions were determined and area loads were applied to the appropriate locations of the building. Any loads that could not be applied directly to panels were converted by hand into uniformly distributed loads and applied to the appropriate locations on the building.

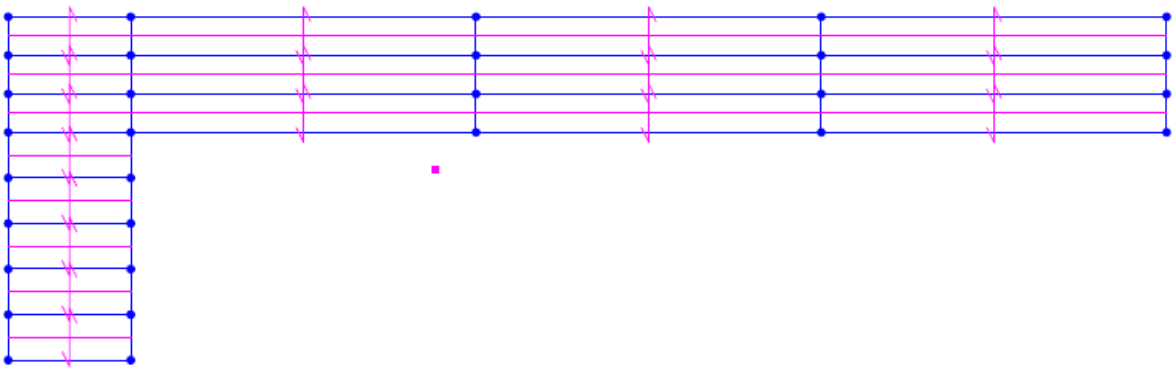


**Figure 14: Plan view of the north terrace panel**

The load transfer direction was chosen as one-way in the short direction for every case except the wall panels. In practice, girts will transfer the wall loads directly to the columns. However, girts were not modeled onto the structure. To simulate the transfer of wall loads from girts directly into columns, the load transfer direction for wall panels was changed from the default option of one-way load transfer in the short direction to one-way load transfer to the left and right edges of each panel as shown in Figure 15.

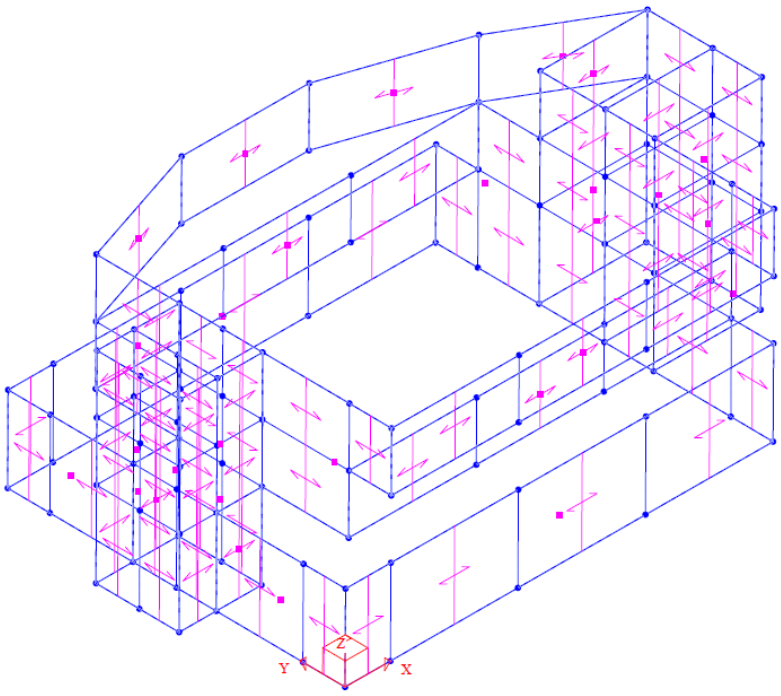



**Figure 15: One-way load transfer from wall panels into columns**

### *7.4.6 Issues*

S-Frame presented new challenges for the group as unfamiliarity resulted in difficulty modeling the building. Initially, many of the core concepts used in S-Frame modeling such as area loading and load distribution were foreign and confusing, but these challenges were quickly overcome through discussion with Amgad Hussein, contact with S-Frame customer support, and utilization of the available online tutorials.

A major error was encountered after placing the infill steel in the model. The structure could not be analyzed due to an error involving zero length members that prevented the software from compiling a stiffness matrix. The team spent some time troubleshooting this issue with the help of Dr. Amgad Hussein and S-Frame customer support. S-Frame support provided the final solution with the integrity check tool, which could be used to automatically remove any elements causing issues when running analysis. It was later discovered that these zero length members were created unintentionally when the joist tool was used between two members that formed a triangle with one node in common.

## 7.5 Steel Design

The majority of steel design was completed using the S-Frame model. When integrated with the S-Steel design package, the required beam and column sizes could be determined. See Appendix E.

### *7.5.1 Beams*

S-Steel was the primary tool used to design the beams within the structure. After analyzing the structure in S-Frame, S-Steel was used to select appropriate steel sections to meet bending, shear, and deflection limit criteria. S-Steel would initially choose an optimal section for each individual member, at which point the team would review the selections and choose one section to apply to similar members for simplicity of design. The team would then assign the selected sections in S-Frame and run S-Steel again to perform code checks as a means of ensuring that all members were not over-utilized or under-utilized to the point that different sections should be selected.
This was an iterative process and was carried out on small groups of beams at a time, floor by floor. In an attempt to ensure accurate design, the beams were designed in the order that the team observed to represent load transfer. First the beams and infill steel spanning the same direction as the joists were designed, followed by the exterior beams, and finally the girders supporting the open web steel joists. This process was carried out first on the roof, then the third floor, and finally the second floor. In the case of the roof, framing around the mechanical equipment was designed first. The rationale and process for this design is detailed in Section 7.5.3

One additional step taken to ensure accurate member sizing and to prevent overdesign was to update the unbraced length of all girders that had joists or infill steel framing into them. Assuming adequate connection of the steel deck to the joists, as well as adequate connection from the joists to the girders, it could be assumed that these girders were braced in specific locations along their length, preventing their moment capacity from being reduced due to lateral torsional buckling.

The following members were utilized as beams in the structural model. For each group of similarly sized members, the governing member and corresponding information (including clause, load case, and utilization) has been tabulated below:

**Table 7: Code checks for each group of beams in S-Steel**

| Steel Section | Governing Clause | Load Case | Bending Check | Shear Check | Alternative Check |
|---|---|---|---|---|---|
| W530X150 * | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.724 | 0.241 | |
| W530X123 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.715 | 0.159 | |
| W530X92 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.779 | 0.188 | |
| W530X82 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.281 | 0.08 | |
| W530X72 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.693 | 0.219 | |
| W460X113 * | Bending + Lateral Torsional Buckling | Comb 12, 1.25D + 1.4Wnorth + 0.5L | 0.127 | 0.021 | 0.994 |
| W410X100 * | Bending + Lateral Torsional Buckling | Comb 12, 1.25D + 1.4Wnorth + 0.5L | 0.223 | 0.044 | 0.823 |
| W410X60 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.626 | 0.034 | |
| W410X54 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.609 | 0.202 | |
| W410X39 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.451 | 0.128 | |
| W410X39 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.281 | 0.08 | |
| W360X72 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.473 | 0.059 | |
| W360X64 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.859 | 0.38 | |
| W360X45 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.256 | 0.037 | |
| W360X33 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.588 | 0.045 | |
| W310X86 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.789 | 0.171 | |
| W310X67 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.881 | 0.116 | |
| W310X31 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.959 | 0.389 | |
| W310X21 * | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.556 | 0.076 | |

### *7.5.2 Columns*

The columns were also designed using S-Steel software, using a slightly different approach. The idea of grouping similar columns together and applying the same section to each was used, but the initial S-Steel design was carried out on all columns at once. The team then selected preliminary member sizes to apply to each column group, and performed a code check in S-Steel to ensure all sections were appropriate on the first level of the structure, where columns would need to be the largest.

For the second and third levels, smaller sections with the same depth were chosen in order to provide more optimal utilization while still carrying through part of the column geometry from the first level. An exception to this scenario was found in the columns taking the load transfer from the cantilevered section on front of the structure. These members were not reduced in size due to higher forces from this particular load transfer.

The following members were utilized as columns in the structural model. For each group of similarly sized members, the governing member and corresponding information (including clause, load case, and utilization) has been tabulated below:

**Table 8: Code checks for each group of columns in S-Steel**

| Steel Section | Governing Clause | Load Case | Utilization |
|---|---|---|---|
| W250x131 | Compression + Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.978 |
| W250x115 | Compression + Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.667 |
| W250x89 | Compression + Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.638 |
| W250x67 | Compression + Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.776 |
| W250x58 | Compression | Comb 2, 1.25D + 1.5L + 0.5S | 0.907 |
| W250x45 | Compression + Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.667 |
| W250x33 | Slenderness | N/A | 0.912 |
| W250x24 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.59 |
| W200x59 | Bending | Comb 2, 1.25D + 1.5L + 0.5S | 0.877 |
| W200x46 | Compression | Comb 2, 1.25D + 1.5L + 0.5S | 0.113 |
| W200x21 | Bending | Comb 7, 1.25D + 1.5S + 0.5L | 0.785 |

Upon detailed analysis of the columns, it was determined that the use of small sections (W200 and W250) made the columns particularly susceptible to small amounts of bending. Some of the smaller columns were governed by bending, and the compression capacity of some of the larger columns was also reduced due to bending. However, the weight savings available by switching to larger column sections (W360 or higher) was not sufficient to warrant redesign.

### *7.5.3 Framing around roof equipment*

The loads on the roof due to the mechanical equipment governed in the design of steel deck and open-web steel joists. Rather than over-design all of the deck and joists, infill steel was provided to frame in the roof equipment. To ensure that the mechanical equipment is fully supported, beams were designed around the opening of each piece of equipment to transfer the loads to the beams and girders. The layout of these beams is included in the roof plan drawing.

## 7.6 Foundation Design

The primary purpose of the structural system of a building is to transfer loads from their point of origin to the ground, where they can be safely distributed. The portion of the structural system that directly distributes these loads to the ground is the building

foundation. Foundations receive loads from the superstructure of the building, primarily through the columns and walls. These loads are then spread out so as not to exceed the safe capacity of the underlying soil. In order for foundations to provide this function, they must meet minimum design requirements such as required widths, depths, and reinforcing steel.

As stated in Section 5.4, Strata did not receive a comprehensive geotechnical report on the soil conditions at the building site. An allowable bearing pressure of 200 kPa was therefore assumed and used in the calculations. The water table was assumed to be below the frost line, and posed no concern to the design. All footings have a 1.6 m depth to allow for adequate frost protection.

The loadings applied on the footings through the first floor columns were determined through S-FRAME analysis. Figure 16 depicts the factored axial load values for the governing load case of 1.25D + 1.5L + 0.5S. Service dead, live, and snow loads were also determined and used in calculations.

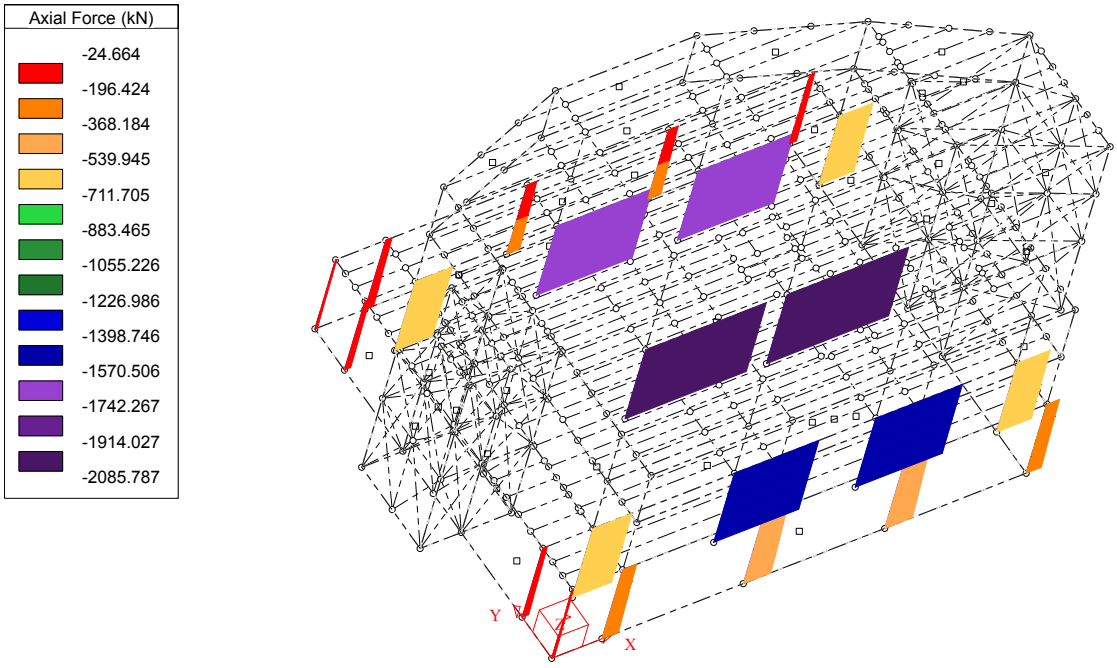



**Figure 16: Factored axial loads applied on the first floor columns**

There are eight interior spread footings located on the building foundation. These footings received the highest axial loads from the superstructure, largely due to the transfer of mechanical equipment load from the roof. A common design was used for the interior footings, and was governed by the largest interior axial load of approximately

2086 kN. The footings were determined to be 3.2 m x 3.2 m x 600 mm with 400 mm x 400 mm piers. 25M rebar was used to provide reinforcement, and 15M dowels were designed at the connection between the footing and the pier.

A common design was also used for the exterior spread footings, and was governed by the largest exterior axial load of 712 kN. In addition to axial loads, it was determined that shear forces were being applied to the tops of the piers due to the wind loading on the first floor girts. This shear force caused a small moment on the footing, which was considered when design was being completed. The footings were determined to be 1.8 m x 1.8 m x 400 mm with 350 mm x 350 mm piers. 20M rebar was used to provide reinforcement, and 15M dowels were designed at the connection between the footing and the pier.

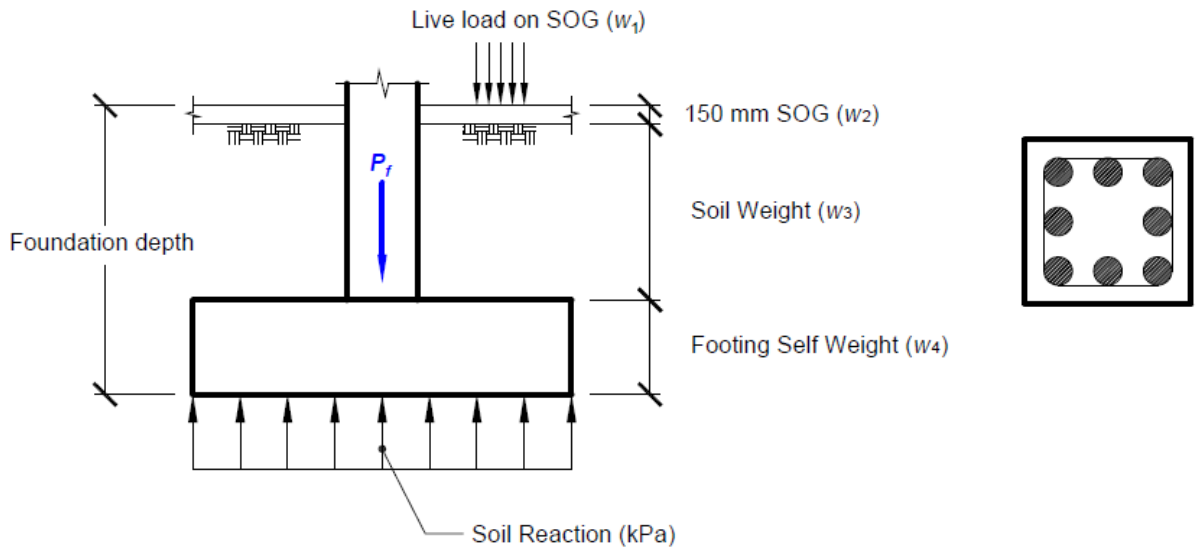



**Figure 17: Design Considerations for Spread Footings**

Wall footings were designed to provide a foundation for the concrete shear cores. Although it was not within Strata's scope of work to design the shear cores themselves, loads that were transferred to them from the building system were determined. These loads, along with the approximated self weights of the cores, were then applied to the wall footings as distributed loads. The worst case distributed loads on the shear wall were 385 kN/m for the west shear core and 363 kN/m for the east shear core. The relatively similar load values resulted in a common wall footing design with a width of 1.6 m and a depth of 300 mm. 15M rebar was used to provide reinforcement, and 15M dowels were designed at the connection between the footing and the foundation wall.

An exterior wall footing was used to support and distribute the load of the 94 mm clay brick facing that surrounds the exterior of the building. This load was determined to be 13 kN/m. Upon calculation of the required footing width, it was clear that the loading due to the brick was very minimal, and only minimum footing design was necessary. The footing has a width of 1.3 m and a depth of 200 mm. 15M rebar was used to provide reinforcement, and 15M dowels were designed at the connection between the footing and the foundation wall. Although, it distributes a relatively insignificant load, the exterior wall footing is still useful as it provides frost protection around the perimeter of the building.

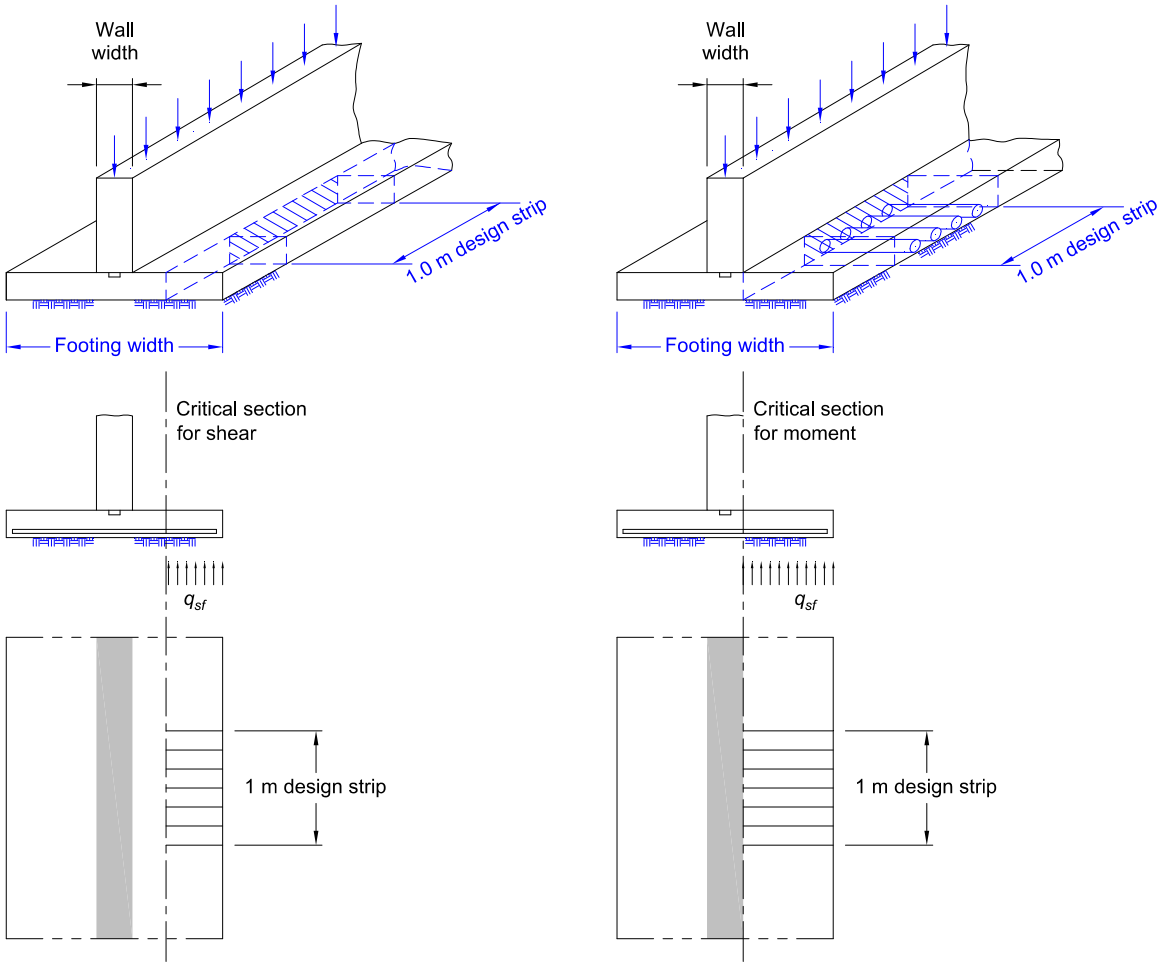



**Figure 18: Design Considerations for Wall Footings**

### *7.6.1 Base Plates*

Steel base plates were designed at for each column for load transfer into the piers. For simplicity, base plates were designed only for the worst case interior and exterior columns and those plates were applied at each interior and exterior column. The design was carried out using CSA S16-09 specifications for column base plates.

The governing factors of the design are the factored axial load of the column and the concrete pier compressive strength. The axial load of the column was assumed to transfer uniformly across the base plate in order to not overload the concrete pier at a specific point and instead distribute evenly. Using the axial force and compressive strength, the required area for this load distribution could be determined. This area was then used along with the dimensions of the steel column to determine the size of the plate. As a construction detail, extra length past the edge of the columns was provided for welded or bolted connections.

The thickness of the plate is based on the length of plate extending past the column edge. This extra length of plate is assumed to act as a cantilever, and the factored moment on this portion is used to determine plate thickness required to provide adequate moment resistance. In addition, the thickness should not be less than 1/5 of the cantilever length in order to minimize deflections. See AutoCAD detail below for sizing.

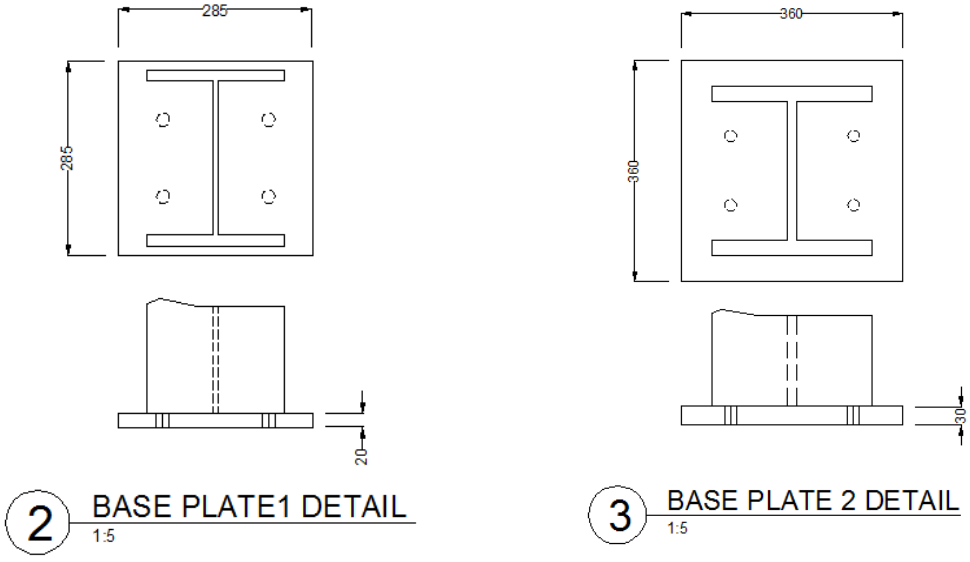



**Figure 19: Base Plate Details**

### *7.6.2 Anchor Rods*

Anchor rods were designed for the base plates according to CSA S16-09. The listed design criteria states that anchor rods are not required for base plates attached to concentrically loaded columns, as there are no end moments or horizontal forces. This criteria was deemed to be appropriate for the base plates present. However, S16-09 also states that at least 4 anchor rods must be present as a means of leveling the base plate, locating the column base, and resisting nominal end moments and horizontal forces which may occur. ¾" anchor rods were selected for this purpose.

These rods were additionally checked for pull-out resistance. Full anchorage is obtained when the factored pull-out resistance of the concrete is greater than the factored tensile resistance of the rods provided. This criterion was checked using S16-09 to determine tensile resistance, as well as A23.3-04 to determine concrete pull-out resistance.

## 7.7 Entrance Canopy

A small canopy was included in architectural drawings above the main entrance of the building. The canopy was measured to extend approximately 2.5 m from the building face on each side of one of the buildings corners, with a length of 7 m on one face and 8 m on the other.

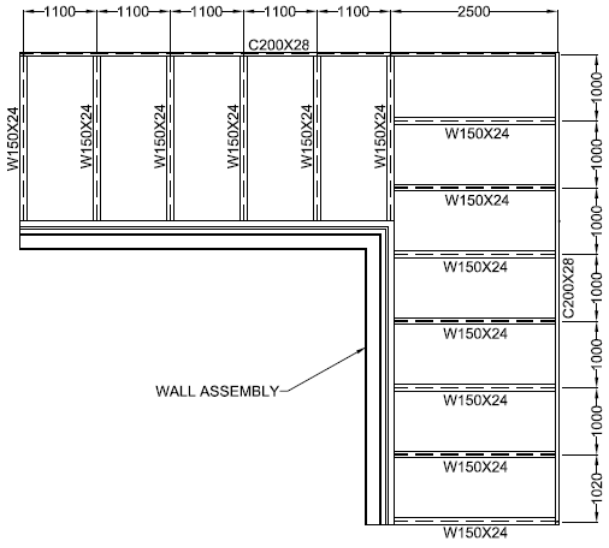



**Figure 20: Canopy Plan View**

The steel framing and tension members for the canopy above the building entrance were designed by hand calculations using conservative approximations. Materials for the canopy were not specified, so the dead load was assumed to be the same 0.55 kPa as the roof assembly. The snow drift on the canopy was conservatively assumed to be the same distribution as that of the second level terrace.

Due to the relatively small geometry of the canopy, very small members were assumed to be used, and as such small spacing (approximately 1m on each side) was used for design. The load supporting members were designed as simply supported, spanning between the wall of the building and a supporting exterior member at the outer edge of the canopy. This exterior member was to be supported by tension members attached to the wall of the building at a 45 degree angle.

For simplicity of design a worst case interior beam was selected from each side of the canopy to be the typical design member for that section. The load patterns were determined manually and applied in S-Frame to determine the maximum moment in the simply supported beams. The reactions at the end supported by the exterior beam were also recorded. W150x24 was selected to resist the moment by using the beam selection tables in S16-09.

The edge members were also modeled in S-Frame, but the only loads applied were the point loads caused by the reactions of the interior beams. The supports were placed at the locations where tension members would be located. The maximum moment in the section was used in conjunction with the beam selection tables to select an appropriate section. In addition, for the edge beams a C200x28 was selected for aesthetic reasons.
The support reactions of the edge members were then taken to represent the vertical component of the force in the tension members. The largest reaction was chosen to govern design, and was applied instead along the axis of the tension member using trigonometry. The tension members were then designed as steel rods sufficient to resist the tension force using Cl. 13.2. 20mm rods were selected.

## 8 COST ANALYSIS

Upon the request of the client, Strata completed cost estimates for all aspects of work related to steel, concrete, and earthworks design. This included the associated costs for materials, labour, and construction waste. Before costs were determined, Strata completed detailed quantity estimates for all of the aforementioned materials. Steel material encompassed all beams, columns, open web-steel joists, steel decking and all

steel hardware. The concrete quantities included the foundations; slab-on-grade and elevated slab quantity, as well as quantities for the concrete shear cores. Despite the fact that Strata was not required to design the shear cores, materials were determined based on some conservative assumptions. Detail excavation and backfill quantities were calculated for the spread footings and wall footings.

The total cost for the building was calculated to be **$1,365,000.00**. See Appendix F for a detailed line item cost estimate.

### 8.1 Concrete

To determine quantities for concrete work, the structural AutoCAD drawings were used alongside detail design sketches and architectural drawings.

For the slab on grade and elevated slabs, surface areas were scaled from the architectural drawings using Foxit .pdf reader software. Slab thickness was determined from hand calculations and Canam selection tables. This data was used to determine concrete volume as well as formwork and finish quantities. Rebar quantities were determined from hand calculations.

RS Means was used to determine an appropriate cost estimate based on prices in the St. John's area for the first quarter of 2013. RS Means capabilities allow the total cost of construction including all associated costs (labor, waste, formwork, etc.).

**Table 9: Concrete Costs**

| Location | Description | Quantity | Unit | Ext. Total | Ext. Total O&P |
|---|---|---|---|---|---|
| Elevated Slabs | Concrete | 163.3 | m3 | $ 38,542.98 | $ 42,482.69 |
| Elevated Slabs | Edge Forms | 120 | m | $ 984.00 | $ 1,484.40 |
| Elevated Slabs | Rebar | 1321 | m2 | $ 10,568.00 | $ 13,130.74 |
| Elevated Slabs | Concrete Finishing | 1321 | m2 | $ 6,221.91 | $ 9,247.00 |
| Foundations | Concrete | 204 | m3 | $ 48,237.84 | $ 53,168.52 |
| Foundations | Formwork, Piers | 12.8 | m2 | $ 1,260.67 | $ 1,767.68 |
| Foundations | Formwork, Spread Footings | 91.6 | m2 | $ 4,274.97 | $ 6,057.51 |
| Foundations | Formwork, Walls and Wall Footings | 530.8 | m2 | $ 36,667.66 | $ 47,097.88 |
| Foundations | Concrete Finishing | 1051 | m2 | $ 20,956.94 | $ 30,752.26 |
| Shear Cores | Concrete | 269 | m3 | $ 63,607.74 | $ 70,109.47 |
| Shear Cores | Formwork, Walls | 588 | m2 | $ 48,327.72 | $ 66,661.56 |
| Shear Cores | Formwork, Walls | 588 | m2 | $ 59,970.12 | $ 83,507.76 |

| | | | | | |
|---|---|---|---|---|---|
| Shear Cores | Formwork, Walls | 588 | m2 | $ 63,709.80 | $ 91,122.36 |
| Shear Cores | Concrete Finishing | 1763 | m2 | $ 35,154.22 | $ 51,585.38 |
| Shear Cores | Rebar | 30.9 | Met. Ton | $ 2,781.62 | $ 3,082.28 |
| Slab on Grade | Concrete | 125.6 | m3 | $ 29,699.38 | $ 32,735.13 |
| Slab on Grade | Edge Forms | 132 | m | $ 1,411.08 | $ 1,977.36 |
| Slab on Grade | Rebar | 1674 | m2 | $ 13,392.00 | $ 16,639.56 |
| Slab on Grade | Concrete Finishing | 837 | m2 | $ 4,243.59 | $ 6,344.46 |
| | | | | **$ 490,012.24** | **$ 628,954.00** |

## 8.2 Structural Steel

Strata used S-Steel to determine the quantity of steel required in metric tonnes. S-Steel capabilities allowed the team to ignore the weight of members that had been added to the model to simulate shear cores and joists, therefore only calculating the total weight of the structural members being quantified. These quantities were again entered into RS Means to determine an appropriate estimate based on labour, waste, and the local market conditions and availability. The group added an additional 15% to this mass to account for the weight of the miscellaneous connection bolts and plates.

**Table 10: Structural Steel Costs**

| Description | Quantity | Unit | Ext. Total | Ext. Total O&P |
|---|---|---|---|---|
| Structural Steel | 112.8 | Met. Ton | **$ 444,759.12** | **$ 590,990.78** |

## 8.3 Steel Decking

The steel decking quantity estimate was calculated by determining the area of material used on each of the floors and the roof. The area of the appropriately sized decks was entered into RS Means and a cost estimate including both labor and material was provided. This estimate is shown in Table 12.

**Table 11: Steel Decking Costs**

| Discipline | Location | Description | Quantity | Unit | Ext. Total | Ext. Total O&P |
|---|---|---|---|---|---|---|
| Steel | Elevated Slabs | Decking | 1321 | m2 | **$ 48,797.74** | **$ 63,275.90** |

### 8.4 Open-Web Steel Joists

The open-web steel joist quantities were calculated using the joist schedule and the structural drawings. The total length for each joist type was found, and these quantities were entered into RS Means. The cost estimate is shown in Table 13.

**Table 12: Open-Web Steel Joist Costs**

| Discipline | Location | Description | Quantity | Unit | Ext. Total | Ext. Total O&P |
|---|---|---|---|---|---|---|
| Steel | Steel Superstructure | Open-Web Steel Joists | 17.78 | Met. Ton | $ 40,901.11 | $ 57,856.48 |
| Steel | Steel Superstructure | Escalation Costs | 1 | | $ 8,180.22 | $ 8,986.72 |
| | | | | | **$ 49,081.33** | **$ 66,843.20** |

### 8.5 Earthworks

Detailed excavation and backfill will be carried out for foundation construction. Assumptions for earthworks quantities include:

- Excavation depth will be from the height of final grade down to the depth of sub-base material;
- One foot of clearance will be provided away from the edge of each side of footings to allow for sufficient working space;
- Excavations will be sloped away from footings at a 1:1 ratio.

Total costs for earthworks were calculated in RS Means and can be found in Table 14.

**Table 13: Earthworks Costs**

| Location | Description | Quantity | Unit | Ext. Total | Ext. Total O&P |
|---|---|---|---|---|---|
| Earthworks | Excavation | 1977 | m3 | $ 4,547.10 | $ 5,733.30 |
| Earthworks | Backfill | 1689 | m3 | $ 2,077.47 | $ 2,685.51 |
| Earthworks | Compaction | 1689 | m3 | $ 456.03 | $ 608.04 |
| Earthworks | Backfill - Structural Fill | 837 | m2 | $ 4,745.79 | $ 5,909.22 |
| | | | | **$ 11,826.39** | **$ 14,936.07** |

## 9 Internal Costs and Hours Worked

The internal costs to Strata throughout the project were minimal. The transportation cost for all meetings was less than $10.00 total. The costs associated with printing and the appropriate binding of the project plan, the final report and the structural drawings was

approximately $80.00. All costs were divided evenly amongst the group members as agreed upon in the original project plan.

Strata spent approximately 280 hours completing this project. This included structural design, modeling, structural drafting, weekly reports, meeting minutes, agendas, report writing and all other miscellaneous tasks. The majority of the time was dedicated to the structural design and drafting. The total hours devoted to certain tasks was greater than expected given the troubleshooting that was necessary with some unfamiliar undertakings. Time was spent referencing tutorial material for AutoCAD and S-Frame to assure that work was completed properly and efficiently. Team members periodically updated the "Hours Worked" spreadsheet with their hours worked broken down by category; a summary of this spreadsheet is shown below.

**Table 14: Task Duration**

| | **TASKS** | | | |
|---|---|---|---|---|
| | Drafting | Structural Modeling and Design | Administrative Tasks/Misc. Taks | Report Writing |
| Kathy Higgins | 35 | | 9 | 28 |
| Mark Reynolds | | 41 | 5 | 22.5 |
| Colin Gibling | 30 | 15 | 5 | 20 |
| Jake Tucker | | 56 | 5 | 13 |
| **TOTAL HOURS PER TASK** | **65** | **112** | **24** | **83.5** |

## 10 CHALLENGES AND LESSONS LEARNED

Besides be issues with modeling discussed in Section 7.4.6, Strata encountered other issues throughout the course of the project which resulted in delays and need for help; both via the client and Professor Hussein; these issues are summarized below.

### *1) Duration of Tasks*

From the challenges, the team realized that planning is a key component in completing every project. Schedules should be made realistic as possible and unfamiliar tasks should be discussed with individuals more familiar with those tasks to determine realistic schedules. For example, Strata's original timeline only allowed 4 days for the design of beams and columns; in reality, this task required ten days to complete due to unforeseen issues with S-Frame.

### *2) Familiarity with software*

The team initially lacked the background knowledge in S-Frame software. Many issues and inefficiencies could have been remediated if the team became better familiar with S-Frame prior to completing the structural model. The team realized this as the design continued and began to use online tutorials and educational resources to better familiarize them with the software.

### *3) Effective use of downtime*

Another issue with planning was making effective use of downtime. Early in the project, time waiting to start a new task should have been used to research future steps in the project. The group learned in the later weeks of the project to make use of all available time. For example, while waiting for the structural design of members to catch up to the drafting phase, the individuals responsible for drafting continued to work on the report and created spreadsheets to more easily complete the future foundation design task.

## 11 CONCLUSION

From the cumulative design calculations and analysis, Strata Solutions is confident that they have provided the client, Morrison Hershfield, with a viable structural design for the three-storey orthodontic clinic.

The cost estimate was carried out using well-established methods in the construction industry and represents the overall cost to carry out the structural scope of work for the project. Strata is confident that this price can be used in making major project decisions.

All structural design was in accordance with the National Building Code of Canada 2010 and all calculations were carried out in accordance with appropriate national design codes. The drawings in Appendix G detail the results of the structural design process. These drawings are complete and represent the details of the structural system as selected and designed by Strata Solutions. They may be issued to the prime contractor after a final review by a professional engineer.

## 12 ACKNOWLEDGEMENTS

Strata Solutions would like to acknowledge the following groups and individuals for their help and guidance throughout the course of this project. Without those mentioned below, the project would not have been such a success.

- Ryan Noel, Lindsay Antle and Vanessa Pynn of Morrison Hershfield, for presenting us with a project that challenged us to learn and develop our skills in the area of structural design. Their weekly meetings provided us with guidance and prompt help with any concerning questions.

- Mrs. Cheryl White, for her help with AutoCAD related work throughout the course of the project and as well our classmates for guidance, suggestions, and motivation.

- Dr. Amgad Hussein, for his guidance in design solutions specific to our project and as well as in teaching Engineering 8705 - Structural Building Systems, which directly contributed to the completion of our project. Dr. Hussein's concern for our education throughout our degree should be commended.

- Dr. Steve Bruneau, for executing a successful civil design project course. Our update meetings with him helped us stay focused, and pushed us to produce a final design and report that went beyond what any of our group members expected. His enthusiasm and positive attitude was always a welcome sight.

## 13 REFERENCES

[1] National Research Council of Canada, (2010), User's Guide – NBC 2010 Structural Commentaries (Part 4 of Division B)

[2] Canadian Institute of Steel Construction, (2006), Handbook of Steel Construction, Ninth Edition

[3] Cement Association of Canada, (2005), Concrete Design Handbook, Third Edition

[4] "Concrete in Practice." *National Ready Mix Concrete Association*. N.p., n.d. Web. 3 Mar. 2013. <www.nrmca.org/aboutconcrete/cips/06p.

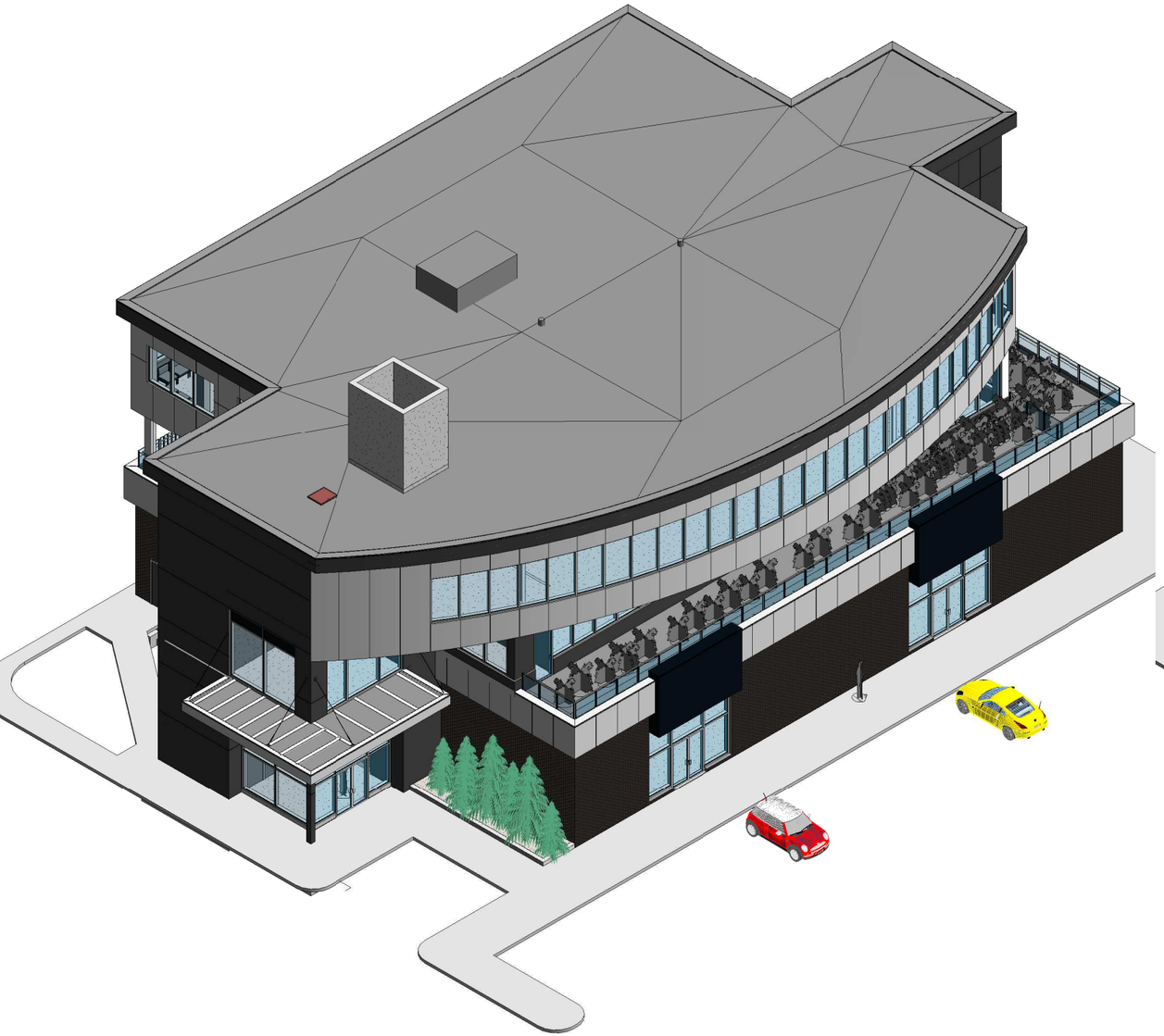
# 14 APPENDICES

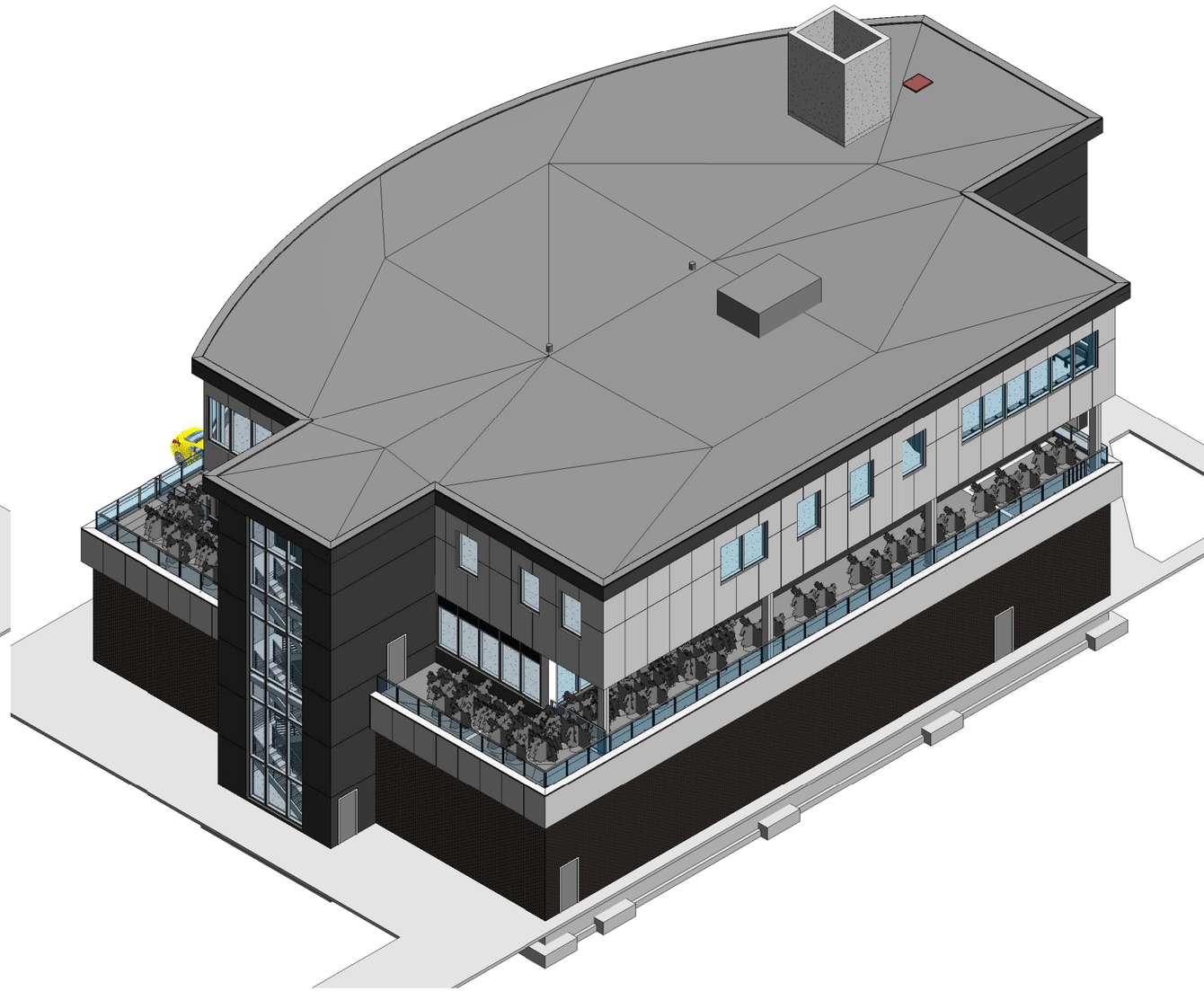
14.1 Appendix A: Architectural Drawings
14.2 Appendix B: Project Schedules
14.3 Appendix C: Loading Calculations
14.4 Appendix D: Design Calculations
14.5 Appendix E: S-Frame/ S-Steel Results
14.6 Appendix F: Quantities and Costs Estimates for Final Design
14.7 Appendix G: Strata Solutions Structural Drawings Package
14.8 Appendix H: Presentation Slides

STRATA
SOLUTIONS

# Appendix A

# Architectural Drawings





# Orthodontic Clinic

## Hebron Way



Issued For Pricing

December 11th, 2012

Client:

## 10 Mile Holdings Inc.

| Sheet List | | |
|---|---|---|
| Sheet Number | Sheet Name | Current Revision Description |
| A100 | Assemblies Legend | Issued For Pricing |
| A201 | Floor Plan Level 1 | Issued For Pricing |
| A202 | Floor Plan Level 2 | Issued For Pricing |
| A203 | Floor Plan Level 3 | Issued For Pricing |
| A401 | North & South Elevations | Issued For Pricing |
| A402 | East & West Elevations | Issued For Pricing |
| A501 | Building Sections | Issued For Pricing |
| A601 | Wall Sections | Issued For Pricing |
| A602 | Wall Sections | Issued For Pricing |
| A603 | Wall Sections | Issued For Pricing |
| A604 | Wall Sections | Issued For Pricing |
| A605 | Wall Sections | Issued For Pricing |
| A701 | East Stairwell Sections | Issued For Pricing |
| A702 | West Stairwell Sections | Issued For Pricing |
| A703 | East Stairwell Plans | Issued For Pricing |
| A704 | West Stairwell Plans | Issued For Pricing |
| A705 | Enlarged Plans | Issued For Pricing |

Architects / Prime Consultants:

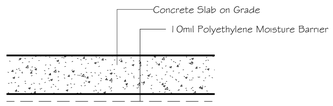
SHEPPARD CASE ARCHITECTS INC

Sub Consultants:

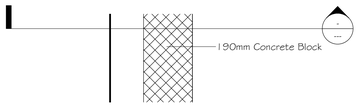
PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

MORRISON HERSHFIELD

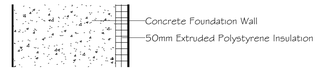
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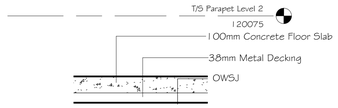

F1 - Concrete Slab On Grade



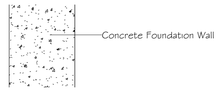

P1 - 190mm Concrete Block



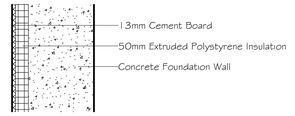

W1 - Concrete Foundation Wall



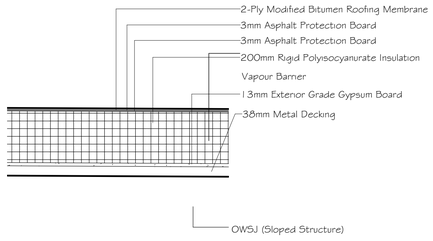

F2 - 100mm Concrete on 38mm Metal Deck




P3 - Concrete




W2 - Concrete Foundation Wall



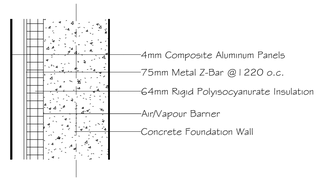

R1 - 2-Ply Membrane



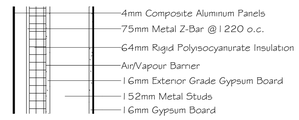

P4 - 92mm Stud w Gypsum



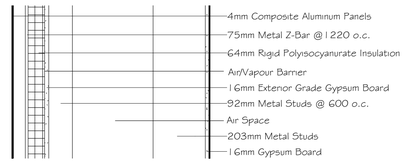

W3 - Brick & Metal Stud



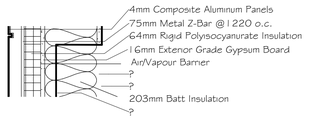

W4 - Composite Panel & Concrete Wall




W6 - Composite Panel & Metal Stud




W7 - Composite Panel Fascia




W8 - Typ. Parapet


SHEPPARD CASE
ARCHITECTS INC

683 Water Stret, 2nd Floor
St. John's, NL, Canada A1E 1B5
t 709 753-7132 f 709 753-6469 info@sheppardcase.nf.ca



Do not scale from this drawing. The Contractor is to verify all dimensions on site before proceeding with this work.


Stamp:

Sub Consultants:

MORRISON HERSHFIELD

PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|
| B | Issued For Pricing | 11/12/12 |
| A | Issued For 33% Review | 13/11/12 |

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10 Mile Holdings Inc.

Project:

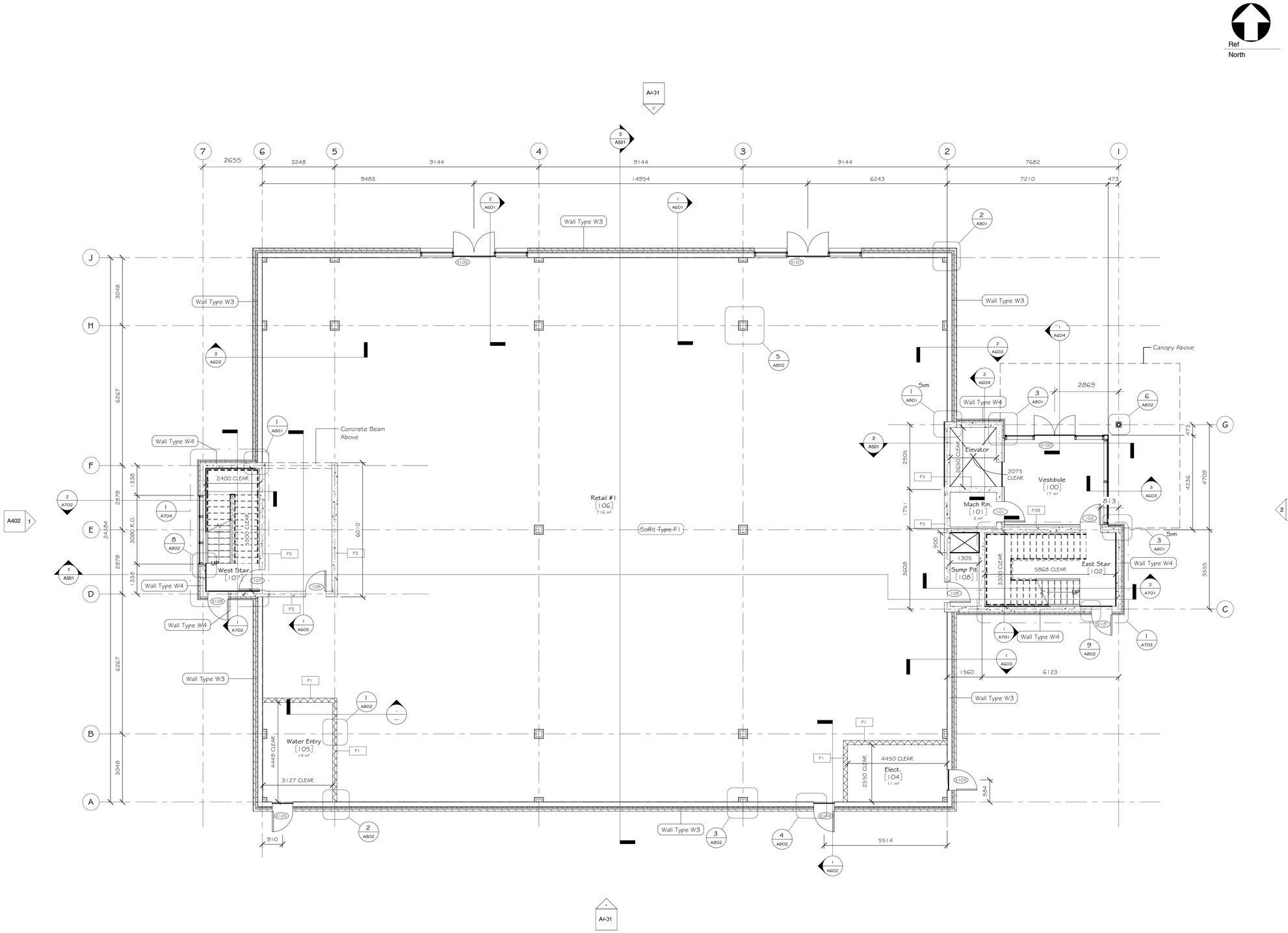
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Assemblies Legend

Scale: 1 : 10
Date: December 2012
Drawn By: A.Winter
Checked By: J.Case
Job Number: 12-1290

A100 RB





SHEPPARD CASE
ARCHITECTS INC

683 Water Stret, 2nd Floor
St. John's, NL, Canada A1E 1B5
t 709 753-7132 f 709 753-6469 info@sheppardcase.nf.ca



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Stamp:

Sub Consultants:

MORRISON HERSHFIELD

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Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|
| B | Issued For Pricing | 11/12/12 |
| A | Issued For 33% Review | 13/11/12 |

Client:

10 Mile Holdings Inc.

Project:

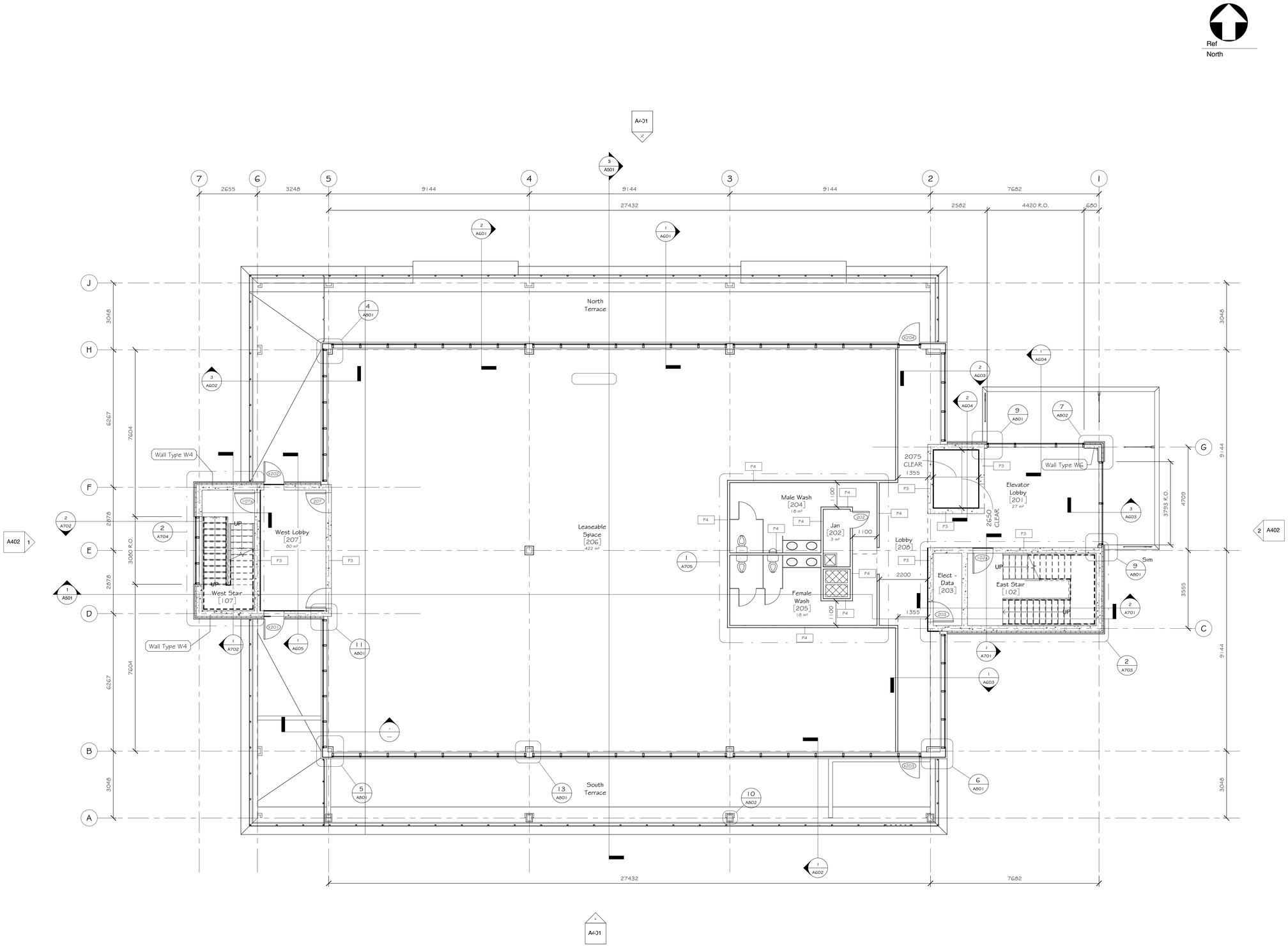
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Floor Plan Level 1

| | |
|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A201 RB





SHEPPARD CASE
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Client:

10 Mile Holdings Inc.

Project:

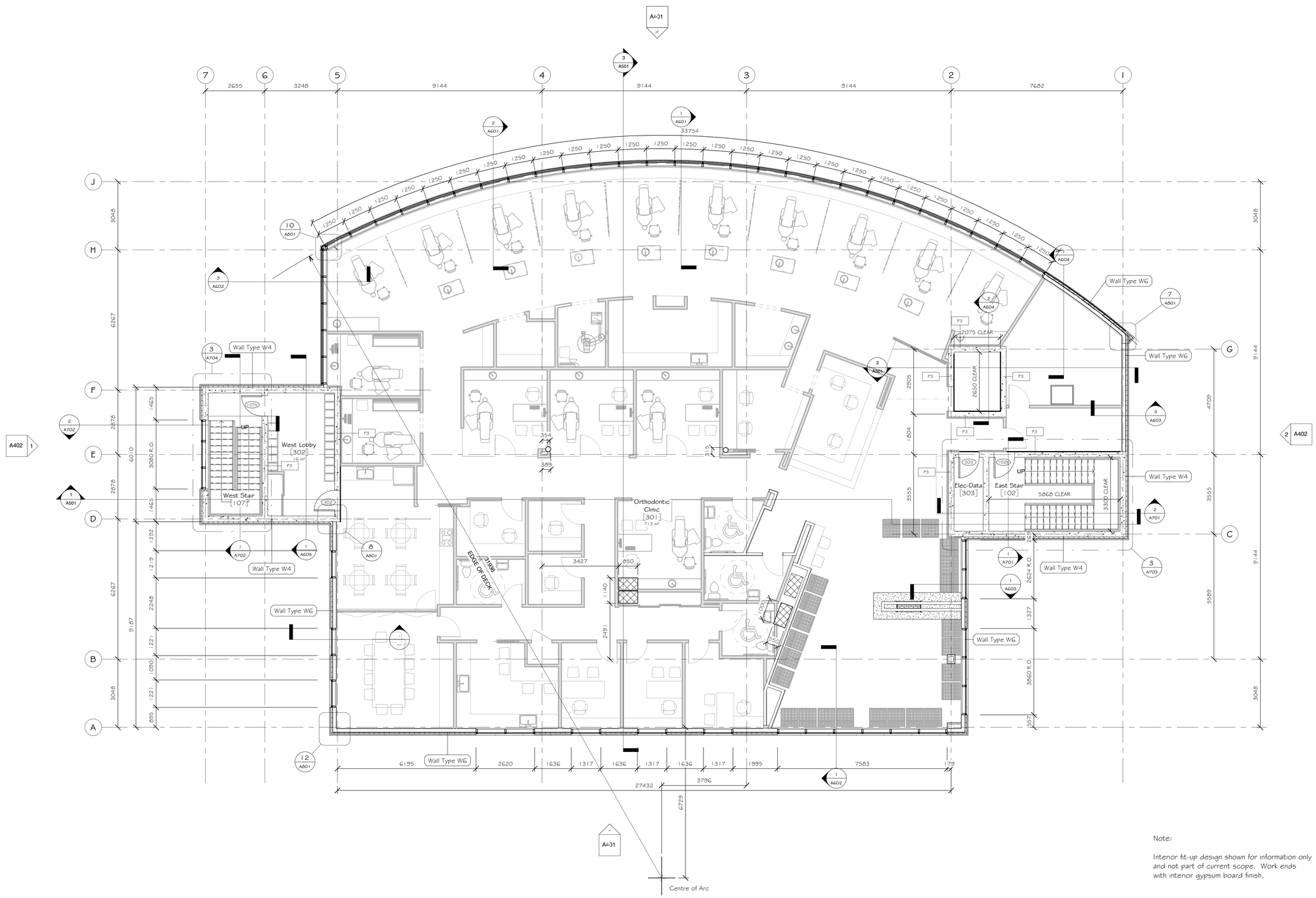
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Floor Plan Level 2

| | |
|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A202 RB




Ref
North

Note:

Interior fit-up design shown for information only and not part of current scope. Work ends with interior gypsum board finish.


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| B | Issued For Pricing | 11/12/12 |
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Client:

10 Mile Holdings Inc.

Project:

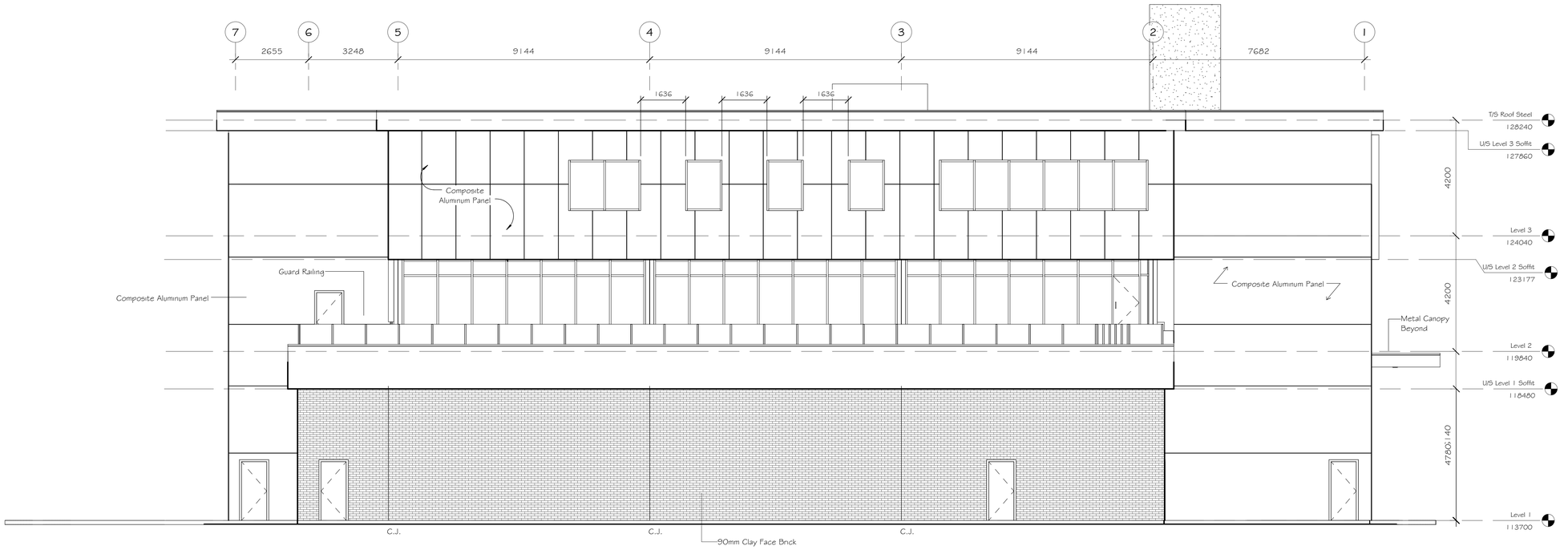
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Floor Plan Level 3

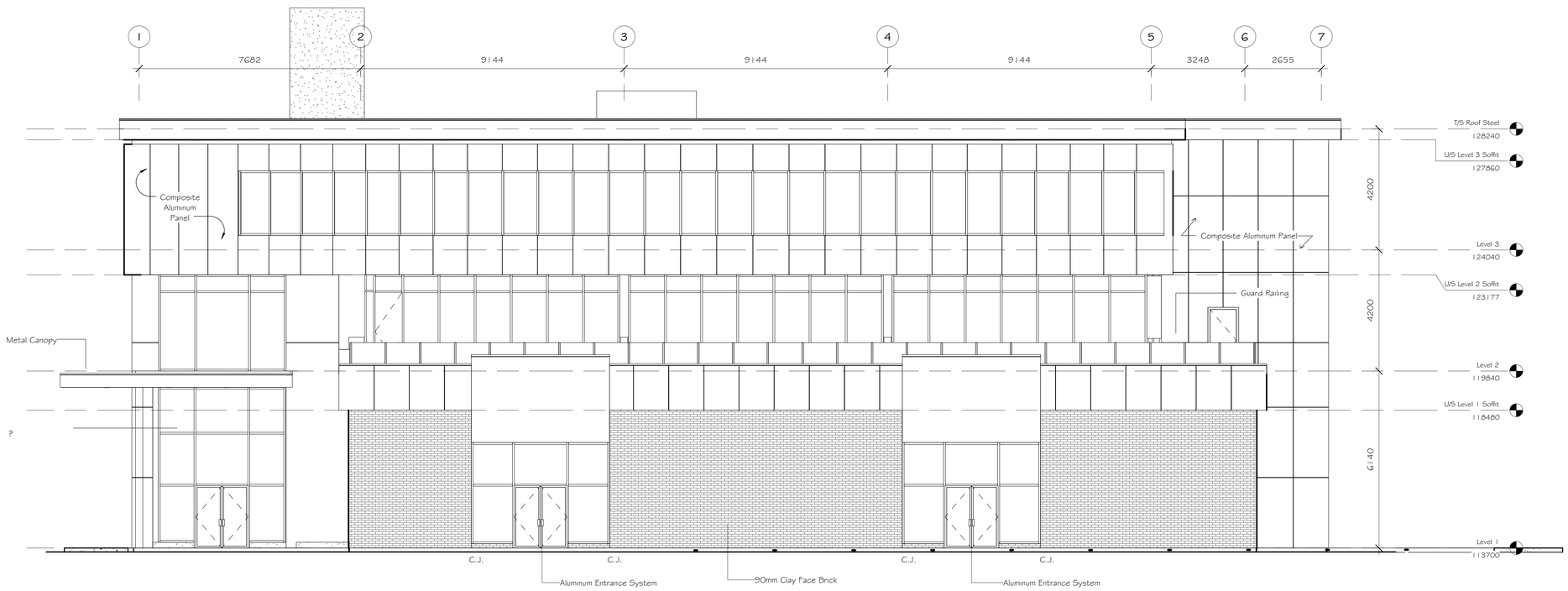
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|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A203
RB




1 A401 South Elevation

1 : 75




2 A401 North Elevation

1 : 75

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Client:

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Project:

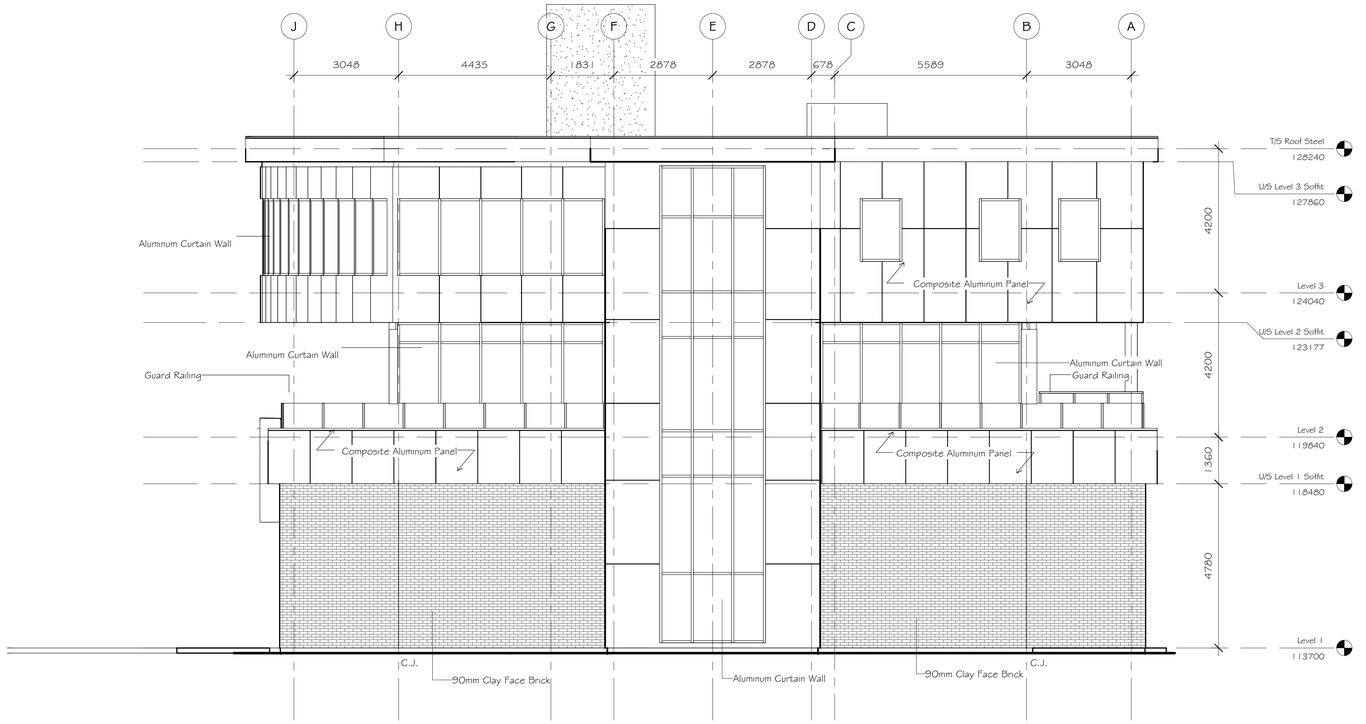
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# North & South Elevations

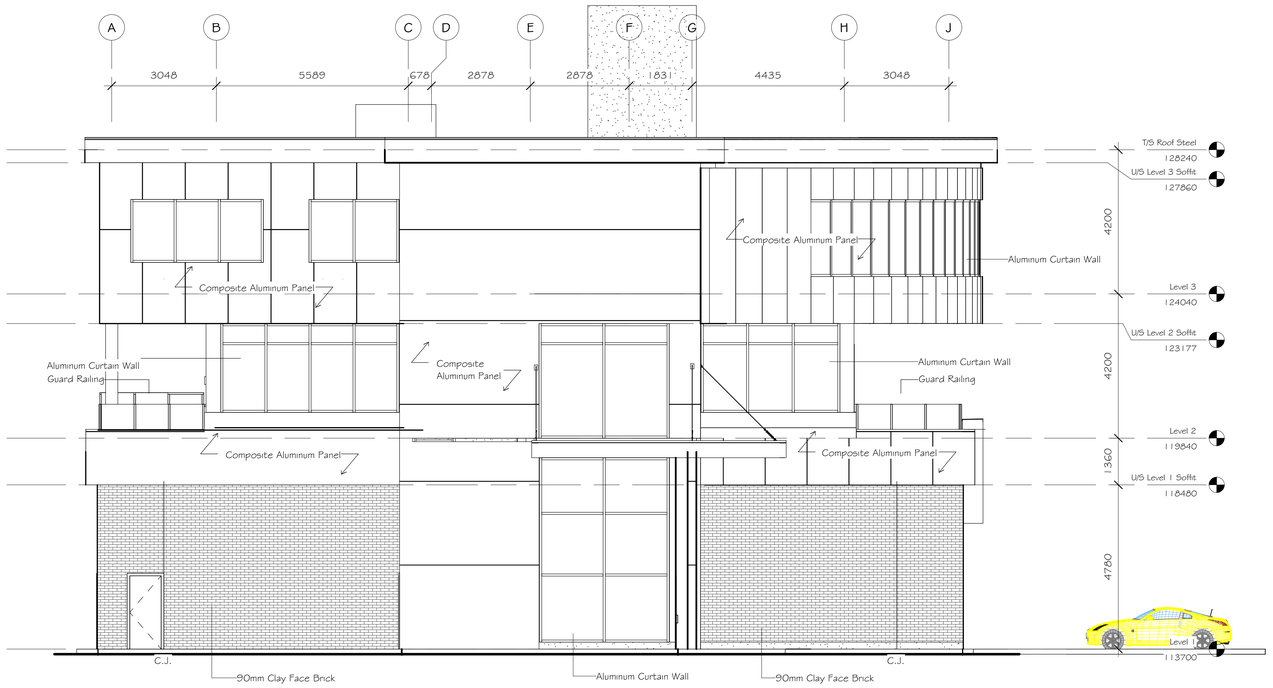
| | |
|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A401 RB




1 / A402 West Elevation

1 : 75




2 / A402 East Elevation

1 : 75


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Project:

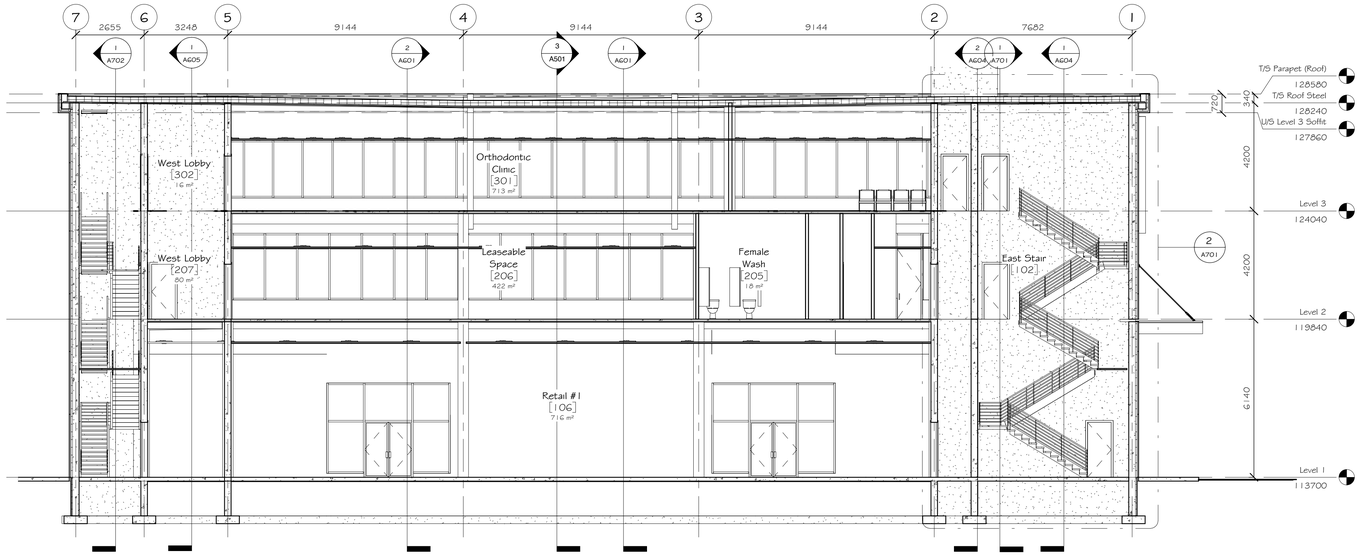
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# East & West Elevations

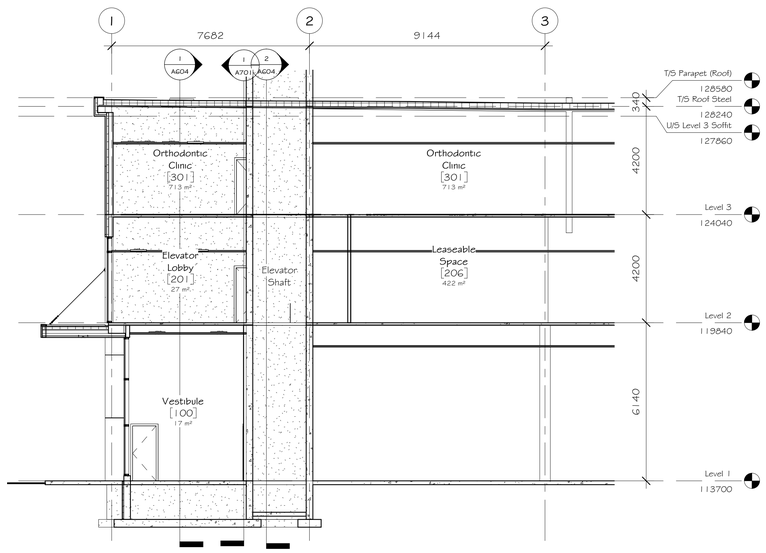
| | |
|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A402 RB



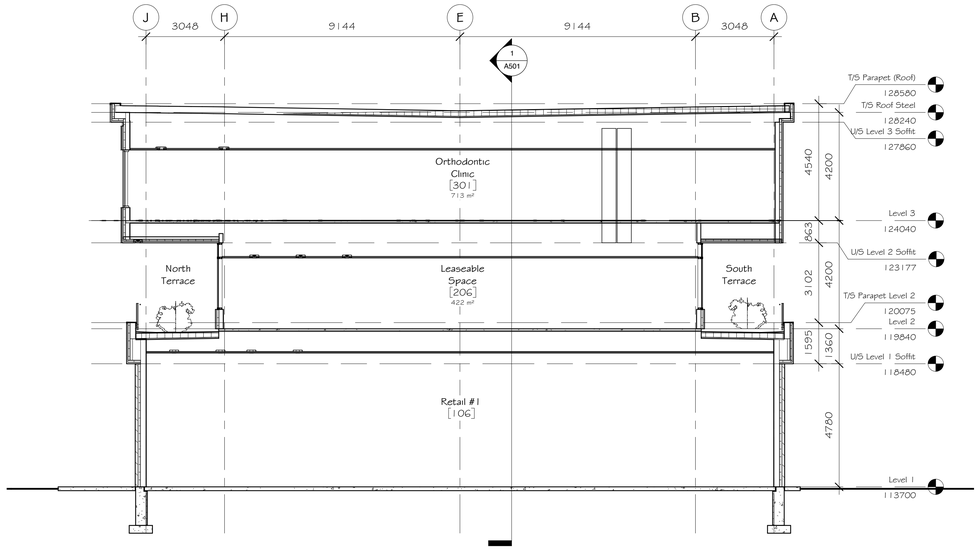

1 A501 **Building Section 1**

1 : 100




2 A501 **Building Section 2**

1 : 100




3 A501 **Building Section 3**

1 : 100


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10 Mile Holdings Inc.

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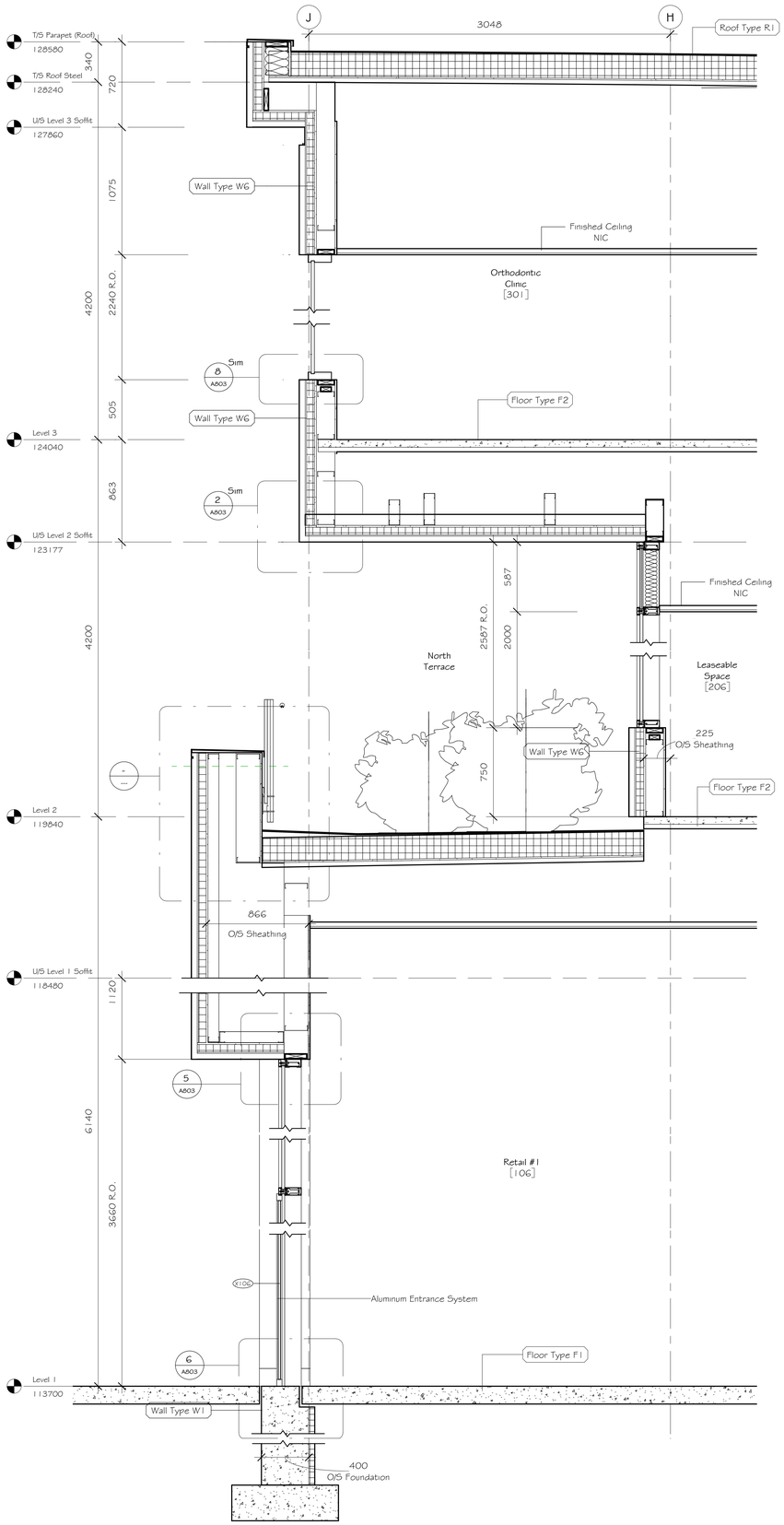
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Building Sections

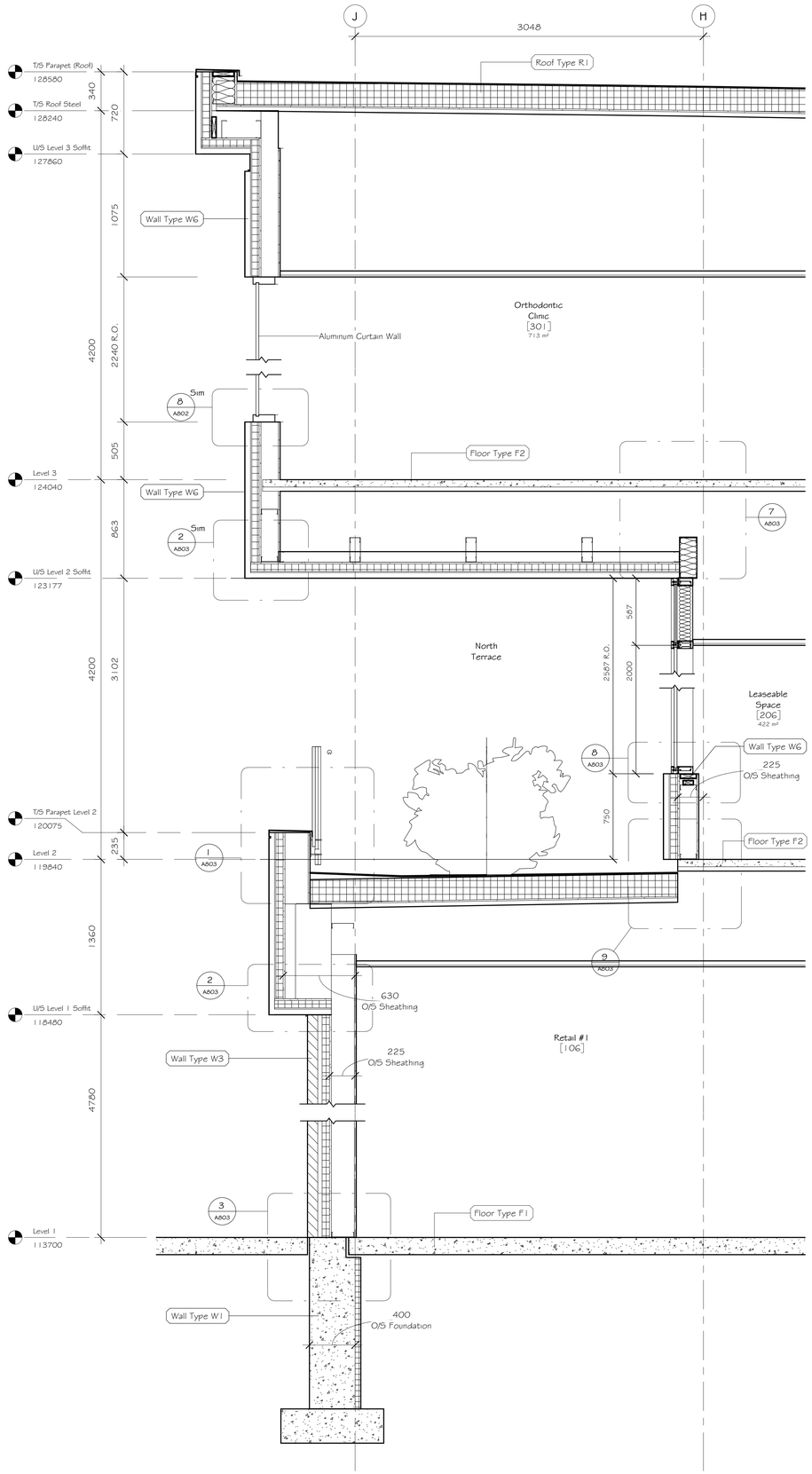
| | |
|---|---|
| Scale: | 1 : 100 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
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A501 RB




2 / A601 Wall Section - North Walls (Retail Entrance)

1 : 20




1 / A601 Wall Section - North Walls (Typ.)

1 : 20

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Client:

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Project:

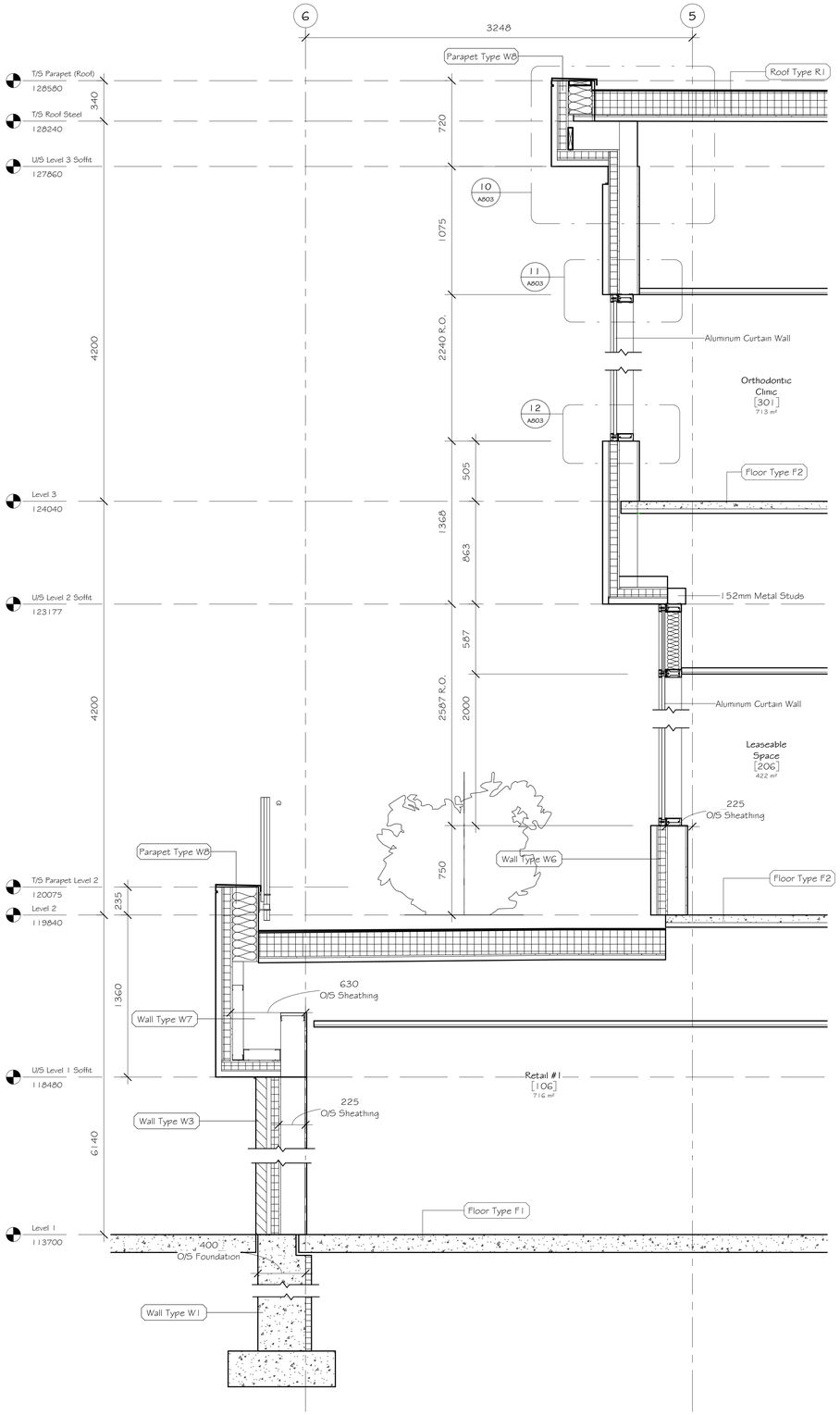
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Wall Sections

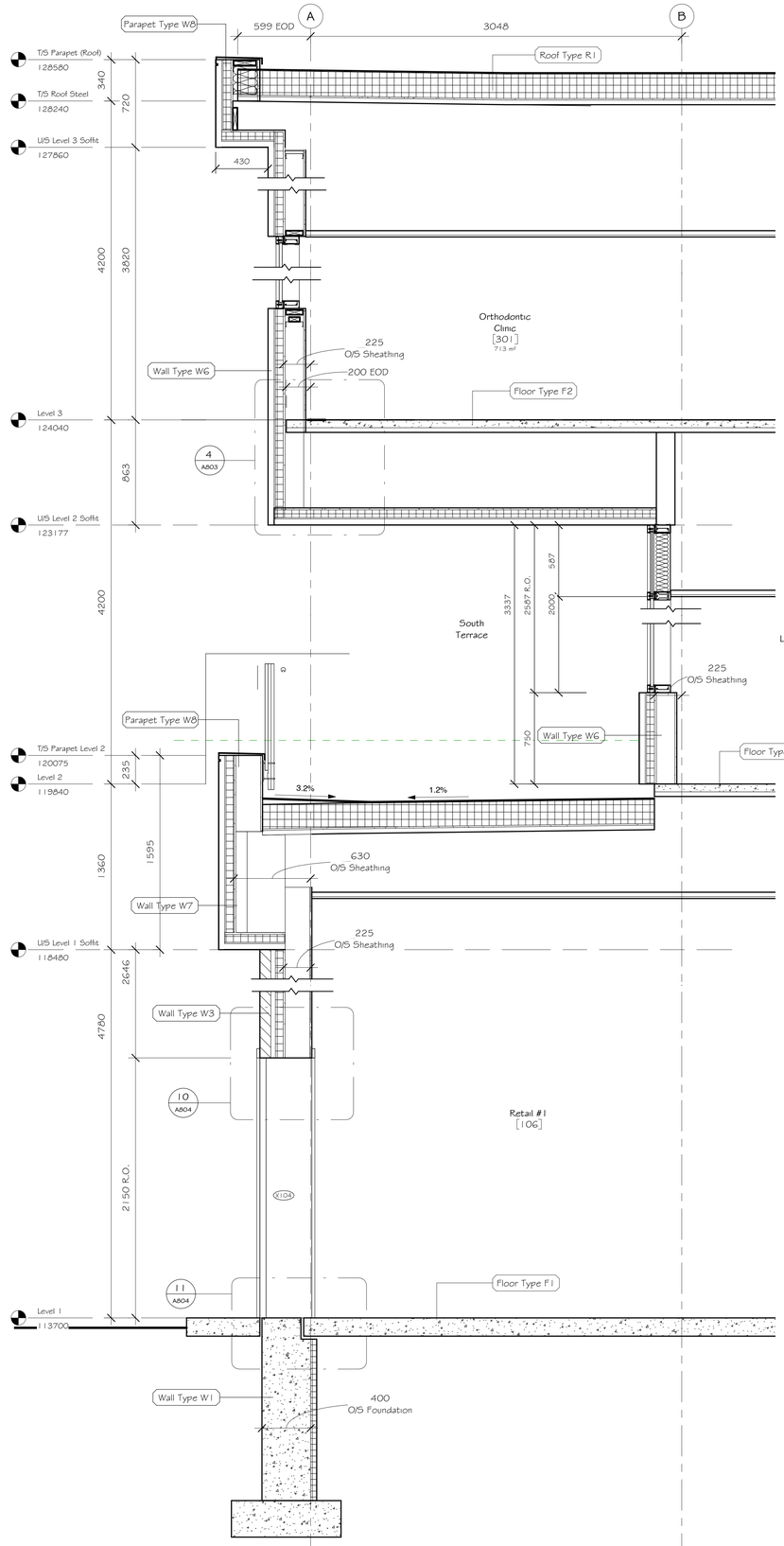
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|---|---|
| Scale: | 1 : 20 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A601 RA




3 / A602 Wall Section - West Walls (Typ.)

1 : 20




1 / A602 Wall Section - South Wall @ Exit Door

1 : 20

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Client:

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Project:

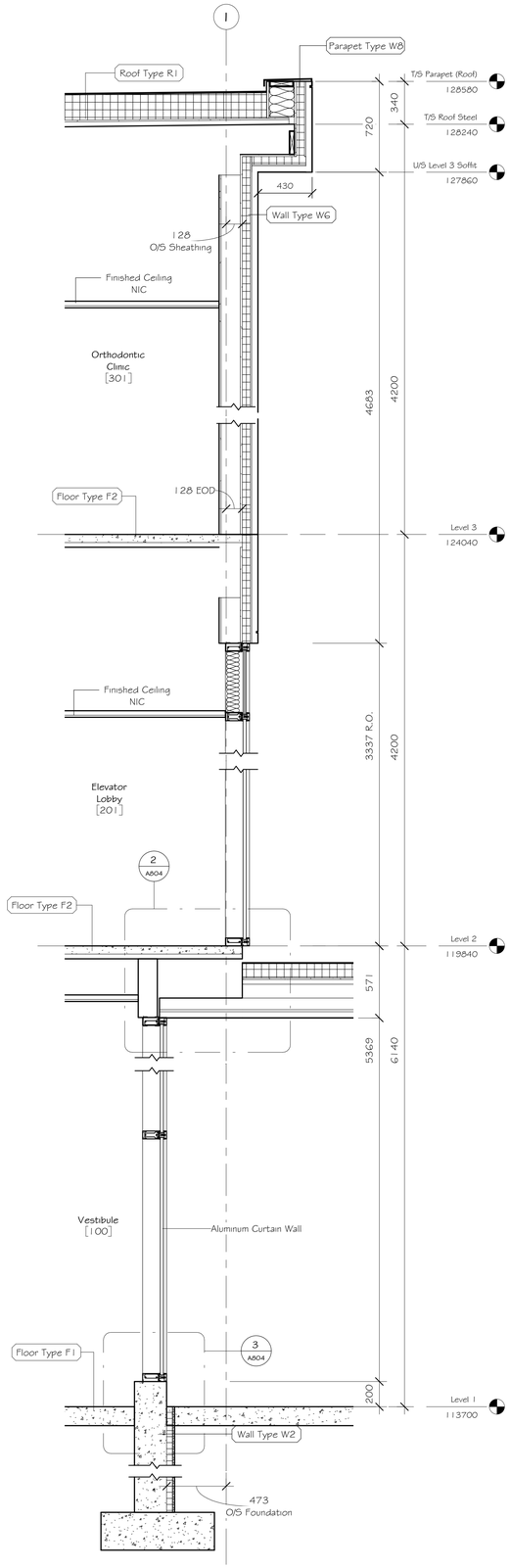
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Wall Sections

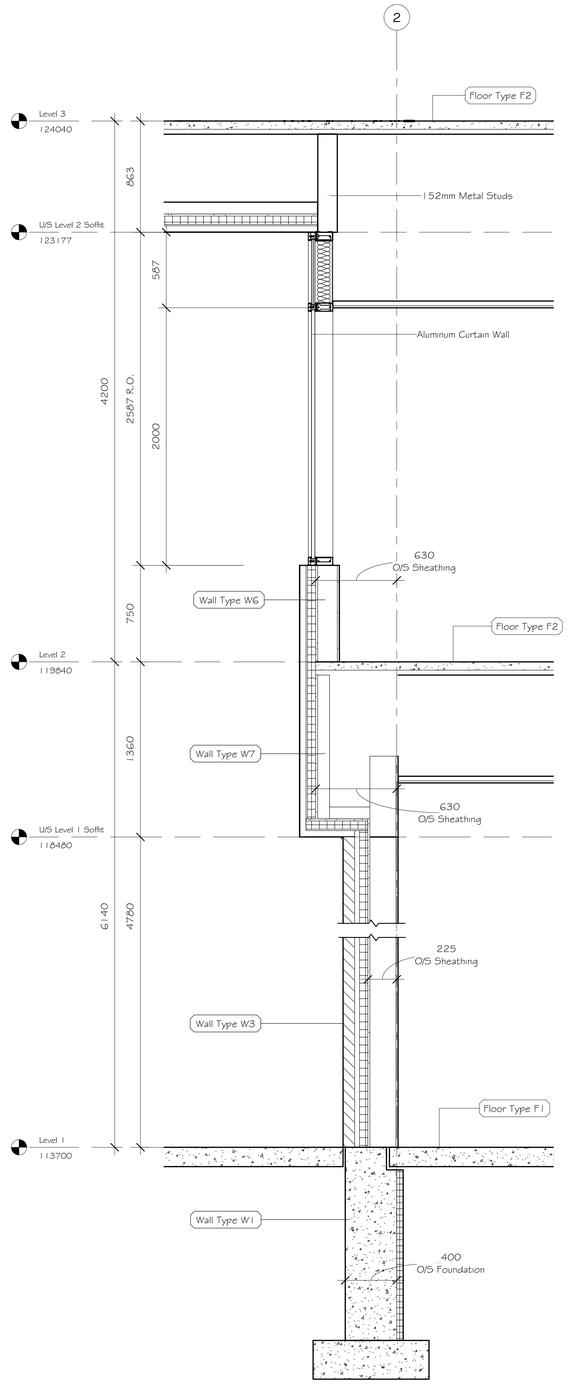
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|---|---|
| Scale: | 1 : 20 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A602 RB



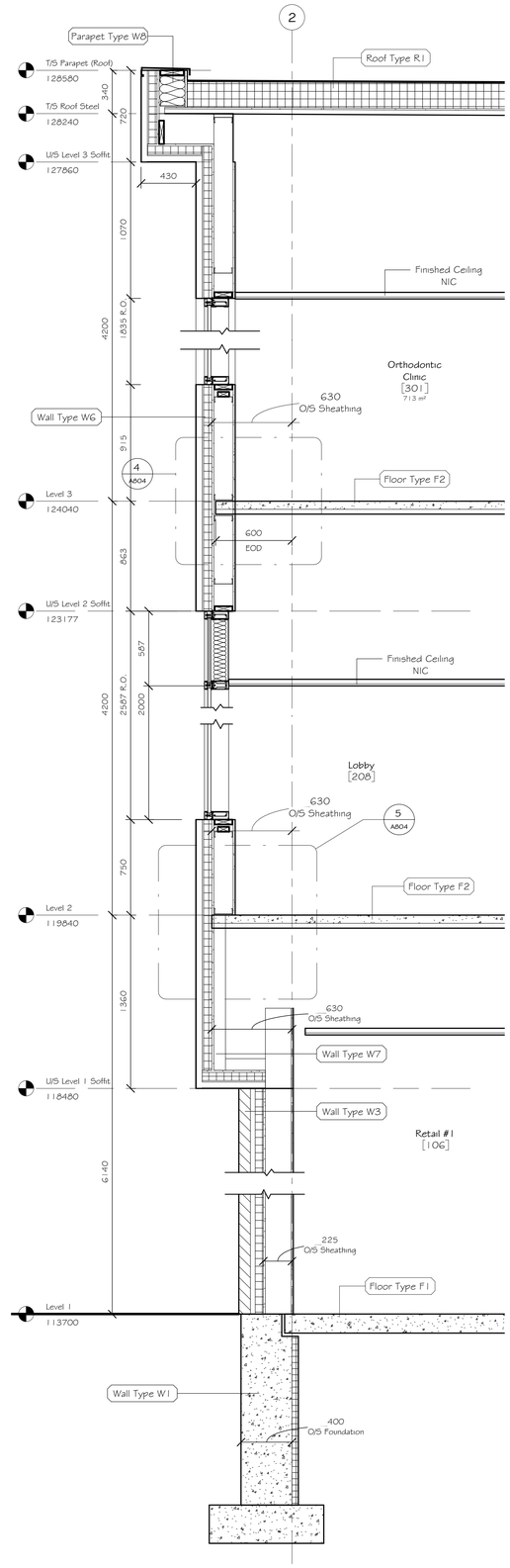

3 / A603 Wall Section - Lobby Entry East Wall

1 : 20




2 / A603 Wall Section - East Wall @ Level 3 Cantelever

1 : 20




1 / A603 Wall Section - East Wall (Typ.)

1 : 20

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| B | Issued For Pricing | 11/12/12 |
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Client:

10 Mile Holdings Inc.

Project:

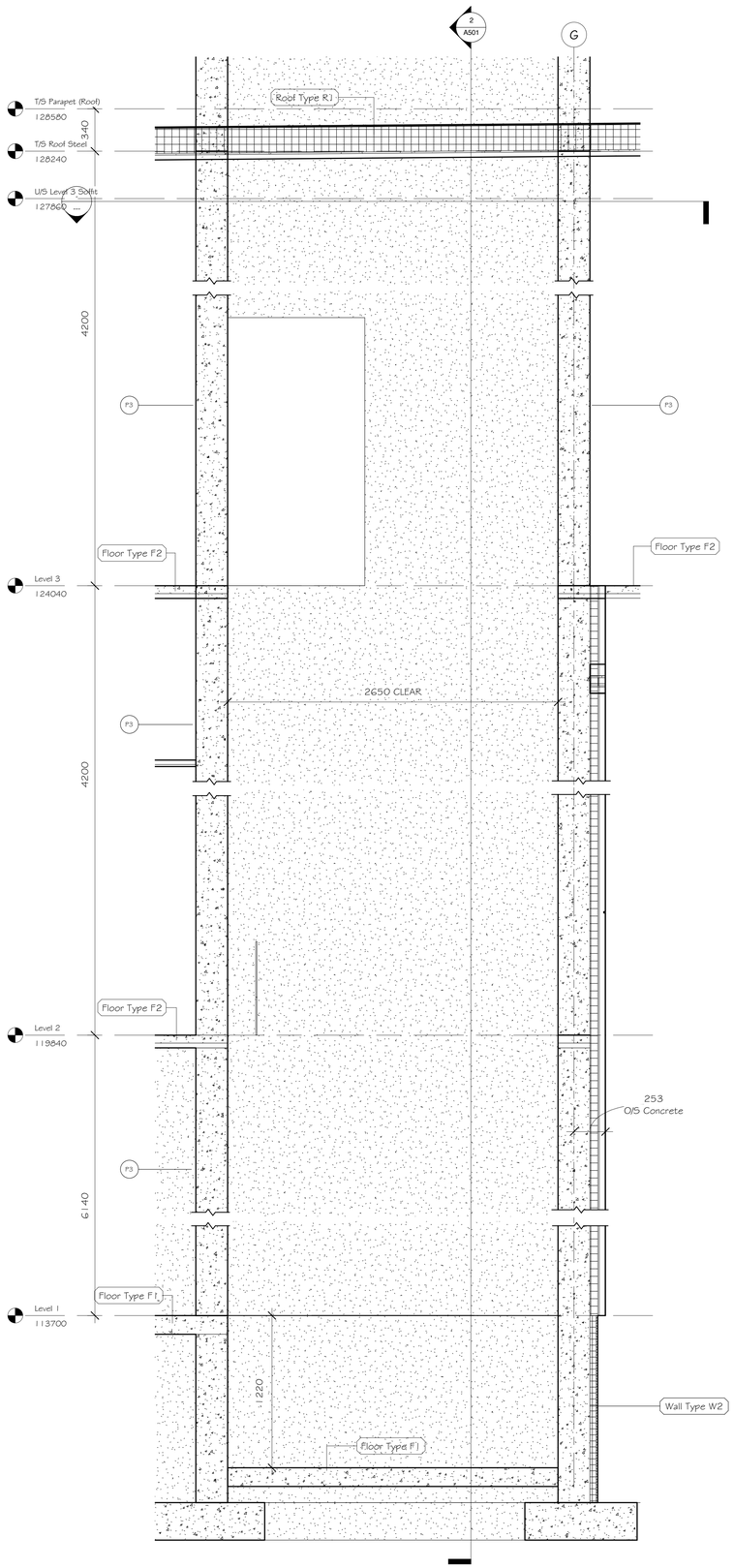
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Wall Sections

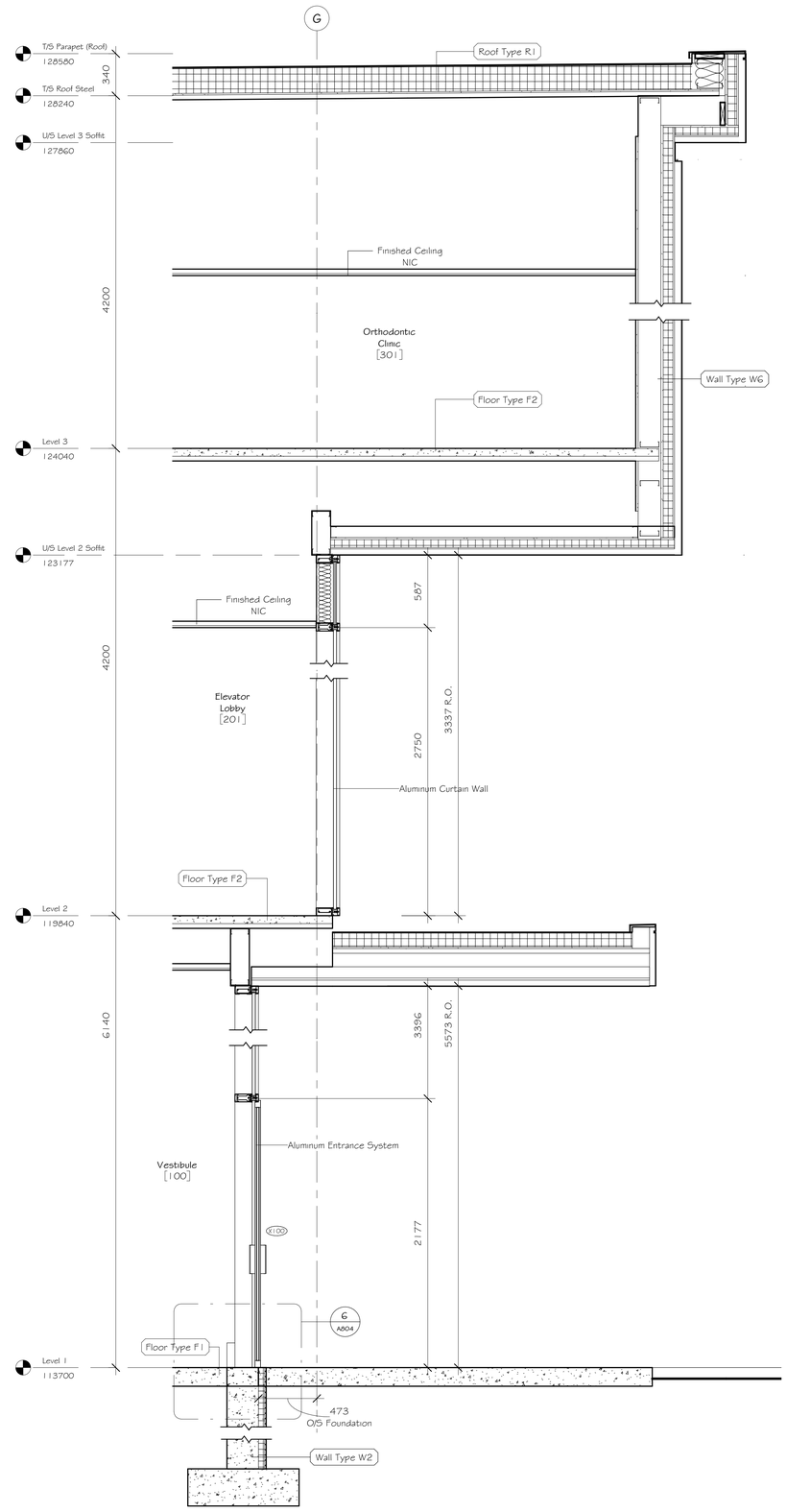
| | |
|---|---|
| Scale: | 1 : 20 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A603 RB




2 A604 Wall Section - Elevator Shaft

1 : 20




1 A604 Wall Section - Lobby Entry North Doors

1 : 20

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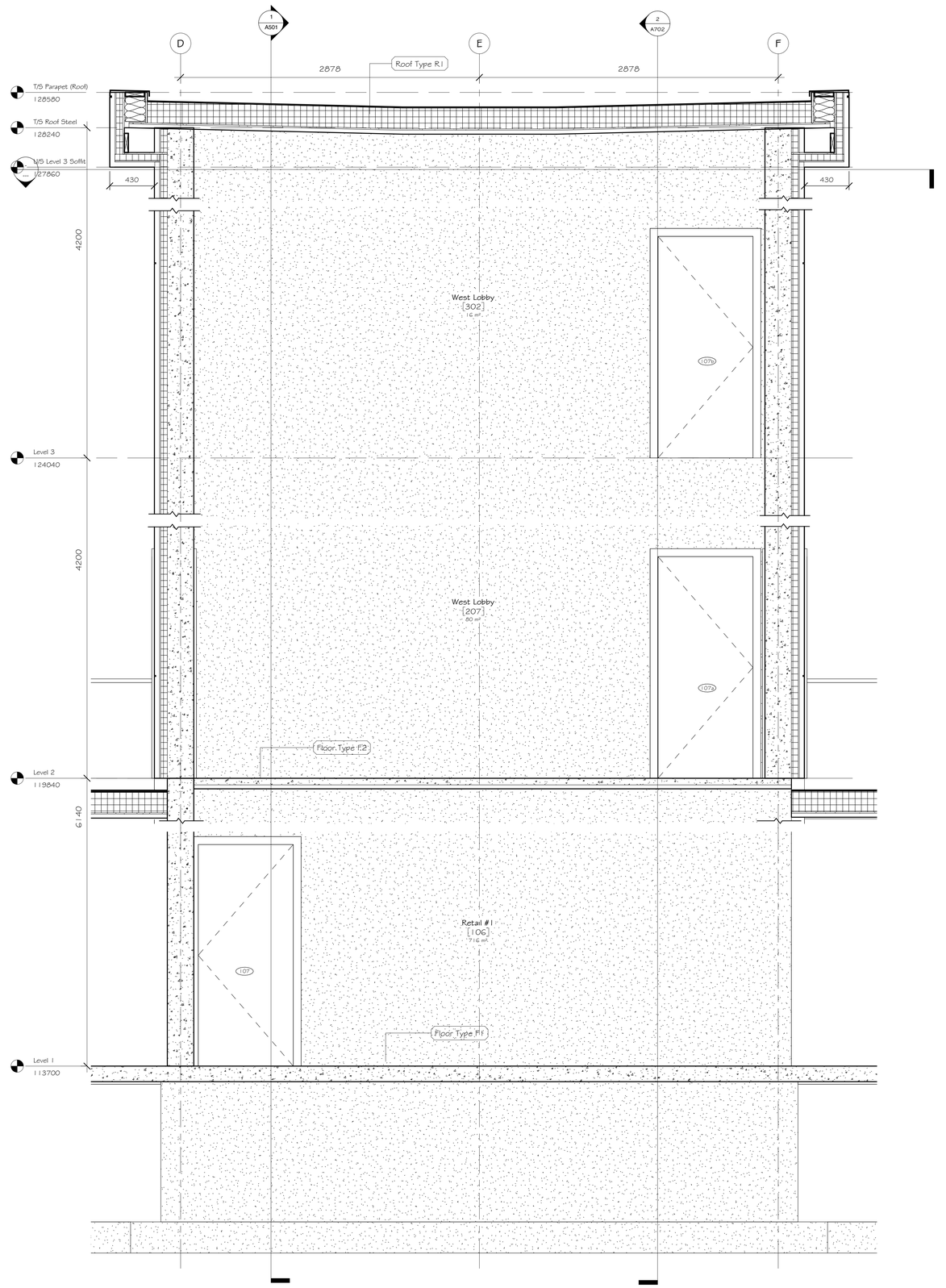
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Wall Sections

| | |
|---|---|
| Scale: | 1 : 20 |
| Date: | December 2012 |
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A604 RB




1 A605 Wall Section - West Core @ Grids 5 & 6

1 : 20

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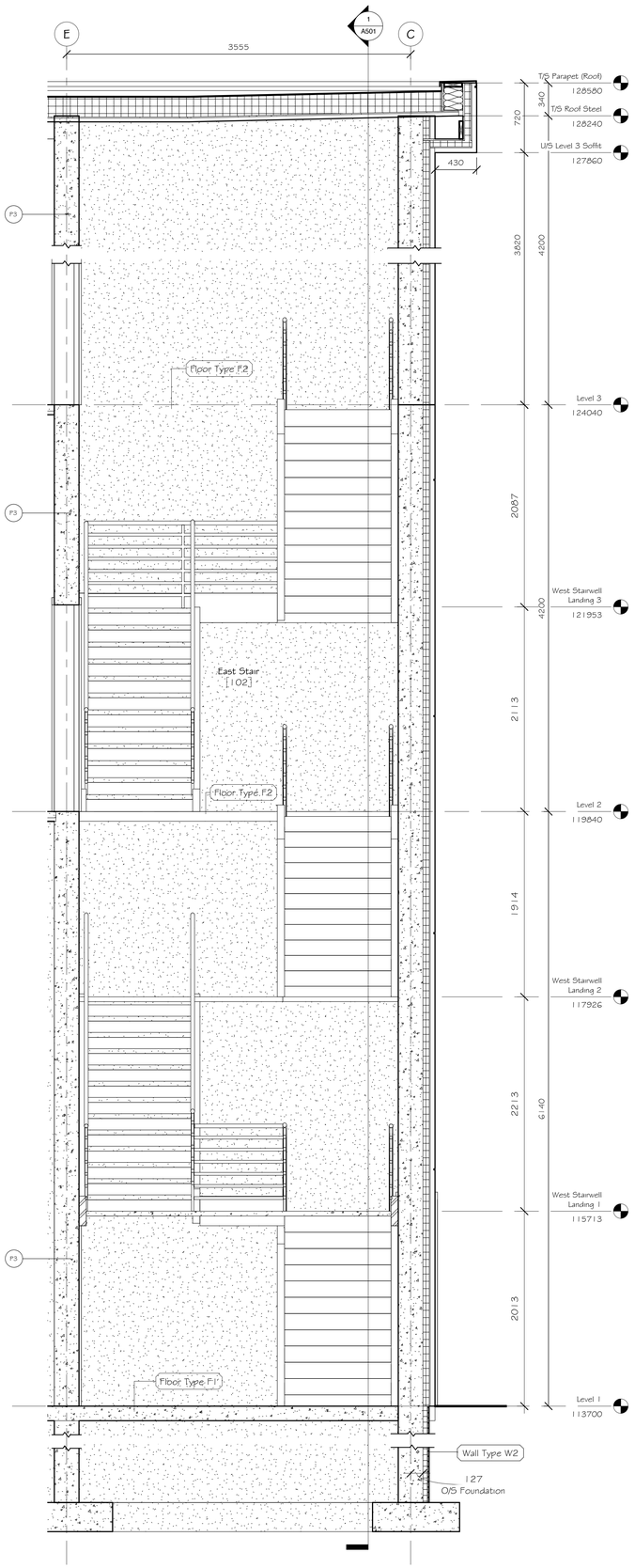
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# Wall Sections

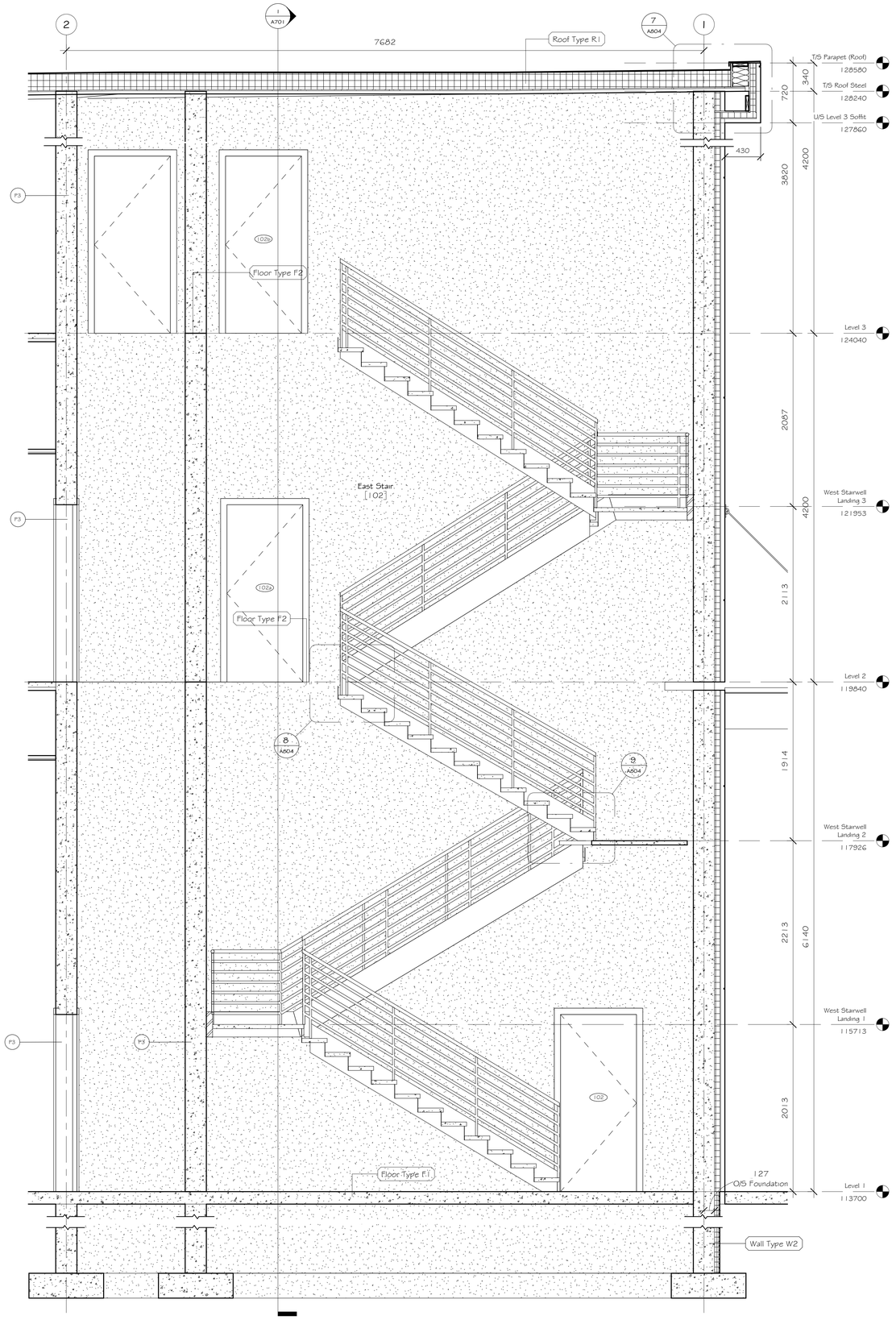
| | |
|---|---|
| Scale: | 1 : 20 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

A605 RB




1 A701 Wall Section - East Stairwell (South Wall)

1 : 25




2 A701 Wall Section - East Stairwell (East Wall)

1 : 25

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10 Mile Holdings Inc.

Project:

Orthodontic Clinic

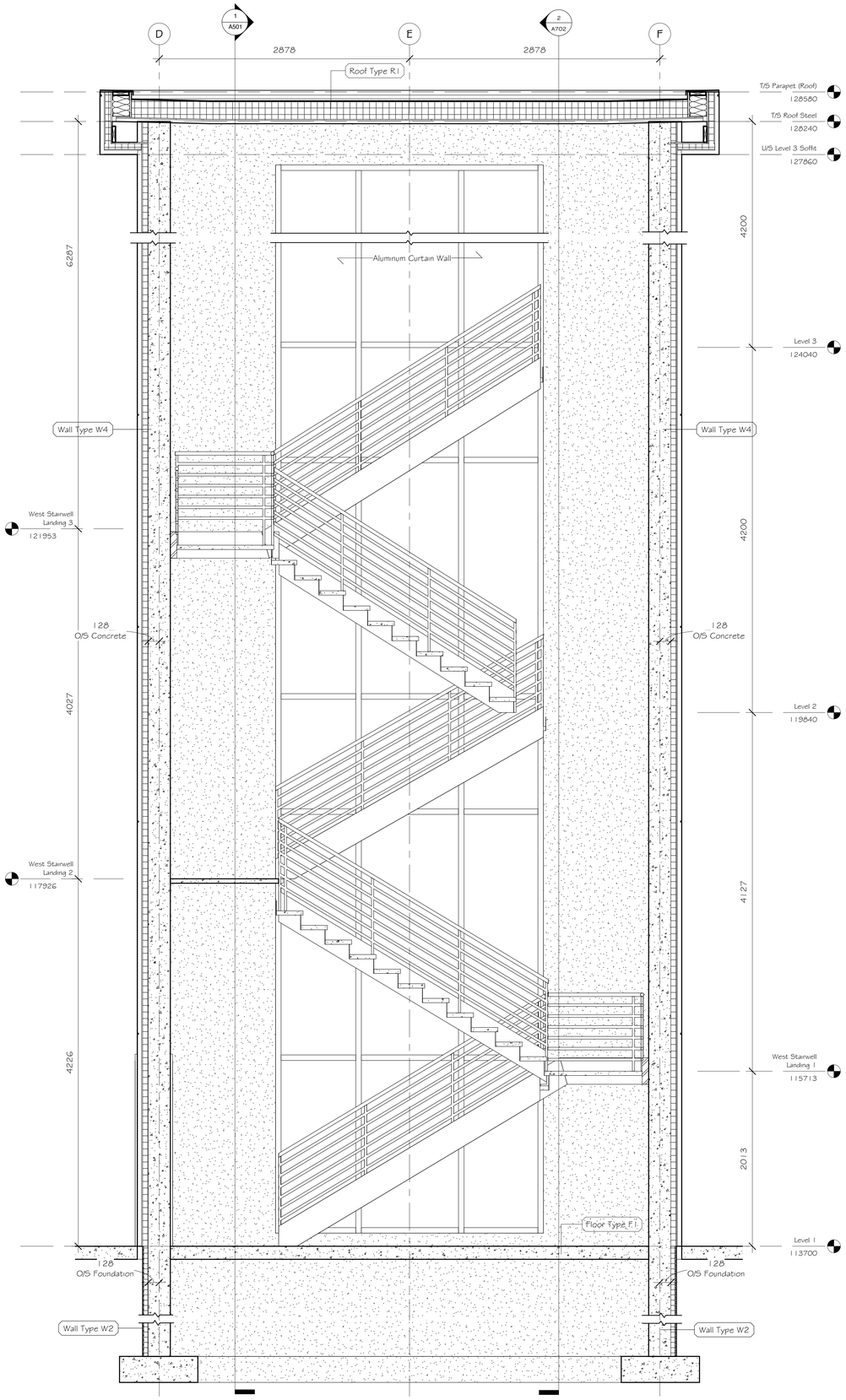
Location: Hebron Way
St. John's, NL

# East Stairwell Sections

| | |
|---|---|
| Scale: | 1 : 25 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

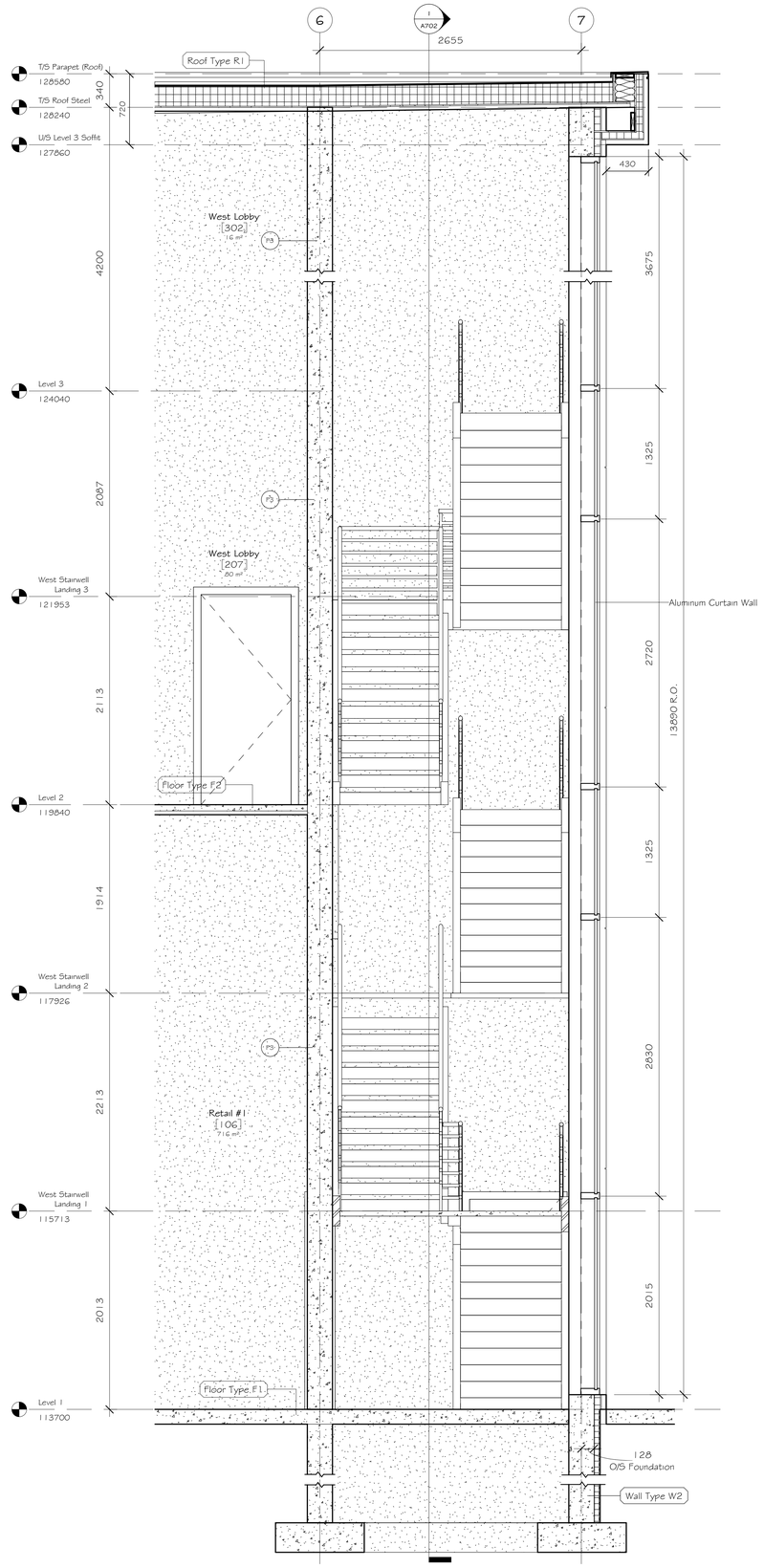
A701

RB




1 / A702 Wall Section - West Stairwell

1 : 25




2 / A702 Wall Section - West Stairwell @ Curtain Wall

1 : 25

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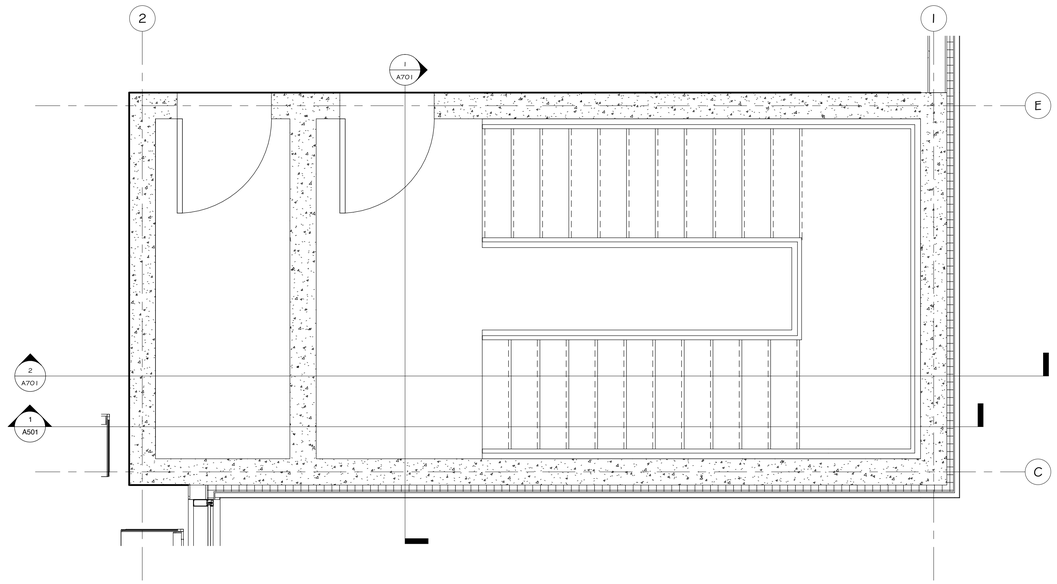
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# West Stairwell Sections

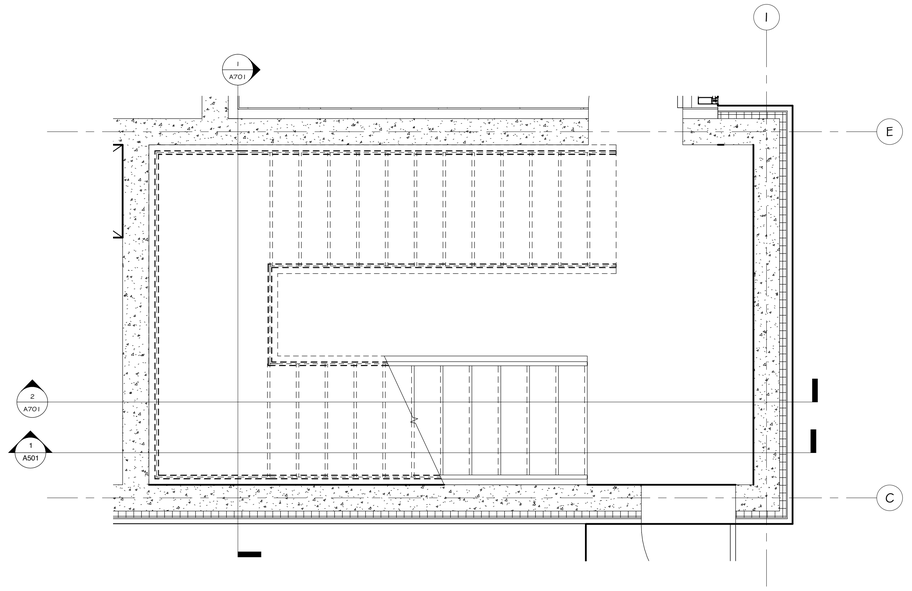
| | |
|---|---|
| Scale: | 1 : 25 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A702 RA



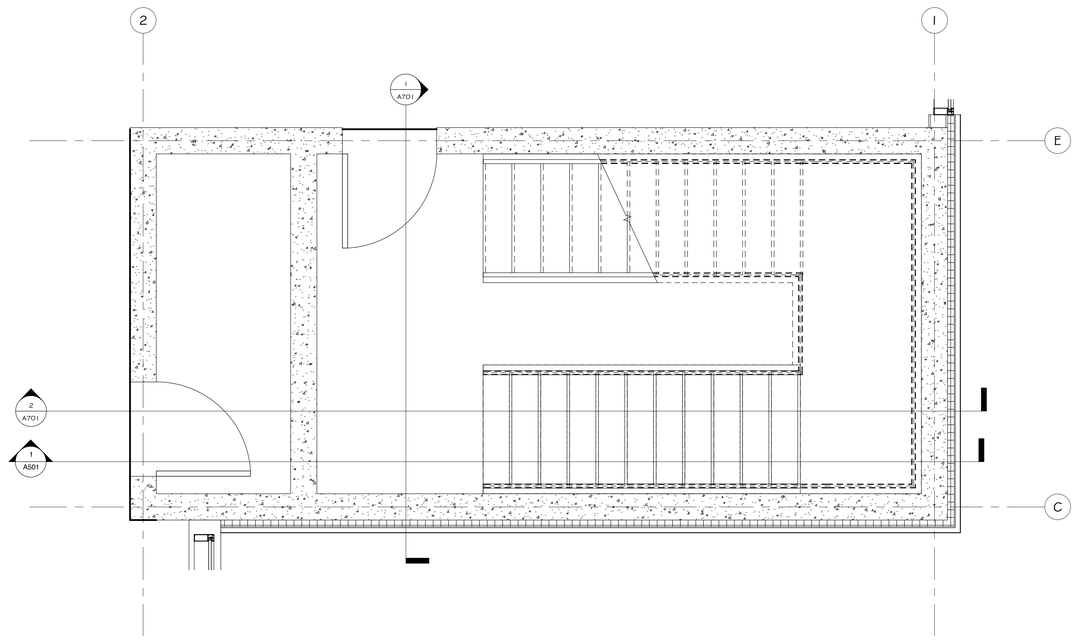

3 / A703 Level 3 - East Stair Plan

1 : 25




1 / A703 Level 1 - East Stair Plan

1 : 25




2 / A703 Level 2 - East Stair Plan

1 : 25

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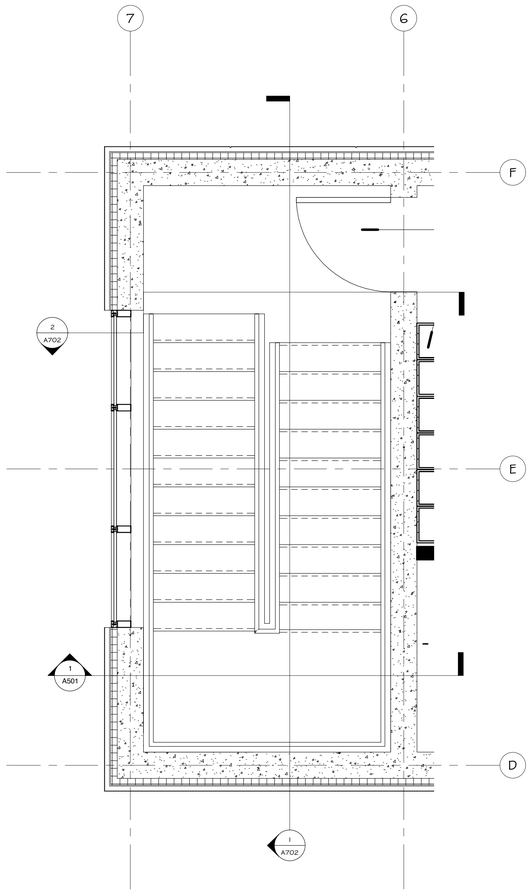
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# East Stairwell Plans

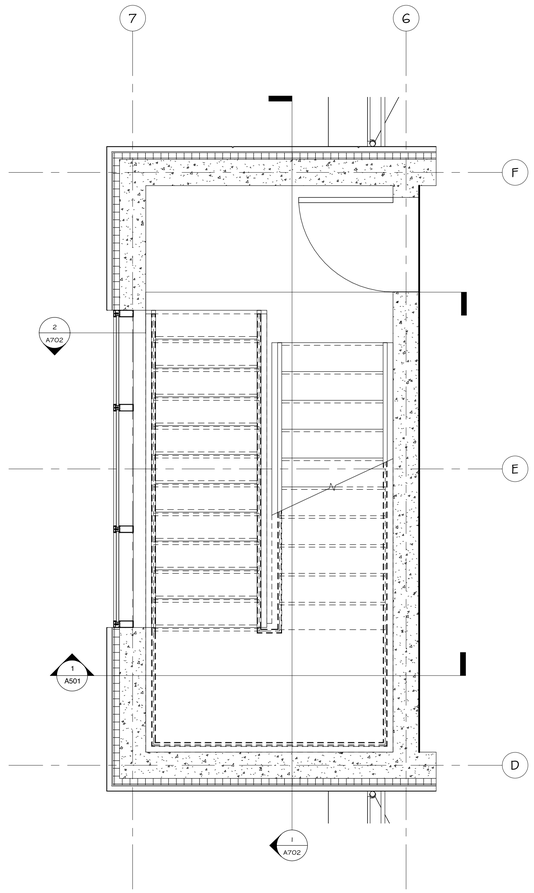
| | |
|---|---|
| Scale: | 1 : 25 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A703 RA



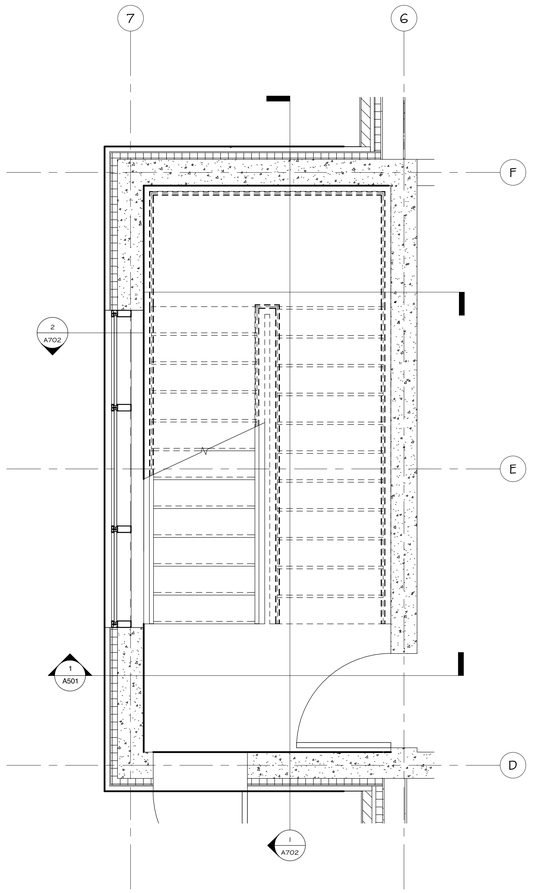

3 A704 Level 3 - West Stair Plan

1 : 25




2 A704 Level 2 - West Stair Plan

1 : 25




1 A704 Level 1 - West Stair Plan

1 : 25

SHEPPARD CASE
ARCHITECTS INC
683 Water Stret, 2nd Floor
St. John's, NL, Canada A1E 1B5
t 709 753-7132 f 709 753-6469 info@sheppardcase.nf.ca

Do not scale from this drawing. The Contractor is to verify all dimensions on site before proceeding with this work.

Stamp:

Sub Consultants:

MORRISON HERSHFIELD

PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|
| A | Issued For Pricing | 11/12/12 |

Client:

10 Mile Holdings Inc.

Project:

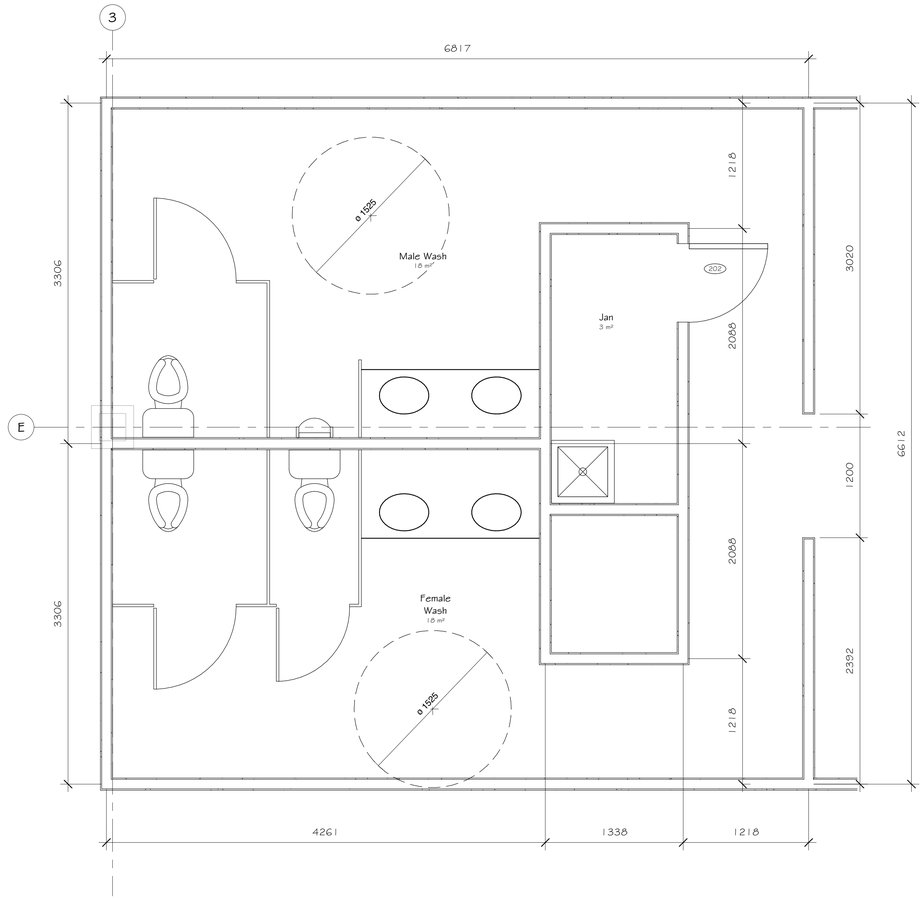
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

# West Stairwell Plans

| | |
|---|---|
| Scale: | 1 : 25 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A704 RA




I
A705
Level 2 - Washroom Plan
1 : 25

SHEPPARD CASE
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Civil Engineering & Project Management

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Revisions:

| No. | Description | Date |
|---|---|---|
| B | Issued For Pricing | 11/12/12 |
| A | Issued For 33% Review | 13/11/12 |

Client:

10 Mile Holdings Inc.

Project:

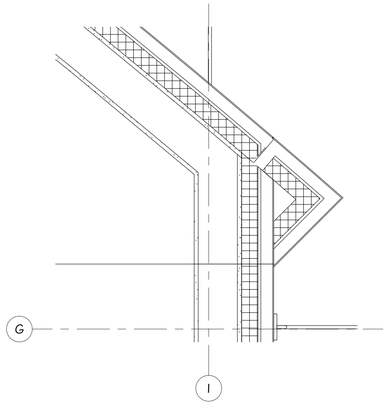
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

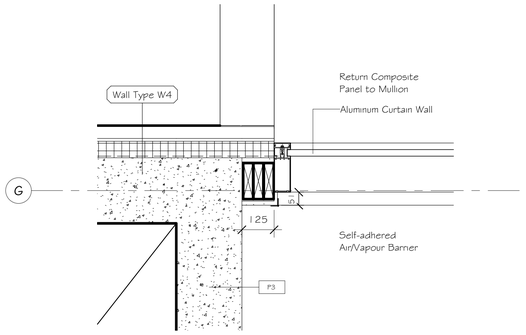
Enlarged Plans

| | |
|---|---|
| Scale: | 1 : 25 |
| Date: | December 2012 |
| Drawn By: | A.Winter |
| Checked By: | J.Case |
| Job Number: | 12-1290 |

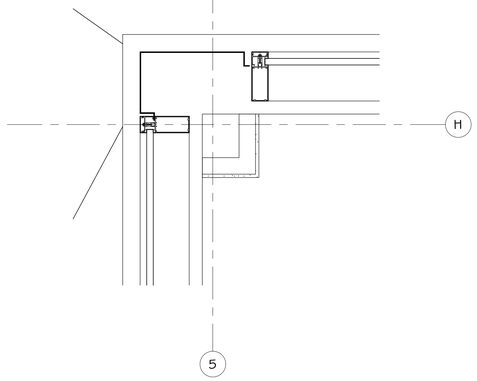
A705 RB



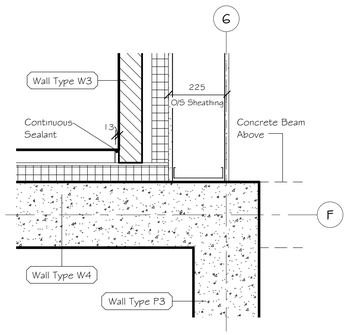

7 A801 Level 3 - Curve Extension
1 : 10



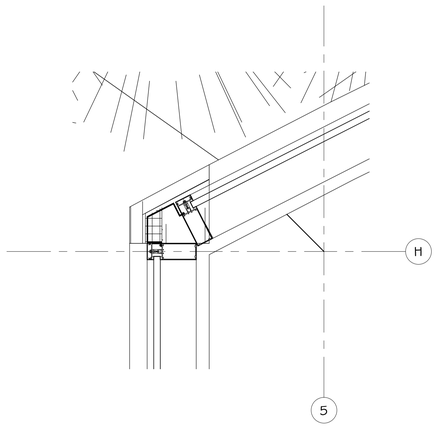

9 A801 Level 2 - Composite/Curtain Wall Jamb @ Concrete Shaft
1 : 10



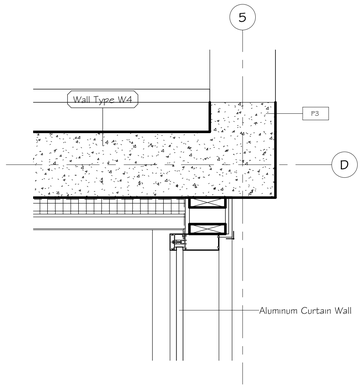

4 A801 Level 2 - Curtain Wall @ NW Corner
1 : 10



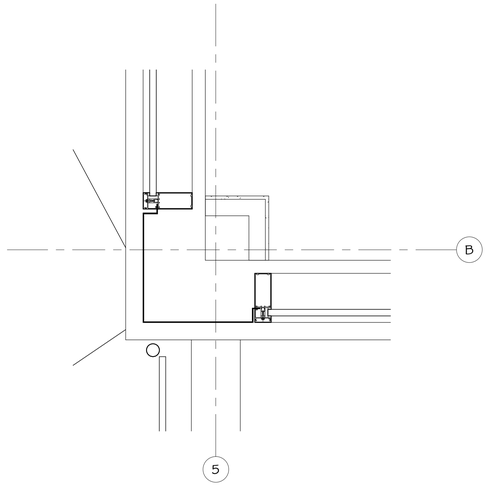

1 A801 Level 1 - Brick/Composite Intersection
1 : 10



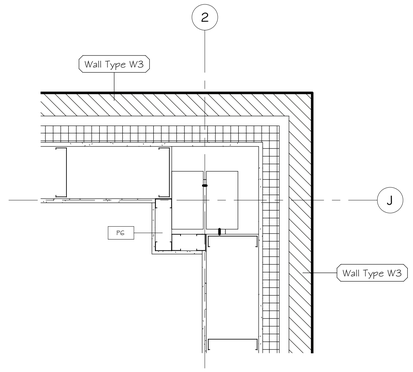

10 A801 Level 3 - Curtain Wall Corner @ Curve Wall
1 : 10



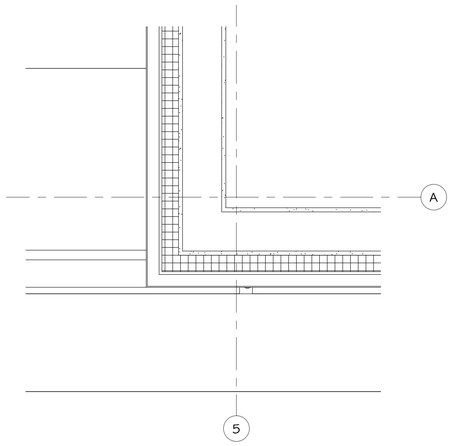

11 A801 Level 2 - Composite & Curtain Wall @ Concrete Shaft (Typ)
1 : 10



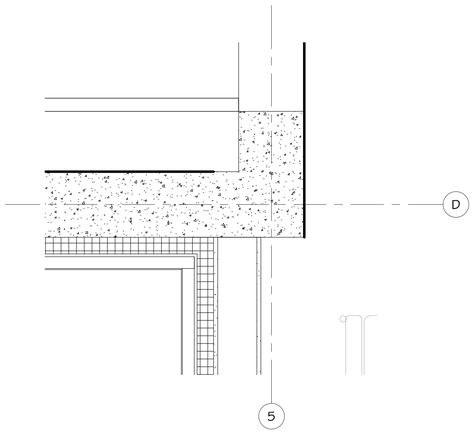

5 A801 Level 2 - Curtain Wall @ SW Corner
1 : 10



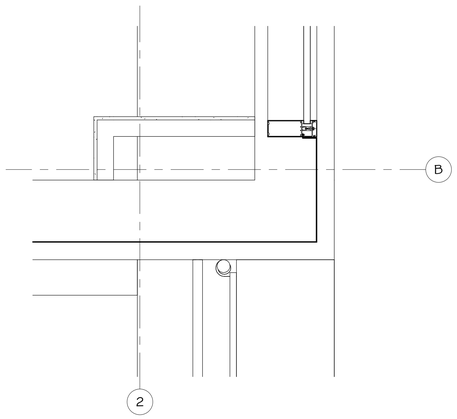

2 A801 Level 1 - Brick Corner (Typ)
1 : 10



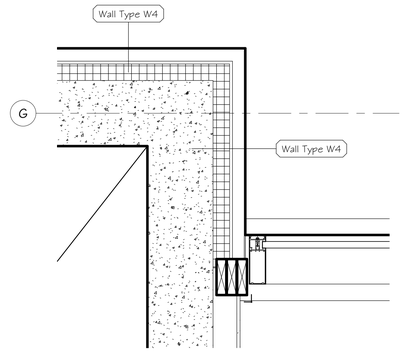

12 A801 Level 3 - Composite @ SW Corner (SE Corner Sim)
1 : 10




8 A801 Level 3 - Composite @ Concrete Shaft (SE Corner Sim)
1 : 10




6 A801 Level 2 - Curtain Wall @ SE Corner (NE Corner Sim)
1 : 10




3 A801 Level 1 - Composite Return @ East Entrance
1 : 10

SHEPPARD CASE
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St. John's, NL, Canada A1E 1B5
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Stamp:

Sub Consultants:

MORRISON HERSHFIELD

PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|

Client:

10 Mile Holdings Inc.

Project:

Orthodontic Clinic

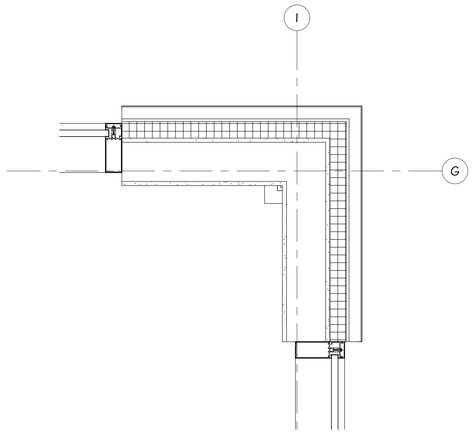
Location: Hebron Way
St. John's, NL

F2

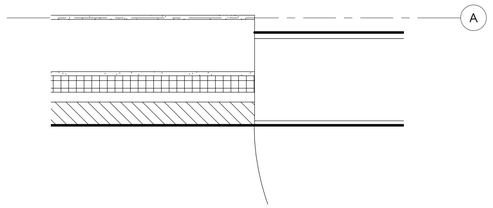
Plan Details

| | |
|---|---|
| Scale: | 1 : 10 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

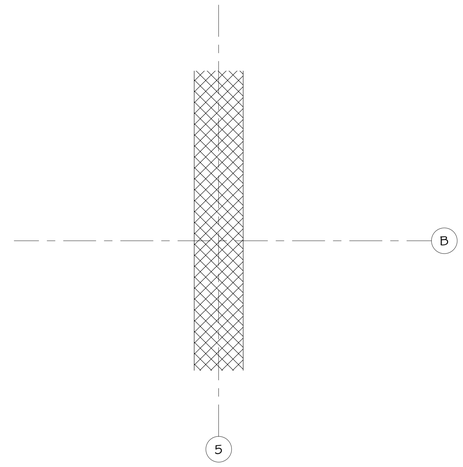
A801



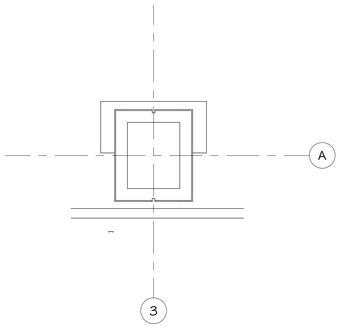

7 A802 — Level 2 - East Elevator Lobby 201 Corner
1 : 10



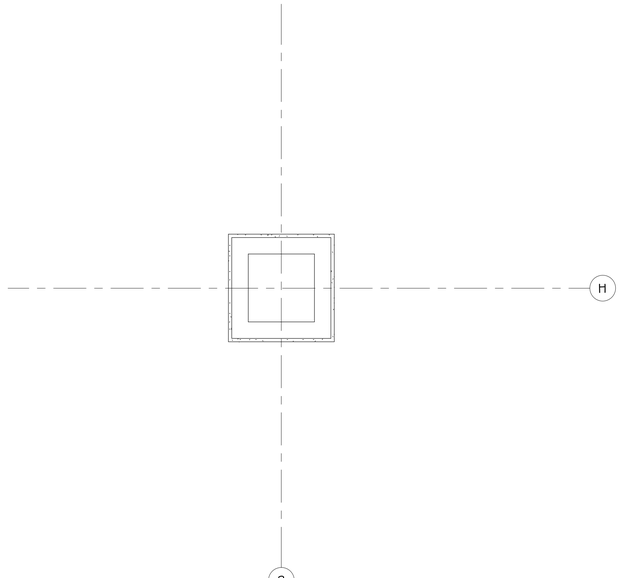

4 A802 — Level 1 - Door Jamb @ Brick
1 : 10



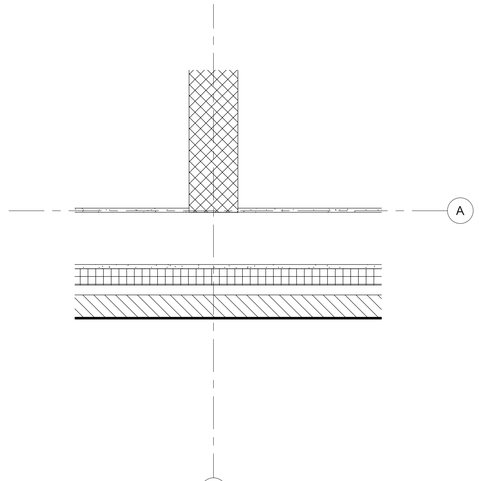

1 A802 — Level 1 - Block Partition @ Column
1 : 10



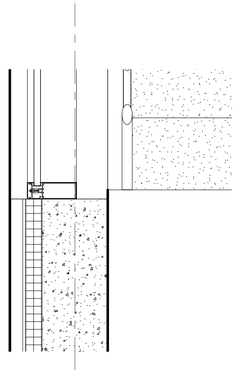

10 A802 — Level 2 - Exterior Column (South Terrace)
1 : 10



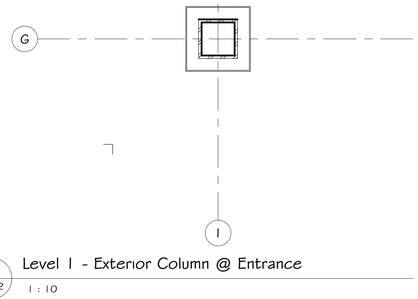

5 A802 — Level 1 - Furring @ Columns (Typ)
1 : 10



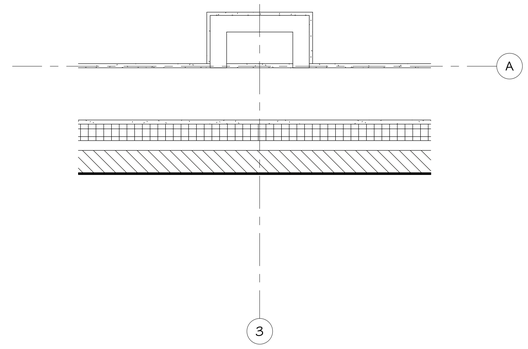

2 A802 — Level 1 - Block Partition @ Wall & Column
1 : 10



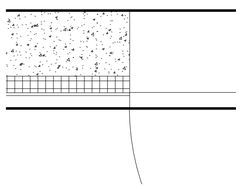

8 A802 — Level 1 - West Stairwell Curtain Wall Jamb
1 : 10




6 A802 — Level 1 - Exterior Column @ Entrance
1 : 10




3 A802 — Level 1 - Typ. Furring @ Column
1 : 10



9 A802 — Level 1 - Stair Exit Door Jamb
1 : 10

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Stamp:

Sub Consultants:

MORRISON HERSHFIELD

PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|

Client:

10 Mile Holdings Inc.

Project:

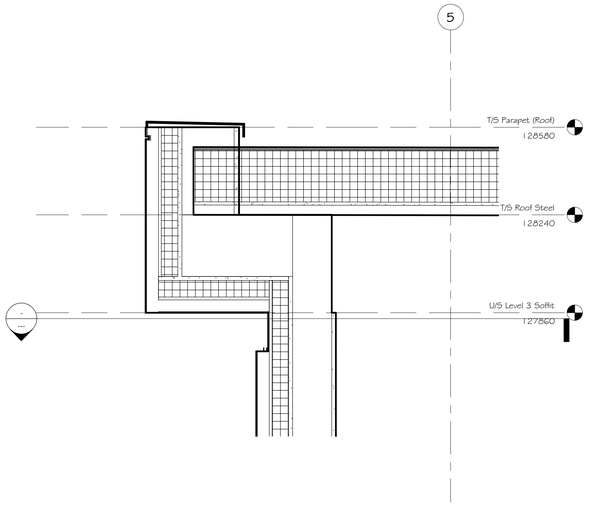
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

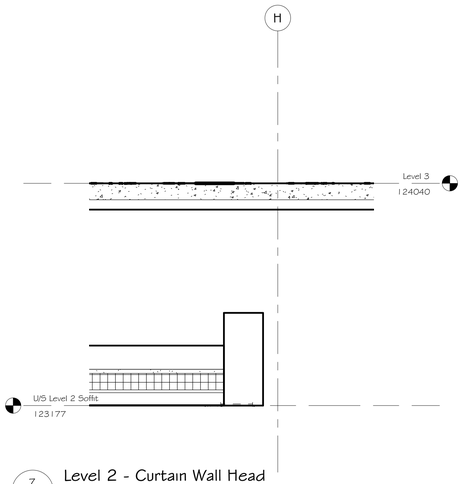
## Plan Details

| | |
|---|---|
| Scale: | 1 : 10 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

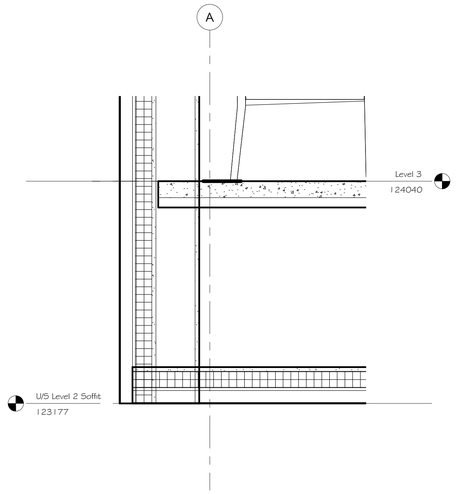
A802



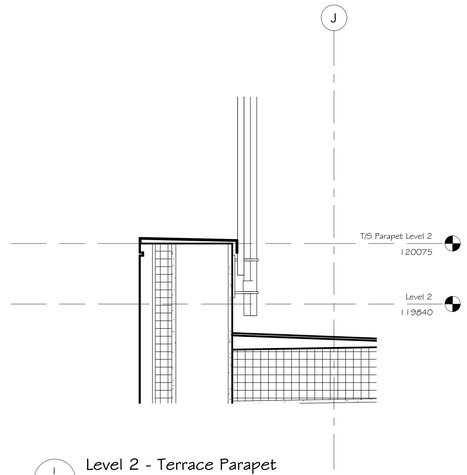

10 A803 — Level 3 - Parapet
1 : 10



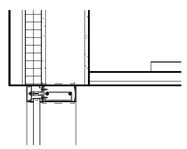

7 A803 — Level 2 - Curtain Wall Head
1 : 10



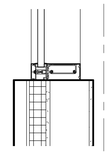

4 A803 — Level 2 - Soffit
1 : 10



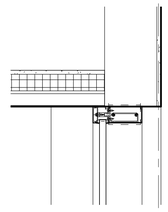

1 A803 — Level 2 - Terrace Parapet
1 : 10



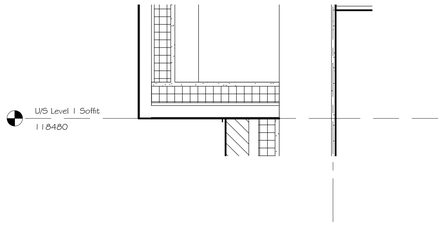
11 A803 — Level 3 - Curtain Wall Head
1 : 10



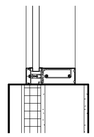

8 A803 — Level 2 - Curtain Wall Sill
1 : 10



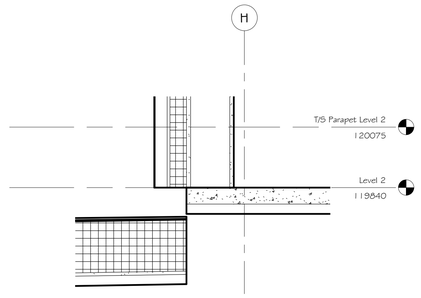

5 A803 — Level 1 - Retail Entrance Head/Jamb
1 : 10



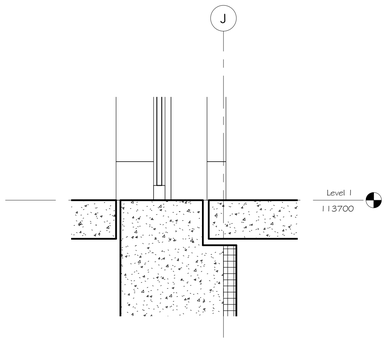

2 A803 — Level 1 - Soffit
1 : 10



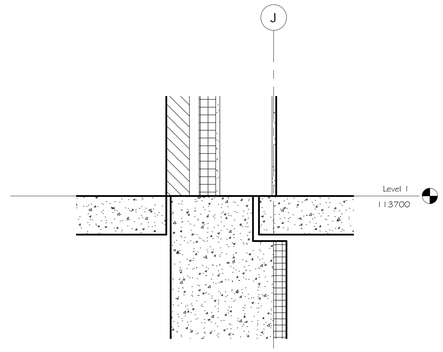
12 A803 — Level 3 - Curtain Wall Sill
1 : 10




9 A803 — Level 2 - Floor/Terrace Roof Intersection
1 : 10




6 A803 — Level 1 - Retail Entrance Threshold
1 : 10




3 A803 — Level 1 - Brick @ Foundation Wall
1 : 10

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Revisions:

| No. | Description | Date |
|---|---|---|

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10 Mile Holdings Inc.

Project:

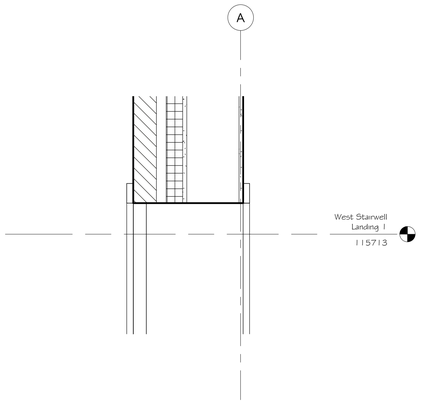
Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Section Details

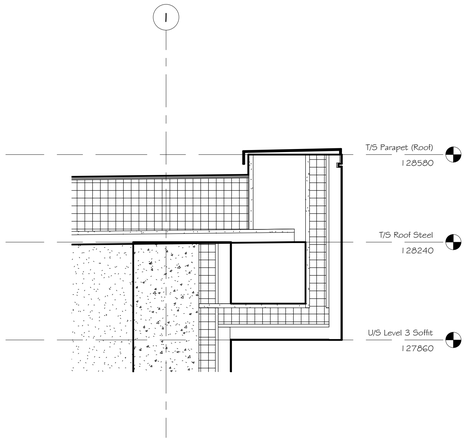
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|---|---|
| Scale: | 1 : 10 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A803



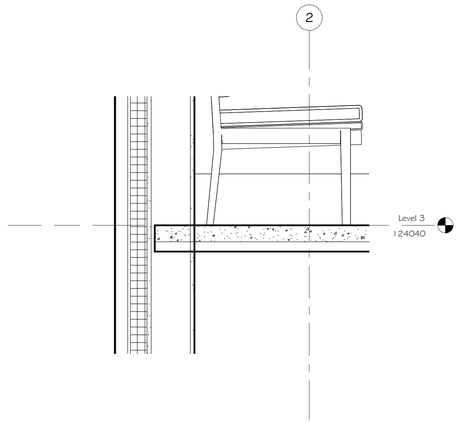

10 / A804 — Level 1 - Pressed Steel Frame Door Head/Jamb

1 : 10



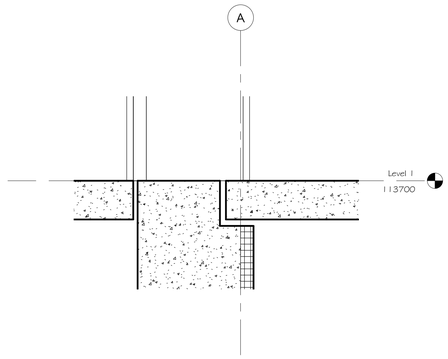

7 / A804 — Stairwell Parapet

1 : 10



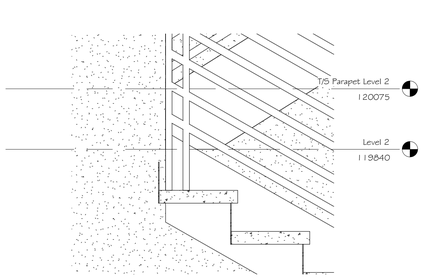

4 / A804 — East Wall - Level 3 Floor/Wall Intersection

1 : 10



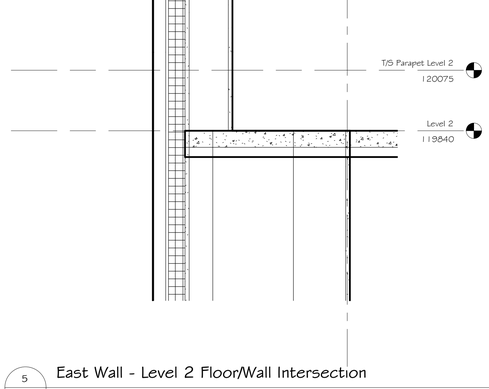

11 / A804 — Level 1 - Pressed Steel Frame Door Threshold

1 : 10



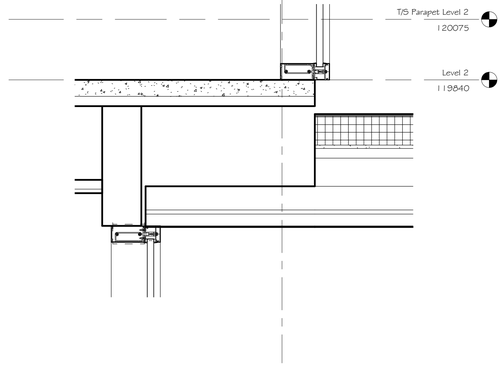

8 / A804 — Stairs @ Top of Flight

1 : 10



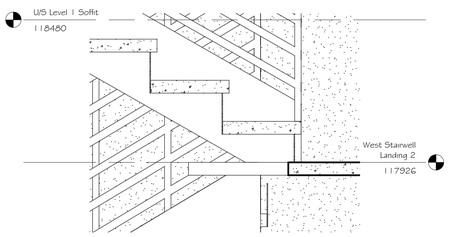

5 / A804 — East Wall - Level 2 Floor/Wall Intersection

1 : 10



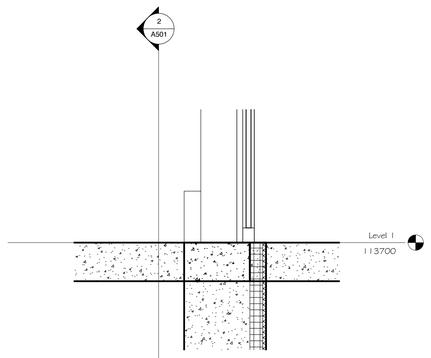

2 / A804 — East Entrance - Metal Canopy Connection

1 : 10



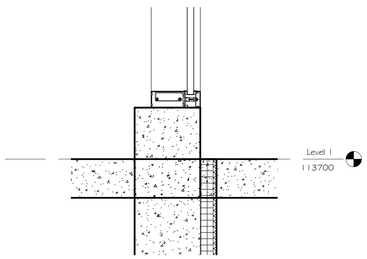

9 / A804 — Stairs @ Bottom of Flight

1 : 10




6 / A804 — East Entrance - Door Threshold

1 : 10




3 / A804 — East Entrance - Curtain Wall Sill

1 : 10

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Stamp:

Sub Consultants:

MORRISON HERSHFIELD

PINNACLE ENGINEERING LIMITED
Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|

Client:

10 Mile Holdings Inc.

Project:

Orthodontic Clinic

Location: Hebron Way
St. John's, NL

## Section Details

| | |
|---|---|
| Scale: | 1 : 10 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A804

Door Schedule

| Mark | Width | Height | HDWR Group | Door Type | Fire Rating | Door Material | Door Finish | Frame Type | Frame Material | Frame Finish | Glazing | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 1 | | | | | | | | | | | | |
| 101 | 915 | 2134 | | | | | | | | | | |
| 102 | 915 | 2134 | | | | | | | | | | |
| 107 | 915 | 2134 | | | | | | | | | | |
| 108 | 915 | 2134 | | | | | | | | | | |
| 109 | 915 | 2134 | | | | | | | | | | |
| X100 | 1830 | 2162 | | | | | | | | | | |
| X101 | 915 | 2134 | | | | | | | | | | |
| X103 | 915 | 2134 | | | | | | | | | | |
| X104 | 915 | 2134 | | | | | | | | | | |
| X105 | 915 | 2134 | | | | | | | | | | |
| X106 | 1842 | 2160 | | | | | | | | | | |
| X107 | 1842 | 2160 | | | | | | | | | | |
| X108 | 915 | 2134 | | | | | | | | | | |
| Level 2 | | | | | | | | | | | | |
| 102a | 915 | 2134 | | | | | | | | | | |
| 107a | 915 | 2134 | | | | | | | | | | |
| 202 | 762 | 2134 | | | | | | | | | | |
| 203 | 915 | 2134 | | | | | | | | | | |
| 207 | 915 | 2134 | | | | | | | | | | |
| X111 | 915 | 2134 | | | | | | | | | | |
| X201 | 915 | 2134 | | | | | | | | | | |
| X202 | 915 | 2134 | | | | | | | | | | |
| X203 | 941 | 1934 | | | | | | | | | | |
| X204 | 941 | 2735 | | | | | | | | | | |
| Level 3 | | | | | | | | | | | | |
| 102b | 915 | 2134 | | | | | | | | | | |
| 107b | 915 | 2134 | | | | | | | | | | |
| 302 | 915 | 2134 | | | | | | | | | | |
| 303 | 915 | 2134 | | | | | | | | | | |


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Sub Consultants:

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Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|

Client:

10 Mile Holdings Inc.

Project:

Orthodontic Clinic

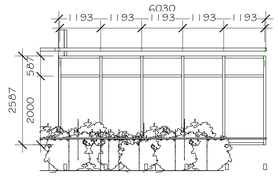
Location: Hebron Way
St. John's, NL

Schedules

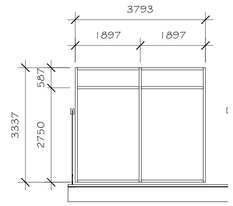
Scale:
Date: December 2012
Drawn By: A. Winter
Checked By: J. Case
Job Number: 12-1290

A1001

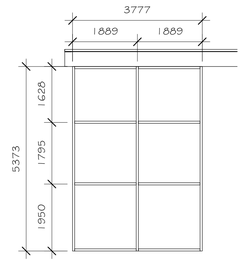


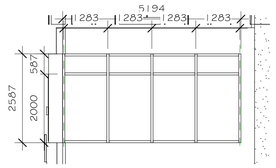

Level 2 - Curtain Wall (NW)



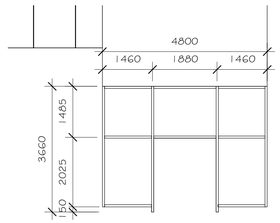

Level 2 - Curtain Wall (East Core - East)



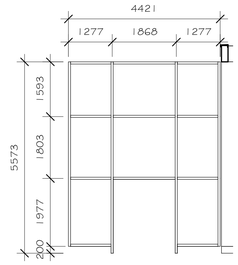

Level 1 - Curtain Wall (East Core - East)



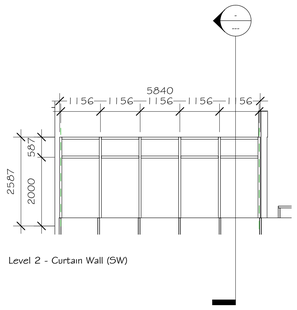

Level 2 - Curtain Wall (SE)



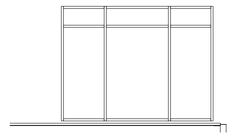

Level 1 - Storefront Entrance



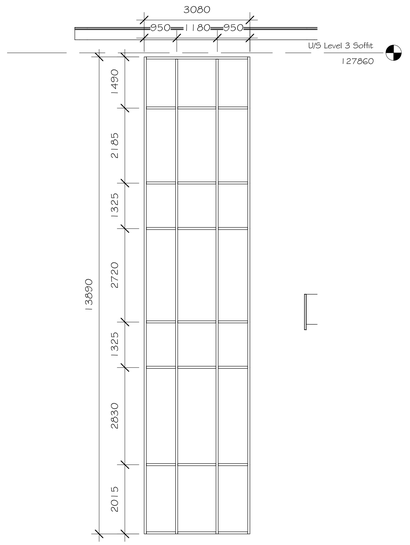

Level 1 - Curtain Wall (East Core - Entrance)



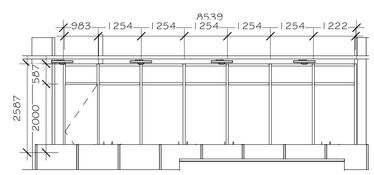

Level 2 - Curtain Wall (SW)



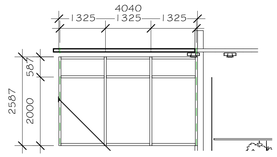
Level 2 - Curtain Wall (East Core - South)




Level 1 - Curtain Wall (West Core)




Level 2 - Curtain Wall btw Columns (Typ)




Level 2 - Curtain Wall (NE)

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Stamp:

Sub Consultants:

MORRISON HERSHFIELD

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Civil Engineering & Project Management

maderra ENGINEERING

Revisions:

| No. | Description | Date |
|---|---|---|

Client:

10 Mile Holdings Inc.

Project:

Orthodontic Clinic

Location: Hebron Way
St. John's, NL

Schedules

| | |
|---|---|
| Scale: | 1 : 75 |
| Date: | December 2012 |
| Drawn By: | A. Winter |
| Checked By: | J. Case |
| Job Number: | 12-1290 |

A1002

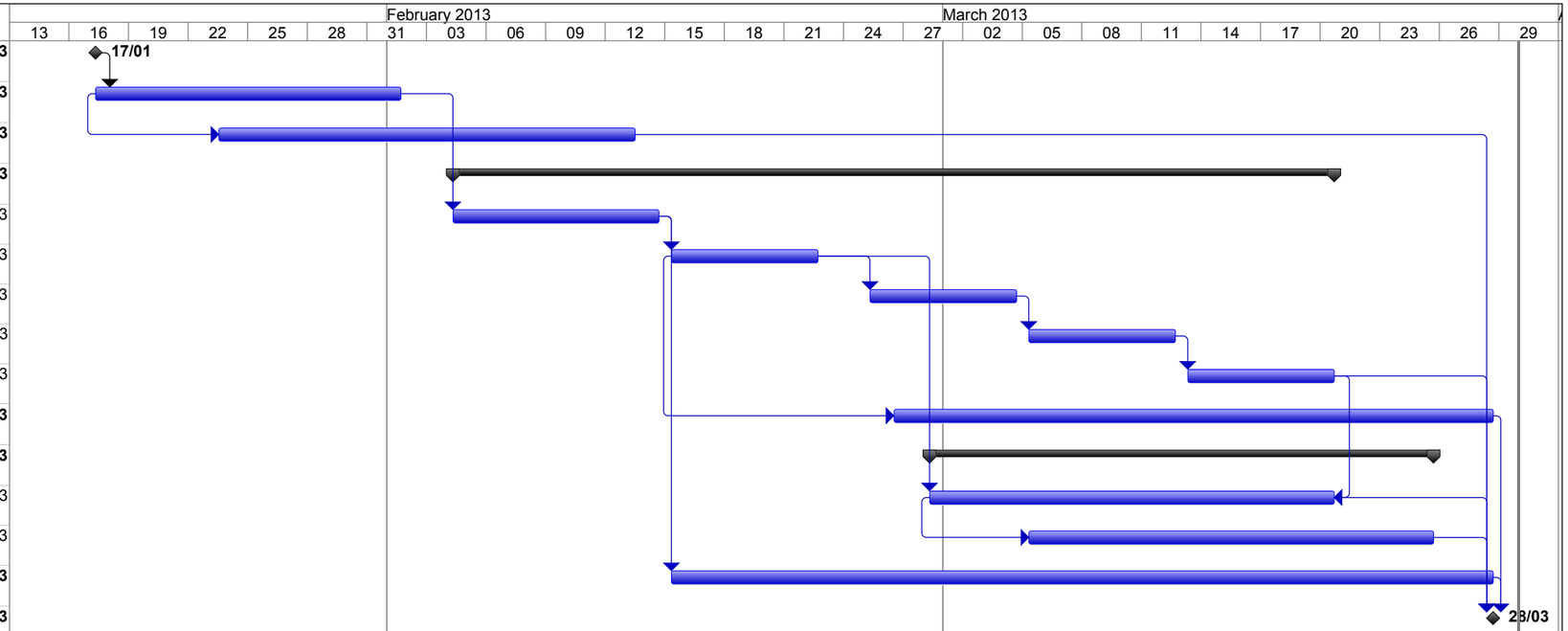
STRATA SOLUTIONS

# Appendix B

# Project Schedules

Baseline Schedule
Final Schedule

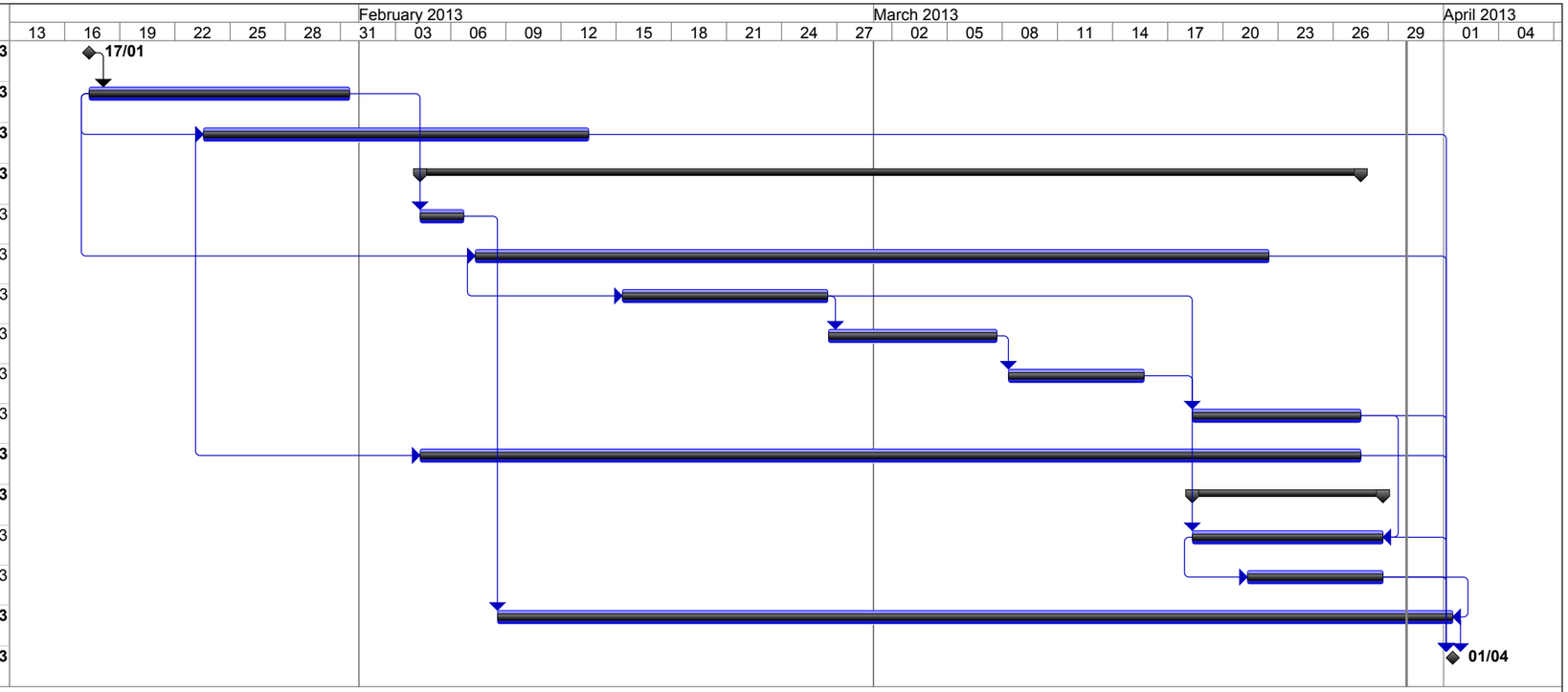
| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Project Start** | **0 days** | **Thu 17/01/13** | **Thu 17/01/13** |
| 2 | **Create project plan** | **8 days** | **Thu 17/01/13** | **Fri 01/02/13** |
| 3 | **Research technical requirements** | **10 days** | **Wed 23/01/13** | **Wed 13/02/13** |
| 4 | **Structural design** | **22 days** | **Mon 04/02/13** | **Wed 20/03/13** |
| 5 | Determination of loading patterns | 6 days | Mon 04/02/13 | Thu 14/02/13 |
| 6 | Roof design | 4 days | Fri 15/02/13 | Fri 22/02/13 |
| 7 | Wall and column design | 4 days | Mon 25/02/13 | Mon 04/03/13 |
| 8 | Floor design | 4 days | Tue 05/03/13 | Tue 12/03/13 |
| 9 | Foundation design | 4 days | Wed 13/03/13 | Wed 20/03/13 |
| 10 | **Drafting** | **15 days** | **Tue 26/02/13** | **Thu 28/03/13** |
| 11 | **Project control** | **12 days** | **Thu 28/02/13** | **Mon 25/03/13** |
| 12 | Quantity takeoffs | 10 days | Thu 28/02/13 | Wed 20/03/13 |
| 13 | Cost estimate | 10 days | Tue 05/03/13 | Mon 25/03/13 |
| 14 | **Project report** | **20 days** | **Fri 15/02/13** | **Thu 28/03/13** |
| 15 | **Project Completion** | **0 days** | **Thu 28/03/13** | **Thu 28/03/13** |




Project: Project Plan
Date: Sat 30/03/13

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | | Project Summary | | Inactive Milestone | | Manual Summary Rollup | | Progress | |
| Split | | External Tasks | | Inactive Summary | | Manual Summary | | Deadline | |
| Milestone | | External Milestone | | Manual Task | | Start-only | | | |
| Summary | | Inactive Task | | Duration-only | | Finish-only | | | |

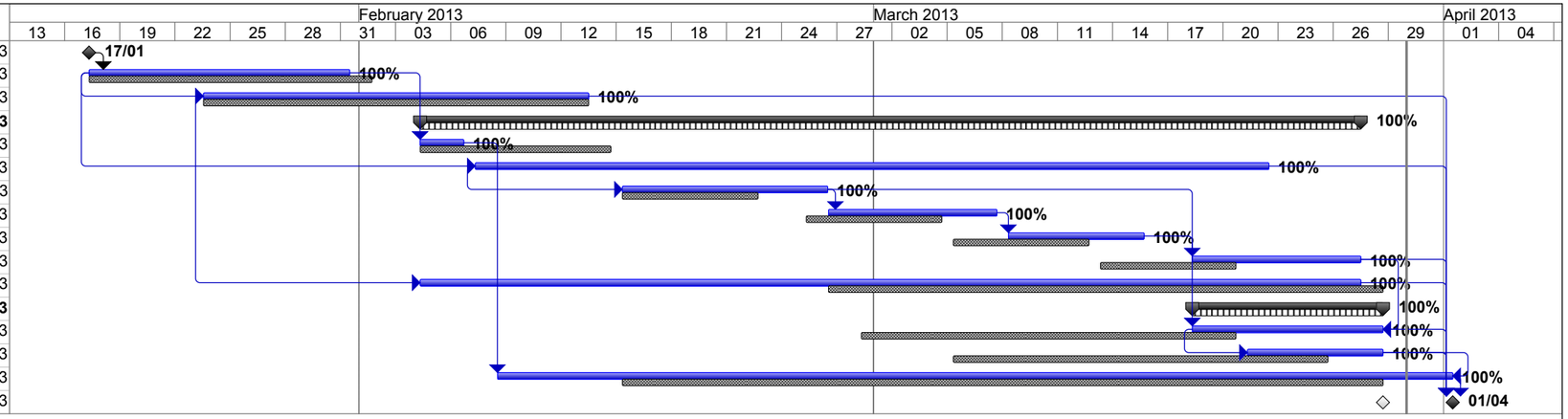
| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Project Start** | **0 days** | **Thu 17/01/13** | **Thu 17/01/13** |
| 2 | **Create project plan** | **7 days** | **Thu 17/01/13** | **Thu 31/01/13** |
| 3 | **Research technical requirements** | **10 days** | **Wed 23/01/13** | **Wed 13/02/13** |
| 4 | **Structural design** | **25 days** | **Mon 04/02/13** | **Wed 27/03/13** |
| 5 | Determination of loading patterns | 2 days | Mon 04/02/13 | Wed 06/02/13 |
| 6 | Model structure in S-Frame | 21 days | Thu 07/02/13 | Fri 22/03/13 |
| 7 | Roof design | 5 days | Fri 15/02/13 | Tue 26/02/13 |
| 8 | Floor design | 5 days | Tue 26/02/13 | Thu 07/03/13 |
| 9 | Beam and column design | 4 days | Fri 08/03/13 | Fri 15/03/13 |
| 10 | Foundation design | 5 days | Mon 18/03/13 | Wed 27/03/13 |
| 11 | **Drafting** | **25 days** | **Mon 04/02/13** | **Wed 27/03/13** |
| 12 | **Project control** | **6 days** | **Mon 18/03/13** | **Thu 28/03/13** |
| 13 | Quantity takeoffs | 6 days | Mon 18/03/13 | Thu 28/03/13 |
| 14 | Cost estimate | 4 days | Thu 21/03/13 | Thu 28/03/13 |
| 15 | **Project report** | **24 days** | **Fri 08/02/13** | **Mon 01/04/13** |
| 16 | **Project Completion** | **0 days** | **Mon 01/04/13** | **Mon 01/04/13** |




Project: Project Plan
Date: Sat 30/03/13

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | | Project Summary | | Inactive Milestone | | Manual Summary Rollup | | Progress | |
| Split | | External Tasks | | Inactive Summary | | Manual Summary | | Deadline | |
| Milestone | | External Milestone | | Manual Task | | Start-only | | | |
| Summary | | Inactive Task | | Duration-only | | Finish-only | | | |

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | Project Start | 0 days | Thu 17/01/13 | Thu 17/01/13 |
| 2 | Create project plan | 7 days | Thu 17/01/13 | Thu 31/01/13 |
| 3 | Research technical requirements | 10 days | Wed 23/01/13 | Wed 13/02/13 |
| 4 | **Structural design** | **25 days** | **Mon 04/02/13** | **Wed 27/03/13** |
| 5 | Determination of loading patterns | 2 days | Mon 04/02/13 | Wed 06/02/13 |
| 6 | Model structure in S-Frame | 21 days | Thu 07/02/13 | Fri 22/03/13 |
| 7 | Roof design | 5 days | Fri 15/02/13 | Tue 26/02/13 |
| 8 | Floor design | 5 days | Tue 26/02/13 | Thu 07/03/13 |
| 9 | Beam and column design | 4 days | Fri 08/03/13 | Fri 15/03/13 |
| 10 | Foundation design | 5 days | Mon 18/03/13 | Wed 27/03/13 |
| 11 | Drafting | 25 days | Mon 04/02/13 | Wed 27/03/13 |
| 12 | **Project control** | **6 days** | **Mon 18/03/13** | **Thu 28/03/13** |
| 13 | Quantity takeoffs | 6 days | Mon 18/03/13 | Thu 28/03/13 |
| 14 | Cost estimate | 4 days | Thu 21/03/13 | Thu 28/03/13 |
| 15 | Project report | 24 days | Fri 08/02/13 | Mon 01/04/13 |
| 16 | Project Completion | 0 days | Mon 01/04/13 | Mon 01/04/13 |




Project: Project Plan
Date: Sat 30/03/13

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical | | Task Progress | | Summary Progress | | Inactive Task | | Manual Summary Rollup | | | |
| Critical Split | | Baseline | | Summary | | Inactive Milestone | | Manual Summary | | | |
| Critical Progress | | Baseline Split | | Project Summary | | Inactive Summary | | Start-only | | | |
| Task | | Baseline Milestone | | External Tasks | | Manual Task | | Finish-only | | | |
| Split | | Milestone | | External Milestone | | Duration-only | | Deadline | | | |

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# Appendix C

# Loading Calculations

Dead Loads
Lives Loads
Basic Snow Loads
Snowdrift Loads
Wind Loads

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# Dead Loads

Calculated by Jacob Tucker
Checked by Mark Reynolds

## Dead Loads - Wall
## Various Wall Materials

| Wall Assembly | Description | psf | kPa |
|---|---|---|---|
| W3 | 64mm rigid poly insulation | 1.875 | 0.090 |
| W3 | 16mm exterior grade gypsum board | 0 | 0.000 |
| W3 | 203mm metal studs + gypsum either side | 8 | 0.383 |
| W3 | 16mm gypsum borad | 0 | 0.000 |
| W4 | 4mm composite aluminum panel | 3 | 0.144 |
| W4 | 75mm metal z-bar @ 1220 o.c. | 1 | 0.048 |
| W4 | 64mm rigid poly insulation | 1.875 | 0.090 |
| W4 | Concrete foundation wall | 143.4829 | 6.870 |
| W6 | 4mm composite aluminum panel | 3 | 0.144 |
| W6 | 75mm metal z-bar @ 1220 o.c. | 1 | 0.048 |
| W6 | 64mm rigid poly insulation | 1.875 | 0.090 |
| W6 | 16mm exterior grade gypsum board | 0 | 0.000 |
| W6 | 152 mm metal studs | 8 | 0.383 |
| W6 | 16mm gypsum borad | 0 | 0.000 |
| W7 | 4mm composite aluminum panel | 3 | 0.144 |
| W7 | 75mm metal z-bar @ 1220 o.c. | 1 | 0.048 |
| W7 | 64mm rigid poly insulation | 1.875 | 0.090 |
| W7 | 16mm exterior grade gypsum board | 0 | 0.000 |
| W7 | 92 mm metal studs | 4 | 0.192 |
| W7 | 203mm metal studs | 8 | 0.383 |
| W7 | 16mm gypsum borad | 0 | 0.000 |
| | | 8 | 0.383 |

# Wall Assemblies
# Dead Loads

| Sum of kPa<br>Row Labels | Total |
|---|---|
| **W3** | **0.47** |
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum borad | 0.00 |
| 203mm metal studs + gypsum either side | 0.38 |
| 64mm rigid poly insulation | 0.09 |
| **W4** | **7.15** |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| Concrete foundation wall | 6.87 |
| **W6** | **0.66** |
| 152 mm metal studs | 0.38 |
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum borad | 0.00 |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| **W7** | **0.86** |
| 16mm exterior grade gypsum board | 0.00 |
| 16mm gypsum borad | 0.00 |
| 203mm metal studs | 0.38 |
| 4mm composite aluminum panel | 0.14 |
| 64mm rigid poly insulation | 0.09 |
| 75mm metal z-bar @ 1220 o.c. | 0.05 |
| 92 mm metal studs | 0.19 |




# Live Load Calculations

Completed by Mark Reynolds & Jacob Tucker

## Live Loads

| Floor | Use | NBCC Loads (kPa) |
|---|---|---|
| 1 | Retail Space | 4.8 |
| 2 | Leasable Space (Office or Retail) | 4.8 |
| 2 | North & South Terrace | 4.8 |
| 3 | Operating Rooms & Laboratories | 3.6 |
| Roof | Roofs | 1 |

Created with Mathcad Express. See www.mathcad.com for more information.

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# Basic Snow Loading

Calculated by Jacob Tucker
Checked by Mark Reynolds

## Basic Snow Loading

$I_s := 1.0$ — Importance factor: Normal

$S_s := 2.9\ kPa$ — Taken from NBCC Climatic Data for St. John's, NL.

$S_r := 0.7\ kPa$

$w := 2 \cdot (3.048\ m + 9.144\ m) = 24.384\ m$

$l := 27.432\ m + 7.682\ m = 35.114\ m$

$$l_c := 2 \cdot w - \left(\frac{w^2}{l}\right) = 31.835\ m$$ — Characteristic length of roof

$C_b := 0.8$ — Section 4.1.6.2, Sentence (2)

$C_w := 1.0$ — Section 4.1.6.2, Sentence (3)

$C_s := 1.0$ — Section 4.1.6.2, Sentence (5)

$C_a := 1.0$ — Section 4.1.6.2, Sentence (8)

$$S := I_s \cdot \left(S_s \cdot \left(C_b \cdot C_w \cdot C_s \cdot C_a\right) + S_r\right) = 3.02\ kPa$$ — Basic Snow Load on Roof

Created with Mathcad Express. See www.mathcad.com for more information.

## Snow Drift loading on mechanical equipment

$b_e := 3.46\ m$ Estimated length of equipment

$w_e := 2.336\ m$ Estimated width of equipment

$\gamma_s := 3\ \frac{kN}{m^3}$ Unit weight of snow

$3 \cdot \frac{S_s}{\gamma_s} = 2.9\ m$

b_e > 2.9m therefore drifting cannot be ignored

w_e < 2.9m therefore drifting can be ignored

$h := 5\ ft = 1.524\ m$ Estimated height of equipment

$x_d := 2\ h = 3.048\ m$

$h' := h - \frac{C_b \cdot C_w \cdot S_s}{\gamma_s} = 0.751\ m$

$10 \cdot h' = 7.507\ m$

$C_a0 := 0.67 \cdot \frac{\gamma_s \cdot h}{C_b \cdot S_s} = 1.32$

$\frac{0.8}{C_b} = 1$ $\frac{2}{C_b} = 2.5$

Use Ca(0) as calculated.

Drift Load (highest)

$S_d := I_s \cdot \left(S_s \cdot \left(C_b \cdot C_w \cdot C_s \cdot C_a0\right) + S_r\right) = 3.763\ kPa$

Drift Load varies linearly from 3.763 kPa against equipment to 3.02 kPa at a distance of 3.048 m (xd) from equipment

Created with Mathcad Express. See www.mathcad.com for more information.

**Snow Drift loading on Second Level Terraces**

**using Paragraph 42 and Figure G-8**

Rationale for drift loading on second level terraces is as follows: Due to the geometry of the structure (i.e. overhangs from third floor) drift loading was not considered based on being a lower roof. Instead, drift loading was considered as though snow would accumulate against the walls of the terrace as though they were an obstruction.

$h := 2587\ mm + 750\ mm = 3.337\ m$ Estimated height of terrace walls

$w := 3.048\ m$ Width of Terrace

$x_d := 2 \cdot h = 6.674\ m$

$C_a0 := 0.67 \cdot \frac{\gamma_s \cdot h}{C_b \cdot S_s} = 2.891$

$\frac{0.8}{C_b} = 1 \qquad \frac{2}{C_b} = 2.5$ Ca(0) > 2/Cb therefore use 2/Cb

$C_a0 := 2.5$

$C_amin := C_a0 - \frac{(C_a0 - 1.0) \cdot w}{x_d} = 1.815$ Minimum Ca value for terrace based on terrace width "w"

Drift Load (highest)

$S_{d1} := I_s \cdot (S_s \cdot (C_b \cdot C_w \cdot C_s \cdot C_a0) + S_r) = 6.5\ kPa$

Drift Load (lowest)

$S_{d2} := I_s \cdot (S_s \cdot (C_b \cdot C_w \cdot C_s \cdot C_amin) + S_r) = 4.911\ kPa$

Drift load varies linearly from 6.5 kPa against terrace wall to 4.911 kPa at a distance of 3.048m from wall (i.e. outer edge of terrace)

Created with Mathcad Express. See www.mathcad.com for more information.

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# Snow Drift UDL's

Calculated by Mark Reynolds
Checked by Jacob Tucker

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 19, 2013

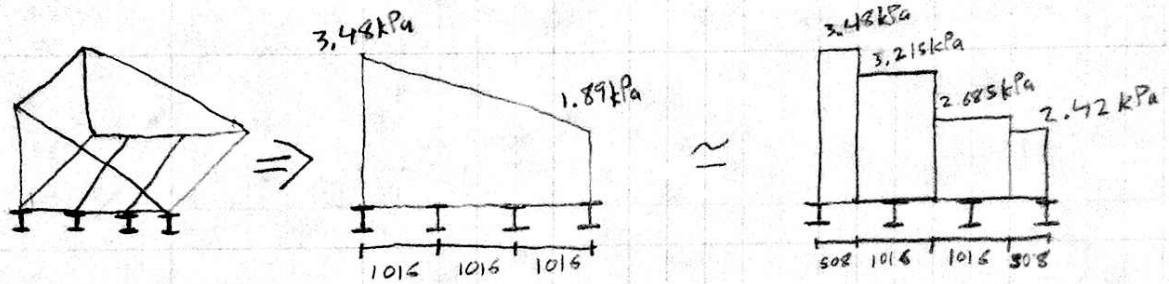

Calculation: Snow Drift UDLs
Created By: Mark Reynolds
Checked By: JACOB TUCKER

# Terrace Snowdrift Loading

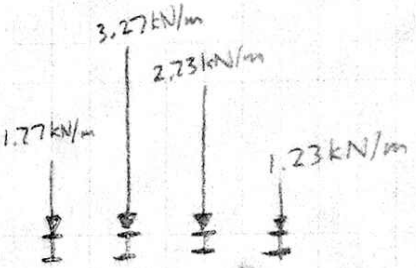
Base Snow Load = 3.02kPa

Peak Drift Load = 6.5 - 3.02 = 3.48kPa
Min Drift Load = 4.911 - 3.02 = 1.89 kPa
1.59 kPa

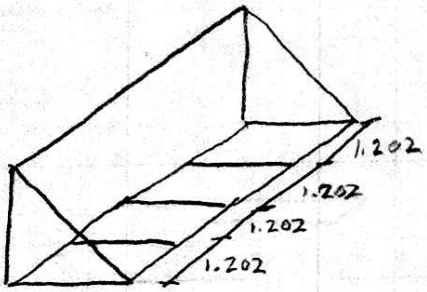
} From Snow Load Calculations ✓




✓




✓




## Edge beams

Peak Load = $\left(\frac{1.202m}{2}\right)$ 3.48kPa = 2.09kN/m ✓

Min Load = $\left(\frac{1.202m}{2}\right)$ 1.89kPa = 1.14 kN/m

## Interior beams

Peak Load = (1.202m) 3.48kPa = 4.18kN/m ✓

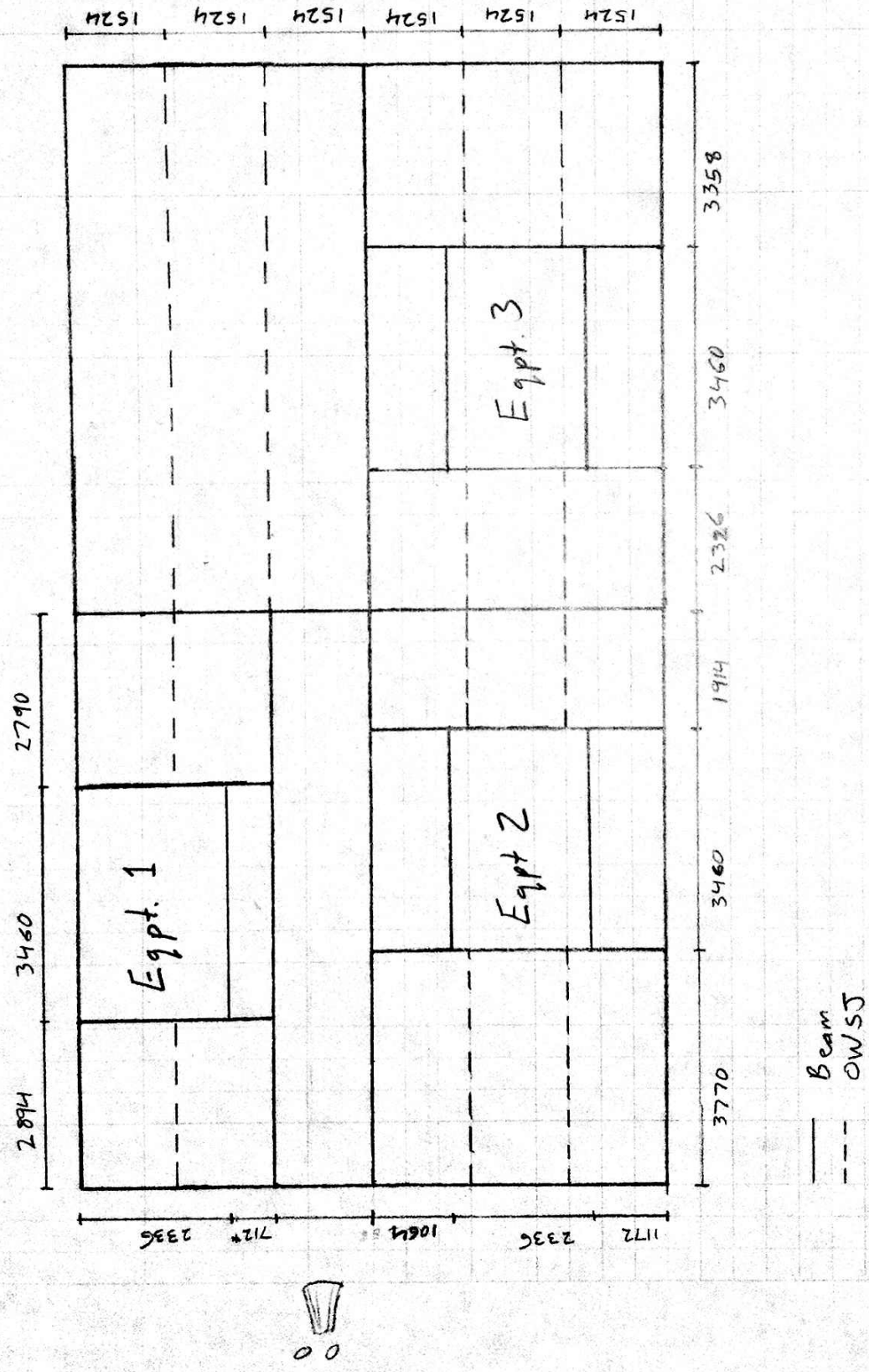
Min Load = (1.202m) 1.89kPa) = 2.28kN/m

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Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 19, 2013


Calculation: Snow Drift UDLs
Created By: Mark Reynolds
Checked By:

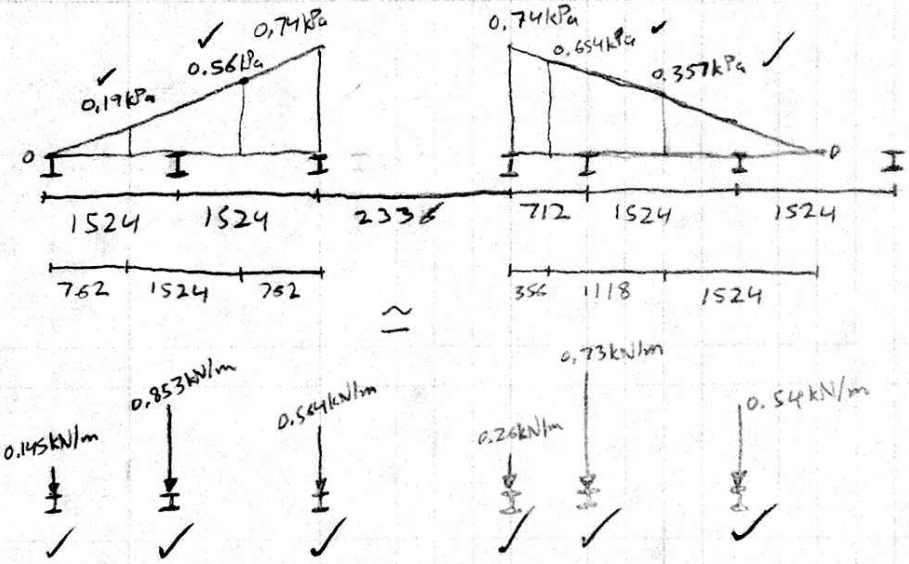



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## Equipment Drift Loading

Peak drift load = 3.76 - 3.02 = 0.74kPa ✓

## Eqpt 1




≃



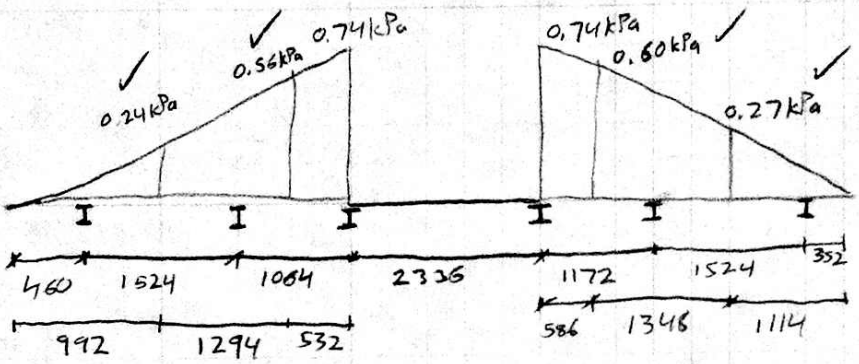

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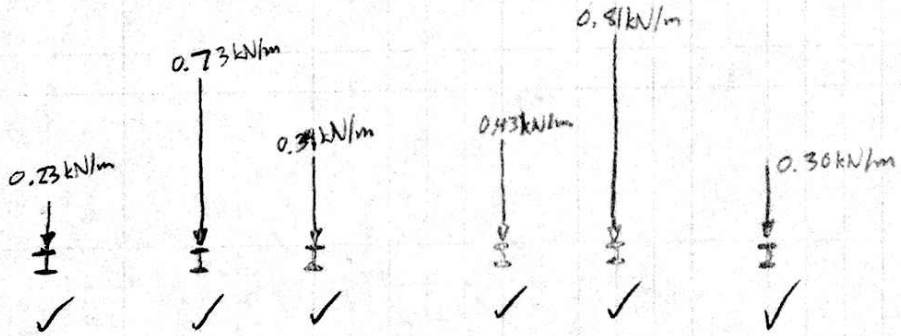
Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 19, 2013


Calculation: Snow Drift UDLs
Created By: Mark Reynolds
Checked By: JACOB TUCKER

Eqpt 2/3




≃




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# Wind Loading

Calculated by Mark Reynolds
Checked by Jacob Tucker

## Wind Loads

Use Figure I-1 of Structural Commentary 4 to classify wind load on buildings:

$H := 128.580\ m - 113.700\ m = 14.88\ m$ From drawing A701;

$H < 120\ m$

$w_1 := 24.384\ m$ From drawing A201;

$h_1 := 119.84\ m - 113.7\ m = 6.14\ m$

$w_2 := 2 \cdot (6.267\ m + 2.878\ m) = 18.29\ m$ From drawing A202;

$h_2 := 123.177\ m - 119.84\ m = 3.337\ m$

$w_3 := 24.384\ m$ From drawing A203;

$h_3 := 128.58\ m - 123.177\ m = 5.403\ m$

$$w := \frac{(w_1 \cdot h_1) + (w_2 \cdot h_2) + (w_3 \cdot h_3)}{h_1 + h_2 + h_3} = 23.017\ m$$

$$\frac{H}{w} = 0.646$$

$\frac{H}{w} < 4$ Not succeptible to vibrations, use the static procedure for analysis;

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$H := 14.88$

$C_e := \left(\frac{H}{10}\right)^{0.2} = 1.083$ Section 4.1.7.1, Sentence (5)

*** for EXPOSED building;

$H := 14.88\ m$

$H < 20\ m$

$D_s := 2 \cdot (6.267\ m + 2.878\ m) = 18.29\ m$

$\frac{H}{D_s} = 0.814$

$\frac{H}{D_s} < 1$ Low-rise building;

Now, use Par. 19-21, 25-28, Fig. I-7 to Calculate CpCg values:

where $I_w := 1.0$ Appendix C, Table C-2

$q := 0.78\ kPa$

$C_e = 1.083$

$p := I_w \cdot q \cdot C_e \cdot C_p C_g$

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| **Case A** | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E |
|---|---|---|---|---|---|---|---|---|
| CpCg | 0.75 | 1.15 | -1.3 | -2 | -0.7 | -1 | -0.55 | -0.8 |
| Pressure (kPa) | 0.632 | 0.970 | -1.096 | -1.686 | -0.590 | -0.843 | -0.464 | -0.675 |

| **Case B** | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E | 5 | 5E | 6 | 6E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CpCg | -0.85 | -0.9 | -1.3 | -2 | -0.7 | -1 | -0.85 | -0.9 | 0.75 | 1.15 | -0.55 | -0.8 |
| Pressure (kPa) | -0.717 | -0.759 | -1.096 | -1.686 | -0.590 | -0.843 | -0.717 | -0.759 | 0.632 | 0.970 | -0.464 | -0.675 |

And:

$H := 14.88\ m$

$\alpha := 0\ deg$

$h := H = 14.88\ m$

$z := min\left(\left(10\% \cdot D_s\right), \left(40\% \cdot H\right)\right) = 1.829\ m$

but not less than $\max\left(\left(4\% \cdot D_s\right), \left(1\ m\right)\right) = 1\ m$ O.K.

$$z = 1.829\ m$$

$y := \max\left(\left(6\ m\right), \left(2 \cdot z\right)\right)$

$$y = 6\ m$$

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Pressure and Suction based on Paragraph 31

$C_{pi1} := -0.45$ Internal Suction Coefficient

$C_{pi2} := 0.3$ Internal Pressure Coefficient

$C_{gi} := 2.0$ Internal Gust Effect Factor

$p_{i1} := I_w \cdot q \cdot C_e \cdot C_{pi1} \cdot C_{gi} = -0.76\ kPa$

$p_{i2} := I_w \cdot q \cdot C_e \cdot C_{pi2} \cdot C_{gi} = 0.507\ kPa$

## Governing Wind Loads

Worst case uplift force will occur when exterior wind forces are combined with internal pressure. Adding internal pressure to each of the forces on the faces gives the following wind loads:

| **Case A** | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E |
|---|---|---|---|---|---|---|---|---|
| Pressure (kPa) | 0.125 | 0.463 | -1.603 | -2.193 | -1.097 | -1.350 | -0.971 | -1.182 |

| **Case B** | 1 | 1E | 2 | 2E | 3 | 3E | 4 | 4E | 5 | 5E | 6 | 6E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure (kPa) | -1.224 | -1.266 | -1.603 | -2.193 | -1.097 | -1.350 | -1.224 | -1.266 | 0.125 | 0.463 | -0.971 | -1.182 |

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# Shear Core- Foundation Wall Loads

Calculated by Mark Reynolds
Checked by Jacob Tucker

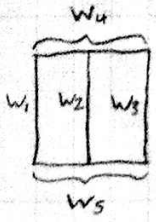
STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 27, 2013


Calculation: Shear Core Fdn. Wall Loads
Created By: Mark Reynolds
Checked By: JACOB TUCKER

West Shear Core

- Use consistent wall sizing
- Wall W3 will govern because of additional loads transferred from steel framing




✓

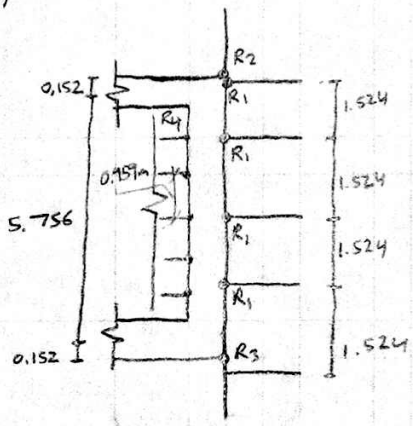
Wall self-weight ⇒ 7.15 kPa (see wall dead load calcs)

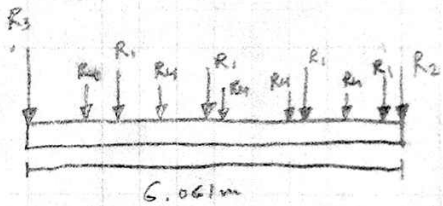
↳ into shear core foundation wall

$= (7.15\,kPa)(14.54\,m) = 104.0\,kN/m$ (height) ✓

Now add loads from steel framing:

Geometry: (same for all floors)




$R_1 \rightarrow$ JOISTS
$R_{2,3} \rightarrow$ GIRDERS
$R_4 \rightarrow$ INFILL

✓

Floor 2:

1.25D + 1.5L + 0.5S governs

$R_1 \simeq 60\,kN$
$R_2 \simeq 105\,kN$
$R_3 \simeq 212\,kN$
} S-Frame ✓

$R_4 \simeq [1.25(1.85\,kPa) + 1.5(4.8\,kPa)][0.959\,m][3.248\,m]/2 \Rightarrow R_4 \simeq 14.8\,kN$ ✓

Floor 3:

Same load case governs

$R_1 \simeq 60\,kN$
$R_2 \simeq 115\,kN$
$R_3 \simeq 174\,kN$
} S-Frame ✓

$R_4 \simeq 14.8\,kN$ ✓

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Roof:
1.25D + 1.5S + 0.5L governs
+ using a different worst-case load is conservative

$R_1 \approx 38\,kN$
$R_2 \approx 65\,kN$
$R_3 \approx 124\,kN$
} S-Frame ✓

$R_4 = [1.25(0.55\,kPa) + 1.5(3.02\,kPa) + 0.5(1.0\,kPa)](0.959\,m)[3.248\,m]/2 \Rightarrow R_4 \approx 8.90\,kN$ ✓

Total Loads from steel

| | | | | |
|---|---|---|---|---|
| $\Sigma R_1 = 158\,kN$ | × 4 instances | = | 632 kN | ✓ |
| $\Sigma R_2 = 285\,kN$ | × 1 " | = | 285 kN | ✓ |
| $\Sigma R_3 = 510\,kN$ | × 1 " | = | 510 kN | ✓ |
| $\Sigma R_4 = 38.5\,kN$ | × 5 " | = | + 193 kN | ✓ |
| | | | 1620 kN / 5.756 m | |

} Assume even distribution over entire wall

= 281 kN/m ✓

TOTAL SELF-WEIGHT + LOADS

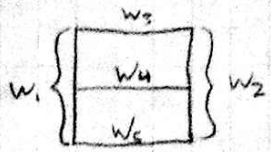
104.0 kN/m
+ 281 kN/m

385 kN/m ← Worst case line load on wall foundations beneath west shear core ✓

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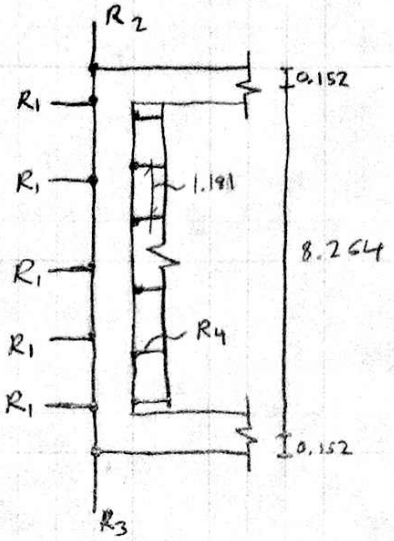
## East Shear Core

Wall Self-Weight = 104.0 kN/m ✓
(From prev. pages)

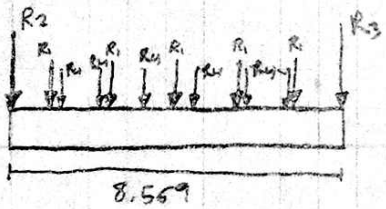



## Loads From steel Framing

Geometry:




$R_1$ → JOISTS
$R_{2,3}$ → GIRDERS
$R_4$ → INFILL




Floor 2:
1.25D + 1.5L + 0.5S governs

$R_1 \simeq 68\,kN$
$R_2 \simeq 72\,kN$
$R_3 \simeq 113\,kN$ ✓

$R_4 = [1.25(1.85\,kPa) + 1.5(4.8\,kPa)](1.181\,m)(7.682\,m)/2 \Rightarrow R_4 \simeq 43.2\,kN$ ✓

Created with Mathcad Express. See www.mathcad.com for more information.

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 27, 2013


Calculation: Shear Core Fdn. Wall Loads
Created By: Mark Reynolds
Checked By: JACOB TUCKER

Floor 3:
Same Load Comb. governs

$R_1 \simeq 68kN$
$R_2 \simeq 109kN$ } S-Frame ✓
$R_3 \simeq 113kN$
$R_4 \simeq 43.2kN$ } same as prev. page ✓

Roof:
1.25D + 1.5S + 0.5L
*using a different worst-case load is conservative

$R_1 \simeq 46kN$
$R_2 \simeq 66kN$ } S-Frame ✓
$R_3 \simeq 85kN$

$R_4 = [1.25(0.55kPa) + 1.5(3.02kPa) + 0.5(1.0kPa)](1.191m)(7.682m)/2 \Rightarrow R_4 = 25.9kN$ ✓

Total Loads From Steel

$\Sigma R_1 = 182kN \times 5$ instances $= 910kN$ ✓
$\Sigma R_2 = 246kN \times 1$ " $= 246kN$ ✓
$\Sigma R_3 = 311kN \times 1$ " $= 311kN$ ✓
$\Sigma R_4 = 112.3kN \times 6$ " $= +674kN$ ✓

$2141kN / 8.264m$

$= 259.1 kN/m$ ✓

Assume even distribution over entire wall

TOTAL SELF-WEIGHT + LOADS

$104.0 kN/m$
$+ 259.1 kN/m$

$363 kN/m$ ← worst case line load on a wall Foundation beneath east shear core ✓

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# Appendix D

# Design Calculations

Slab on Grade Design
Roof Deck Design
Roof Joist Design
Elevated Slab Design
Elevated Slab Joist Design
Canopy Design
Column Base Plates
Wall Footing Design
Pier Foundation Design
Spread Footing Design

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# Slab-on-Grade Design

Completed by Mark Reynolds
Checked by Jacob Tucker

## Slab on Grade Design

Allowable bearing pressure: $200\ kPa$

Concrete strength: $f'_c := 30\ MPa$

## Minimum Reinforcement

$A_g := 150\ mm \cdot 1000\ mm = 150000\ mm^2$ per 1m length of slab;

$A_{smin} := 0.002 \cdot A_g = 300\ mm^2$ Cl. 7.8.1

For each row of reinforcement, use 150 mm^2 of reinforcement as a minimum.

## Maximum Spacing

Spacing shall be the lesser of: Cl. 7.4.1.2

$s_{max} := 500\ mm$

$s_{max} := 3\ (150\ mm) = 450\ mm$

## Cover

$b_c := 30\ mm$ Table 2.6, Part II, Concrete Design Handbook.

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Use structural welded wire reinforcement. From Table 5M in the Structural Welded Wire Reinforcement code:

$s_w := 152\ mm$

Bars per 1m width of slab:

$bars := \frac{(1000\ mm)}{152\ mm} = 6.579$

Cross-sectional area required per bar:

$A_{bar} := \frac{(0.5 \cdot A_{smin})}{bars} = 22.8\ mm^2$

Therefore use MW25 bars

Use a 150mm concrete slab with 152 x 152 - MW25 x MW25 welded wire mesh on top and bottom, each way.

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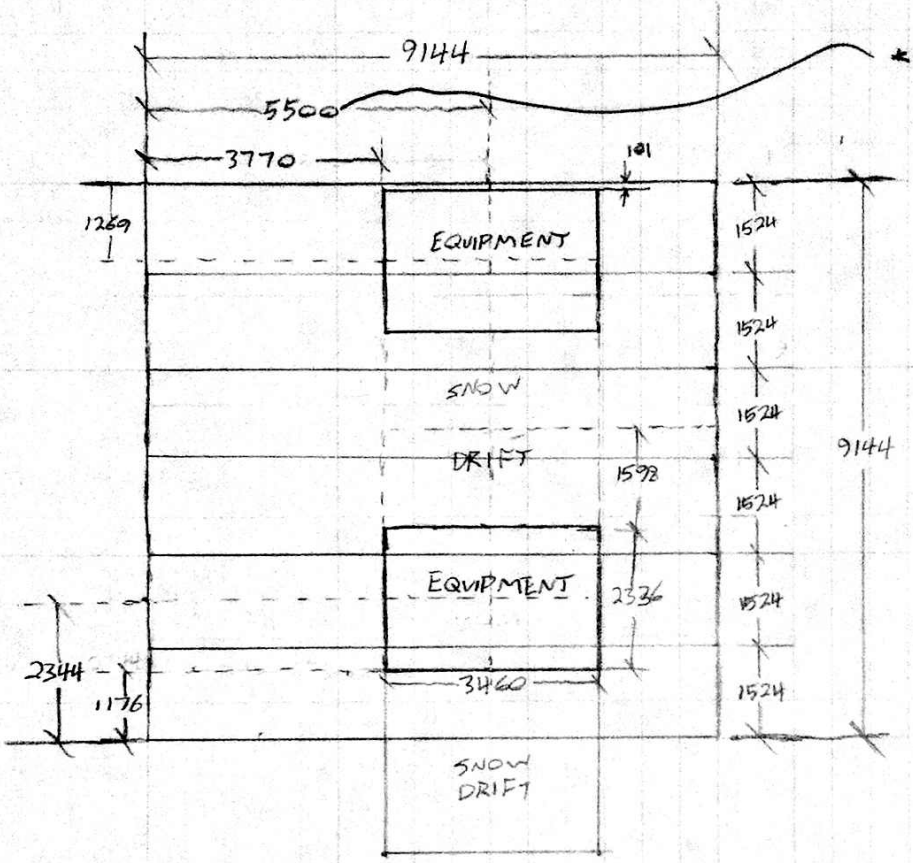
# Roof Deck Design

Completed by Jacob Tucker
Checked by Mark Reynolds

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: 11 MAR, 2013


Calculation: ROOF DECK DESIGN
Created By: JACOB TUCKER
Checked By: Mark Reynolds




* this distance is 4624 mm, but does not affect results

## UNFACTORED LOADS

D.L = 0.55 kPa
↳ EQUIPMENT → 44.482 kN (10 000 lbs)
$A_{EQUIP}$ = 8.083 $m^2$
$w_e$ = 44.482 kN / 8.083 $m^2$ = 5.503 kPa ✓

LL = 1.0 kPa ✓

S = 3.02 kPa ✓
$S_{Dmax}$ = 3.763 kPa ✓

$S_D$ (@ Ⓕ) = $3.76 - \left(\frac{1176}{3048}\right)(3.76 - 3.02) = 3.47$ kPa
* $S_D$ (BETWEEN EQUIPMENT) = $3.76 - \left(\frac{1598}{3048}\right)(3.76 - 3.02) = 3.37$ kPa ✓
$S_D$ (@ Ⓐ) = $3.76 - \left(\frac{101}{3048}\right)(3.76 - 3.02) = 3.74$ kPa

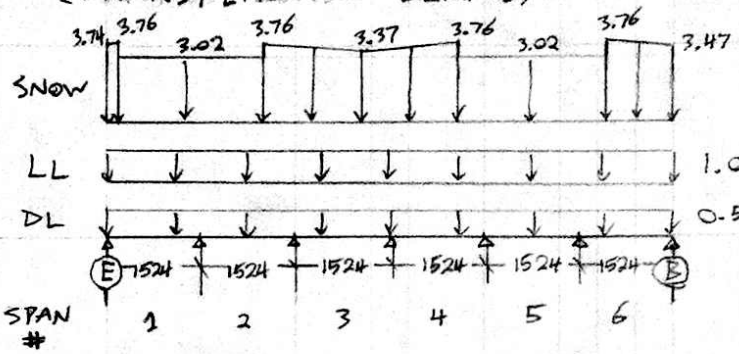
* ASSUME DRIFT BETWEEN EQUIPMENT HITS MINIMUM MIDWAY ✓

MR

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USE 5 ft (1524 mm) JOIST SPACING

NEGLECT ROOF EQUIPMENT (TRANSFERS TO BEAMS)




APPLY LOADS TO 1m STRIP USING S-FRAME, DETERMINE MAX MOMENT ON EACH DECK SPAN. THEN USE $M = wl^2/8$ TO DETERMINE EQUIVALENT DISTRIBUTED LOAD

↳ agreed upon with client

SERVICE LOADS

SPAN 1
$M = 1.329$ kN·m → $w = 4.58$ kN/m

SPAN 2
$M = 1.392$ kN·m → $w = 4.79$ kN/m

SPAN 3
$M = 1.451$ kN·m → $w = 5.00$ kN/m ← upon review of deck framing, THIS will govern because there are openings below the equipment

SPAN 4
$M = 1.479$ kN·m → $w = 5.09$ kN/m

SPAN 5
$M = 1.327$ kN·m → $w = 4.57$ kN/m

SPAN 6
$M = 1.489$ kN·m → $w = 5.13$ kN/m ← WORST CASE

APPLY WORST CASE BACK OVER 1m STRIP

∴ 5.13 kPa SERVICE LOAD

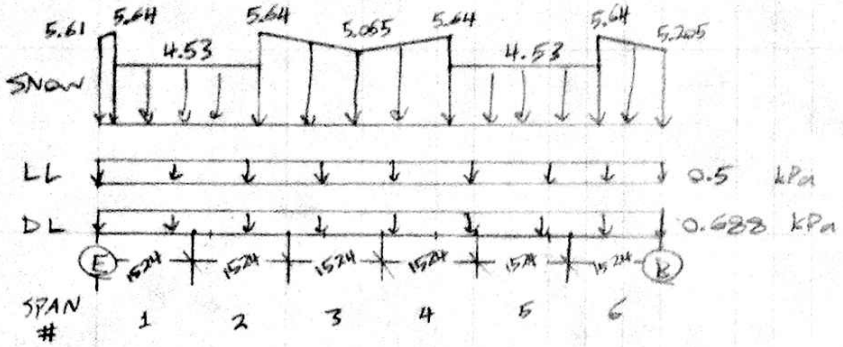
5.00 kPa service load

MR

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BY OBSERVATION, WORST LOAD CASE PER NBCC 2010 =

CASE 3: 1.25 D + 1.5 S + 0.5 L




USE S-FRAME AS BEFORE TO FIND EQUIVALENT UNIFORM LOAD ON EACH SPAN

FACTORED LOADS

SPAN 1
M = 1.663 kN·m → w = 5.73 kN/m

SPAN 2
M = 1.758 kN·m → w = 6.06 kN/m

SPAN 3
M = 1.846 kN·m → w = 6.36 kN/m ← THIS case governs. See previous page for comments.

SPAN 4
M = 1.888 kN·m → w = 6.50 kN/m

SPAN 5
M = 1.660 kN·m → w = 5.72 kN/m

SPAN 6
M = 1.903 kN·m → w = 6.55 kN/m ← WORST CASE

APPLY WORST CASE BACK OVER 1 m STRIP

∴ 6.55 kPa = FACTORED LOAD

6.36 kPa Factored load

MR

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STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: 11 MAR, 2013


Calculation: ROOF DECK DESIGN
Created By: JACOB TUCKER
Checked By: Mark Reynolds

STEEL DECK SELECTION → CANAM TABLES

SPAN 1500 mm (5 ft)

SERVICE LOAD → 5.13 kPa * 5.00kPa

FACTORED LOAD → 6.55 kPa * 6.36 kPa

↳ CHOOSE TYPE 18 P-3615 STEEL DECK

Deck selection is still valid

MR

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**Roof Dead Load**

$W_{D1} := 0.55\ kPa$

Mechanical Equipment - Load Distribution

$l := 3.46\ m$

$w := 2.336\ m$

$A := l \cdot w = 8.083\ m^2$

$W := 10000\ lbf = 44.482\ kN$

$W_M := \frac{W}{A} = 5.503\ kPa$ Distributed load of Mechanical Equipment

Total Dead Load

$W_D := W_{D1} + W_M = 6.053\ kPa$

**Roof Live Load**

$W_L := 1.0\ kPa$

**Roof Snow and Drift Load (against mechanical units)**

$W_S := 3.02\ kPa$

$W_{Dr} := 3.763\ kPa$

**Wind Load**

Ignore wind load on roof deck as it provides uplift therefore cases with wind will not govern

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## Load Case Combinations

Case 1

$W_{f1} := 1.4 \cdot W_D = 8.475\ kPa$

Case 2

$W_{f2} := 1.25 \cdot W_D + 1.5 \cdot W_L + 0.5 \cdot W_S = 10.577\ kPa$

Case 3

$W_{f3} := 1.25 \cdot W_D + 1.5 \cdot W_S + 0.5 \cdot W_L = 12.597\ kPa$

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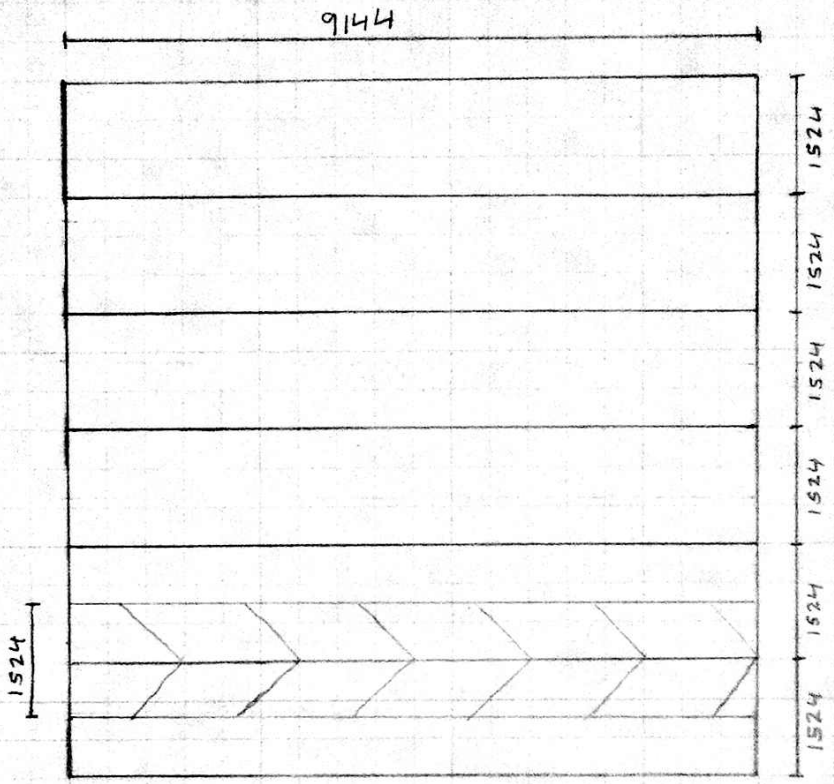
# Roof Joist Selection

Completed by Mark Reynolds
Checked by Jacob Tucker

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 10, 2013


Calculation: Joist Selection - Roof
Created By: Mark Reynolds
Checked By: JACOB TUCKER




Roof joist loading

Use 5-ft joist spacing (1.524m) ✓

By tributary area method:

**Dead Loads**

| | | | | | |
|---|---|---|---|---|---|
| roof assembly | 0.55kPa | × | 1.524m | = 0.84kN/m | ✓ FR COURSE NOTES |
| OWSJ | ~25kg/m | | | ~ 0.25kN/m | ✓ |

**Live Loads** 1.0 kPa × 1.524m = 1.52 kN/m ✓

**Snow Loads** 3.76kPa × 1.524m = 5.73kN/m ✓ PEAK DRIFT

+

**SERVICE LOADS** 8.34 kN/m
↳ GOVERNS

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## FACTORED LOADS

↳ by observation, worst case @ 1.25D + 1.5S + 0.5L ✓

1.25(1.09 kN/m) = 1.36 kN/m ✓
1.50(5.73 kN/m) = 18.60 kN/m ✓
0.50(1.52 kN/m) = + 0.76 kN/m ✓

10.72 kN/m ✓
↳ GOVERNS

## Wind Load Check

$\alpha < 7°$
∴ use Fig. I-9 in NBC 2010 for $C_p C_g$ values ✓

$$z = \min \begin{cases} 0.1(D_s) = 0.1(18.29) = 1.829\,m \\ 0.4(H) = 0.4(14.88) = 5.95\,m \end{cases} > \begin{cases} 1\,m \\ 0.04 D_s \end{cases}$$ ✓ ✓

∴ $z = 1.829\,m$ ✓

$A_c = (1.829)^2 = 3.35\,m^2 \Rightarrow C_p C_g \simeq -3.8$ OR $+0.4$ (CC) ✓

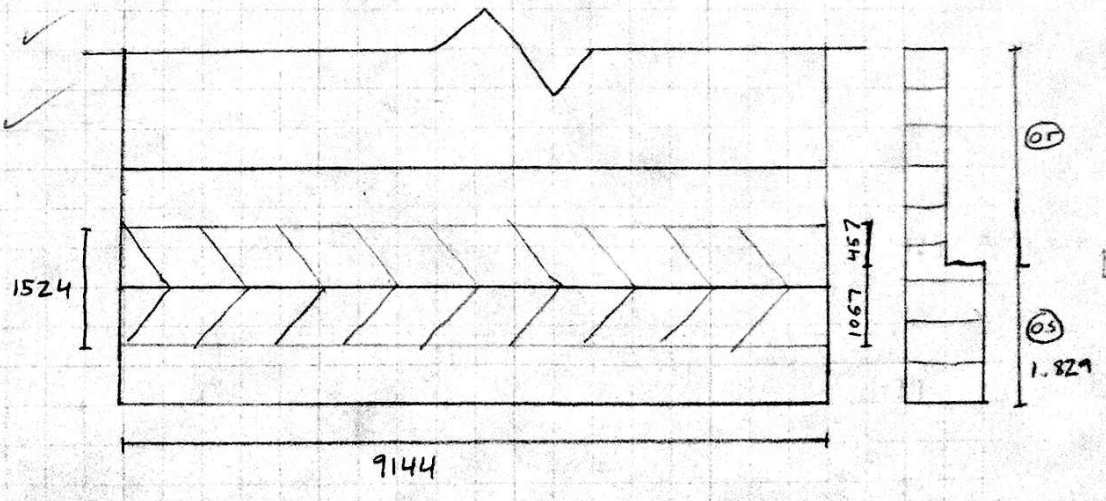
$A_{s1} = (1.829)[(27.432) - (2 \times 1.829)] = 43.5\,m^2 \Rightarrow C_p C_g \simeq -2.0$ OR $+0.35$ (S) ✓

$A_r$ = Large $\Rightarrow C_p C_g \simeq -1.5$ OR $+0.35$ (R) ✓

$I_w = 1.0$ ✓ Worst Case for Wind Loads

$q = 0.78\,kPa$ ✓

$Ce = 1.0$ ✓




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$I_w \, q \, C_e \left[ (C_p C_g)_{os} W_{os} + (C_p C_g)_r W_r \right]$ ✓

$(1.0)(0.78 kPa)(1.0)\left[(-2.0)(1.067m) + (-1.5)(0.457m)\right]$ ✓

$(0.78 kPa)(-2.134_m - 0.686 m)$

$-2.20 kN/m$ ✓

Interior Pressure

↳ Assume building is category

$I_w \, q \, C_e \, C_{pi} C_{gi}$

$(1.0)(0.78 kPa)(1.0)(0.3)(2.0)(1.524 m)$

$0.71 kN/m$

* $C_{pi}$ SCH, $C_{gi}$ from NBC 4.1.7.1(6)(c)

***

Worst Case For Wind

Serviceability: $-2.20 kN/m - 0.71 kN/m = -2.91 kN/m$ uplift

Factored: $1.4(-2.91 kN/m) = -4.07 kN/m$ uplift

↳ * assume $\underline{Q}$ D, L, & S

These do NOT govern ✓

Governing Design Values

Unfactored: 8.34 kN/m ✓
Factored: 10.72 kN/m ✓

Using Conam Joist Depth Selection Table for 10m span:

Use 750mm deep joist* | 18.3 / 90 |* ✓

* pending final review and approval by Canam structural engineer.

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STRATA
SOLUTIONS

# Elevated Slab Design

Completed by Jacob Tucker
Checked by Mark Reynolds

## Elevated Slab Design

Concrete strength: $f'_c := 30\ MPa$

## Minimum Reinforcement

$A_g := 100\ mm \cdot 1000\ mm = 100000\ mm^2$ per 1m length of slab;

$A_{smin} := 0.002 \cdot A_g = 200\ mm^2$ Cl. 7.8.1

Use 200 mm^2 of reinforcement as a minimum.

## Maximum Spacing

Spacing shall be the lesser of: Cl. 7.4.1.2

$s_{max} := 500\ mm$

$s_{max} := 3\ (100\ mm) = 300\ mm$

## Cover

$b_c := 30\ mm$ Table 2.6, Part II, Concrete Design Handbook.

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Use structural welded wire reinforcement. From Table 7M in the Structural Welded Wire Reinforcement code:

$s_w := 152\ mm$

Bars per 1m width of slab:

$bars := \frac{(1000\ mm)}{152\ mm} = 6.579$

Cross-sectional area required per bar:

$A_{bar} := \frac{A_{smin}}{bars} = 30.4\ mm^2$

Therefore use MW35 bars

Use a 100mm concrete slab with 152 x 152 - MW35 x MW35 welded wire mesh each way.

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STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: MAR 12, 2013


Calculation: STEEL DECK - ELEVATED SLABS
Created By: JACOB TUCKER
Checked By: Mark Reynolds

SPAN $l = 1500\,mm = 5\,ft$ ✓
SLAB $t = 100\,mm$

∴ SELECT 0.76 mm thick P-3615 COMPOSITE DECK ✓
FACTORED RESISTANCE = 20 kPa

CHECK RESISTANCE

DEAD LOADS

SELF WEIGHT = 1.85 kPa (FROM TABLE) ✓
* ACCOUNTS FOR DECK & CONCRETE

LIVE LOADS

LL = 4.8 kPa ✓

FACTORED LOADS

$w_f = 1.25\,DL + 1.5\,LL$

$w_f = 9.51$ kPa

$9.51 < 20$ ∴ SELECTION IS OK ✓

MR

Created with Mathcad Express. See www.mathcad.com for more information.

STRATA SOLUTIONS

# Joist Selection- Elevated Slabs

Completed by Jacob Tucker
Checked by Mark Reynolds

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: MAR 14, 2013


Calculation: JOIST SELECTION - ELEVATED SLABS
Created By: JACOB TUCKER
Checked By: Mark Reynolds

# JOIST SELECTION FOR ELEVATED SLABS ON STEEL DECKING

## DEAD LOADS

STEEL DECK W/SLAB
- ↳ 0.76 mm thick P-3615 COMPOSITE DECK
- ↳ 100 mm SLAB
- ↳ FROM CANAM GUIDE, SELF WEIGHT = 1.85 kPa ✓

1.85 kPa × 1.524 m = 2.82 kN/m ✓

OWSJ

≈ 25 kg/m → 0.25 kN/m ✓

LIVE LOADS → 4.8 kPa × 1.524 m = 7.32 kN/m ✓

SERVICE LOADS → (2.82 + 0.25) + 7.32 = 10.39 kN/m ✓

FACTORED LOADS → BY OBSERVATION, 1.25 D + 1.5 L GOVERNS

↳ 1.25 × (2.82 + 0.25) + 1.5 × 7.32 = 14.82 kN/m ✓

FOR 10 m SPAN, USING CANAM TABLES FOR SELECTION

SELECT 750 mm JOIST | 21.6 / 87 | ✓

⚠ CONSIDER SPACE LIMITATIONS
- ↳ 3rd FLOOR ELEVATED SLAB
  - ↳ JOISTS BETWEEN GRIDLINE A-B & H-J

CLEARANCE = 863 mm
− 138 mm
725 mm ∴ CHANGE JOIST DEPTH TO 700 mm

| 22.3 / 76 | ✓

MR

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STRATA
SOLUTIONS

# Canopy Design

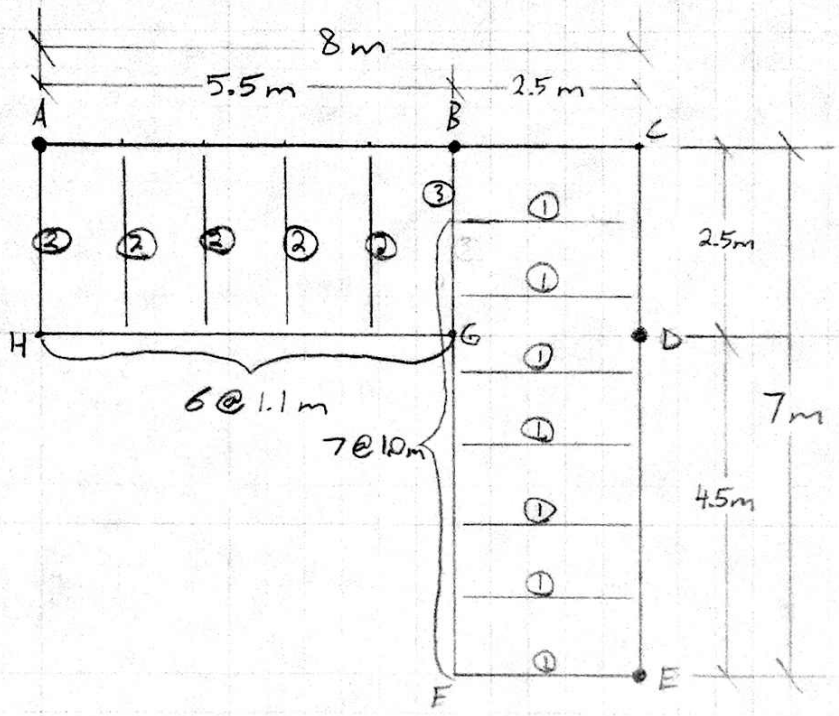
Completed by Jacob Tucker
Checked by Mark Reynolds

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: MAR 27, 2013


Calculation: CANOPY DESIGN
Created By: JACOB TUCKER
Checked By: Mark Reynolds

LAYOUT




TENSION RODS CONNECT AT A, B, D, E
MEMBERS AC & CE CONSTANT, USED FOR FRAMING

## LOADS

DEAD LOAD
↳ CONSIDER SIMILAR TO ROOF
↳ DL = 0.55 kPa

NO LIVE LOAD

SNOW LOAD
↳ CONSIDER SIMILAR DRIFT TO TERRACE
↳ 6.5 kPa @ WALL, 5.2 kPa @ EDGE

WORST CASE LOAD COMBINATION
↳ 1.25 DL + 1.5 SL

DESIGN INTERIOR BEAMS AS SIMPLY SUPPORTED

MR

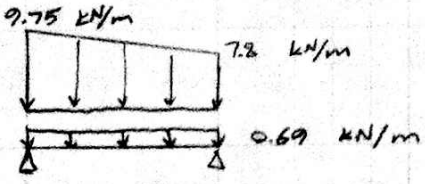
Created with Mathcad Express. See www.mathcad.com for more information.

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: MAR 27, 2013


Calculation: CANOPY DESIGN
Created By: JACOB TUCKER
Checked By: Mark Reynolds

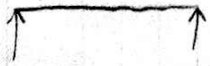
DESIGN BEAM ① → 1m TRIB AREA




→ APPLY IN S-FRAME

MAX MOMENT → 7.63 kN·m

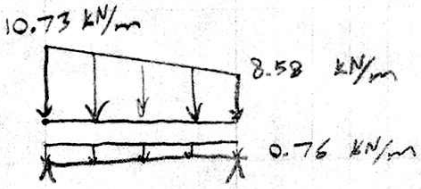
REACTIONS → 12.61 kN 11.79 kN



FROM BEAM SELECTION TABLES CHOOSE

W150 x 24
($M_r$ = 56.4 kN·m)
($V_r$ = 216 kN)

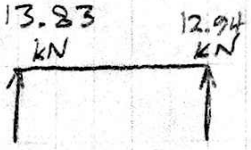
DESIGN BEAM ② → 1.1 m TRIB AREA




→ APPLY IN S-FRAME

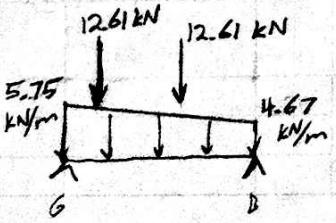
MAX MOMENT → 8.37 kN·m

REACTIONS → 13.83 kN 12.94 kN

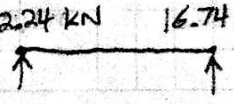


CHOOSE SAME AS BEAM ①
↳ W150x24

CONSIDER BEAM ③ WITH ADDITIONAL PT LOADS DUE TO BEAM ①, & HALF DIST LOADS OF BEAM ② DUE TO LOAD TRANSFER




MAX MOMENT → 14.19 kN·m
RXNS → 22.24 kN 16.74 kN

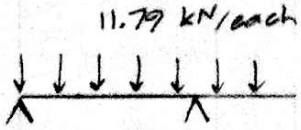


∴ USE W150x24

MR

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BY OBSERVATION, 7m SPAN EDGE BEAM WILL GOVERN DESIGN DUE TO LOAD TRANSFER MECHANISM ✓




→ APPLY IN S-FRAME

MAX MOMENT = 42.88 kN·m ✓

MAX SHEAR = 26.60 kN ✓

FROM SELECTION TABLES CHOOSE ✓

C 200×28

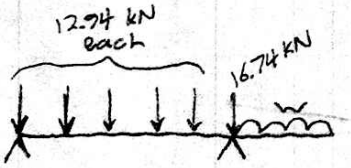
$M_R$ = 48.6 kN·m ✓

$V_R$ = 449 kN

REACTIONS (TENSION MEMBER FORCES) ✓




CHECK 8m SPAN EDGE BEAM




w → ASSUME MIN DRIFT LOAD + DEAD LOAD ✓

1.25×0.55 + 1.5×5.2 = 8.49 kPa

APPLY IN S-FRAME

TRIB WIDTH = 0.5m

w = 8.49 kPa × 0.5 m = 4.25 kN/m ✓

MAX MOMENT = 38.20 kN·m ✓

MAX SHEAR = 24.21 kN ✓

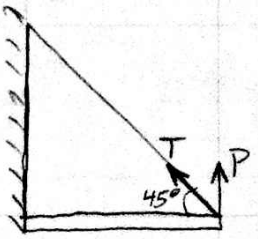
REACTIONS → 


WORST CASE REACTION → 57.65 kN ✓

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# DESIGN TENSION MEMBERS (RODS)

$P = 57.65$ kN (VERTICAL ✓




$$T = \frac{57.65\ kN}{\cos 45^\circ} = 81.53\ kN$$ ✓

$$T = \phi A_s F_y$$

$$\frac{81.53\ kN}{0.9\,(350\ MPa)} = A_s = 258.8\ mm^2$$ ✓

$$d = \sqrt{\frac{A \times 4}{\pi}} = 18\ mm$$ ∴ USE 20 mm STEEL RODS ✓

## SUMMARY

USE W150 x 24 FOR ALL INTERIOR FRAMING ✓

USE C200 x 28 FOR EDGE FRAME ✓

USE 20 mm STEEL RODS FOR TENSION MEMBERS ✓

MR

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STRATA
SOLUTIONS

# Base Plate Selection

Calculations by Jake Tucker
Checked by Colin Gibling

Column Section Information

W250x131

$d := 275\ mm$

$b := 261\ mm$

W250x67

$d := 257\ mm$

$b := 204\ mm$

W200x59

$d := 210\ mm$

$b := 205\ mm$

Concrete Properties

$f'_c := 30\ MPa$

$\phi_c := 0.65$

Steel Properties (300W)

$\phi := 0.9$

$F_y := 300\ MPa$

$F_u := 450\ MPa$

Design steel base plates using procedure from Page 4-149 of CSA S16-09

Created with Mathcad Express. See www.mathcad.com for more information.

Base plate for W250x131

$d := 275\ mm$

$b := 261\ mm$

$C_f := 2100\ kN$

$B_r := 0.85 \cdot \phi_c \cdot f'_c = 16.575\ MPa$

$A_{req} := \frac{C_f}{B_r} = (1.267 \cdot 10^5)\ mm^2$ ✓

$B := \sqrt{A_{req}} = 355.945\ mm$ Therefore set B=C=360mm

$B := 360\ mm$ $C := 360\ mm$

$m := \frac{(C - (0.95 \cdot d))}{2} = 49.375\ mm$

$n := \frac{(B - (0.8 \cdot b))}{2} = 75.6\ mm$

Use n for design

$t_p := \sqrt{\frac{2 \cdot C_f \cdot n^2}{B \cdot C \cdot \phi \cdot F_y}} = 26.192\ mm$ ✓ Therefore use 30mm Plate

$\frac{n}{5} = 15.12\ mm$ 15.12mm < 30mm Therefore OK

CG

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Base plate for W250x67

$d := 257\ mm$

$b := 204\ mm$

$C_f := 710\ kN$

$B_r := 0.85 \cdot \phi_c \cdot f'_c = 16.575\ MPa$

$A_{req} := \frac{C_f}{B_r} = (4.284 \cdot 10^4)\ mm^2$ ✓

$B := \sqrt{A_{req}} = 206.968\ mm$

Therefore Column size governs plate dimensions. Set B=C=285mm ✓

$B := 285\ mm \qquad C := 285\ mm$

$m := \frac{(C - (0.95 \cdot d))}{2} = 20.425\ mm$

$n := \frac{(B - (0.8 \cdot b))}{2} = 60.9\ mm$

Use n for design

$t_p := \sqrt{\frac{2 \cdot C_f \cdot n^2}{B \cdot C \cdot \phi \cdot F_y}} = 15.497\ mm$ ✓

Therefore use 20mm Plate

$\frac{n}{5} = 12.18\ mm$

12.18mm < 20mm Therefore OK

CG

Created with Mathcad Express. See www.mathcad.com for more information.

Base plate for W200x59

$d := 210\ mm$

$b := 205\ mm$

$C_f := 540\ kN$ * Smaller load on smaller column - warrants check

$B_r := 0.85 \cdot \phi_c \cdot f'_c = 16.575\ MPa$

$A_{req} := \frac{C_f}{B_r} = (3.258 \cdot 10^4)\ mm^2$ ✓

$B := \sqrt{A_{req}} = 180.497\ mm$

Therefore Column size governs plate dimensions. Set B=C=240mm ✓

$B := 240\ mm$ $C := 240\ mm$

$m := \frac{(C - (0.95 \cdot d))}{2} = 20.25\ mm$

$n := \frac{(B - (0.8 \cdot b))}{2} = 38\ mm$

Use n for design

$t_p := \sqrt{\frac{2 \cdot C_f \cdot n^2}{B \cdot C \cdot \phi \cdot F_y}} = 10.014\ mm$ ✓

Therefore use 15mm Plate

$\frac{n}{5} = 7.6\ mm$

7.6mm < 15mm Therefore OK

Base plate selected for W250x67 governs for exterior columns. ✓

CG

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Anchor Rods designed as per CSA S16-09 Cl. 25.3.2

Assume 3/4" rods

$d := 0.75\ in = 19.05\ mm$

$A_g := \frac{\pi}{4} \cdot d^2 = 285.023\ mm^2$ ✓

Tensile Resistance of Anchor Rod (S16-09 25.3.2.1)

$\phi_{ar} := 0.67$

$A_n := 0.85 \cdot A_g = 242.27\ mm^2$

$T_r := \phi_{ar} \cdot A_n \cdot F_u = 73.044\ kN$ ✓

Maximum Resistance of Anchor in Tension (A23.3-04 D.6.1.2)

$n := 1$ Number of rods per group

$A_{se} := 0.7\ A_g = 199.516\ mm^2$ Effective Cross Section Area

$f_{ut} := 1.9\ F_y = 570\ MPa$

$R := 0.8$ CSA A23.3-04 D.5.4

$N_{sr} := n \cdot A_{se} \cdot \phi \cdot f_{ut} \cdot R = 81.881\ kN$ CSA A23.3-04 D.6.1

Tr < Nsr Therefore OK ✓

C6

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## Pullout Resistance of Anchor in Tension (A23.3-04 D.6.3)

Set Npr = Tr to determine required depth of rod
(Full Anchorage obtained when Pull-out resistance of concrete is equal to or greater than tensile resistance of rods - S16-09 25.3.2.2)

$N_{pr} := 73.044\ kN$ Pullout Resistance

$R := 0.8$ CSA A23.3-04 D.5.4

$A_{bh} := \frac{N_{pr}}{8 \cdot \phi_c \cdot f'_c \cdot R} = 585.288\ mm^2$ Required bearing area of rod

$h_{ef} := \frac{A_{bh}}{d} = 30.724\ mm$ Required depth of rod

Therefore use a minimum depth of 35mm ✓

$h_{ef} := 35\ mm$ Depth of Rod (assumed)

$A_{bh} := d \cdot h_{ef} = 666.75\ mm^2$ Bearing Area of Rod

$N_{pr} := 8 \cdot A_{bh} \cdot \phi_c \cdot f'_c \cdot R = 83.21\ kN$ Pullout Resistance

$T_r = 73.044\ kN$

83.21 kN > 73.044 kN Therefore Full Anchorage is obtained ✓

Colin Gibling

Created with Mathcad Express. See www.mathcad.com for more information.

STRATA
SOLUTIONS

# Wall Footing Design

Design by Colin Gibling
Checked by Jacob Tucker

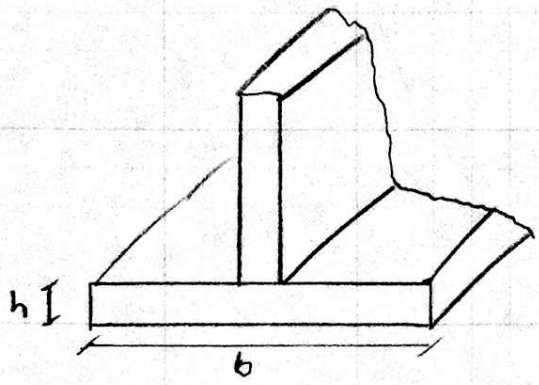
STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 27, 2013


Calculation: Wall Footing
Created By: Colin Gibling
Checked By: JACOB TUCKER

(and East)

# Wall Footings for West Shear Core




Wall thickness equivalent to exterior pier, 350mm ✓

Use 1.6 m foundation depth ✓
Assume $q_{su}$ = 500 kPa
$q_a$ = 200 kPa

Worst case line load = 385 kN/m ✓ Assume $P_s = 0.7(385)$ ✓
$= 270$ kN/m

## 1. Size of Footing

Assume a footing thickness of 300 mm

$q_{sa(net)} = 200 - 0.3^{\text{footing}}(24) - (1.6 - 0.3)^{\text{soil}}(17) = 170.7$ kN/m² ✓

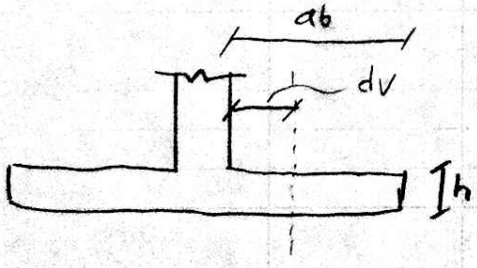
Required width of footing (for 1m strip):

$b = \frac{P}{q_{sa(net)}} = \frac{270 \times 1000}{170.7} = 1582$ mm use 1600 mm ✓

Factored soil pressure:

$q_{sf} = \frac{385}{1.6 \times 1.0} = 241$ kPa $= 0.241$ MPa $< q_{sa} = 500$ MPa ∴ ok ✓

## 2. Footing depth (h)




$V_f = q_{sf}(a_b - d_v) \times 1000\,\text{mm} \le V_c = \phi_c \lambda \beta \sqrt{f'_c}\, b_w d_v$

$\Rightarrow 0.241(625 - d_v) \times 1000\,\text{mm} = 0.65(1.0)(0.21)\sqrt{30} \times 1000\, d_v$

$\Rightarrow d_v = \cancel{201\text{ mm}}$ ✗ 152 mm

$d = \frac{d_v}{0.9} = \cancel{224\text{ mm}}$ ✗ 169 mm

Clear cover of 75mm
No 15M bars

$h = \cancel{224}^{169} + 75 + 16/2 = \cancel{307\text{ mm}}^{252\text{ mm}}$ use $h = \cancel{325\text{ mm}}^{300}$

$\therefore d = \cancel{325}^{300} - 75 - 16/2 = \cancel{242\text{ mm}}^{217} > 150$ mm

∴ OK
Cl. 15.7

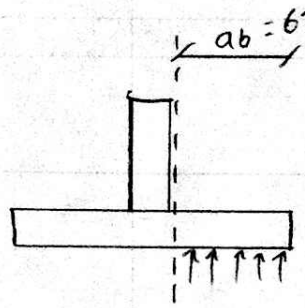
Created with Mathcad Express. See www.mathcad.com for more information.

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 27, 2013


Calculation: Wall Footing
Created By: Colin Gibling
Checked By: JACOB TUCKER

## 3. Design for Moment




Max moment at wall face:

$$M_F = \frac{q_{sf}\, a_b^2}{2} = \frac{0.241(625)^2}{2} \times 1000 = 47.1 \times 10^6\ N\cdot mm \quad ✓$$

$$M_r = k_r b d^2 \times 10^{-6}$$

$$k_r = \frac{47.1 \times 10^6}{1000(217)^2} = 1.00$$

From Table 7.1, $\rho = 0.3\%$, $\rho_{max} = 2.63\%$

$$A_{s,req} = \frac{0.003}{}(1000)(217) = 651\ mm^2$$

$$A_{s,min} = 0.002 \times 1000 \times \frac{300}{600} = 600\ mm^2 \quad \therefore \text{use } A_s = 650\ mm$$

Select 4 - 15M bars per m, spacing 250mm

$$s_{max} = \text{lesser} \begin{cases} 3h = 3(300) = 900 \\ 500 \end{cases} \quad \therefore \text{OK} \quad \text{Cl. 7.4}$$

Check development:

Table 12.1, $l_d = 0.45(0.8)\frac{400}{\sqrt{30}} \times 16.0 = 421\ mm$ ✓

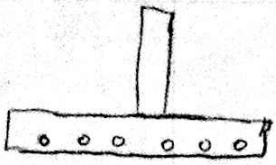
Actual length available = $a_b - 75 = 625 - 75 = 550 > 421\ mm \therefore$ OK ✓

Created with Mathcad Express. See www.mathcad.com for more information.

## 4. Secondary Reinforcement

$A_{s,min} = 0.002 (\overset{300}{\cancel{395}})(1600) = \overset{960}{\cancel{1040}}\ mm^2$

Select 6 No. 15M bars, $A_s = 1700\ mm^2$ ✓



$s = \frac{1600}{6} = 267\ mm$ ✓

$s_{max} = \text{lesser} \begin{cases} 5h \\ 500 \end{cases}$ ∴ OK ✓

## 5. Wall - Footing Connection

Column bearing: $B_r = 0.85 \phi_c f'_c A_1 + \phi_s f_y A_{dowel}$

$0.85(0.65)(30)(350 \times 1000)$ $5.801 \times 10^6\ N$ ✓

$= 5801\ kN$ per 1 m

$B_r > P_f$ ∴ Dowels not required to transfer force. ✓

However, minimum area of reinforcement (C1.14.1.8)

$A_{s,min} = 0.0015 A_g = 0.0015(350 \times 1000) = 525\ mm^2$

∴ use 3 No. 15M, $A_s = 600\ mm^2$ ✓

* Provide dowels to match wall reinforcement

YES.

* Note: East shear core has similar, but slightly smaller applied axial load.
∴ It will use the same design.

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# Wall Footing- Exterior

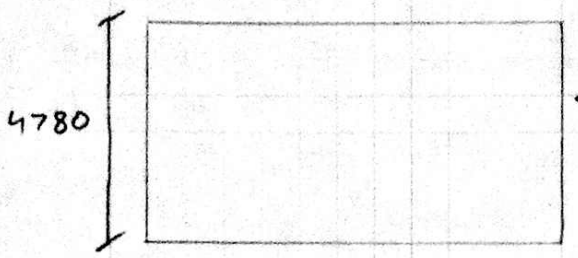
Calculations by Colin Gibling
Checked by Jacob Tucker

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 26, 2013


Calculation: Wall Footing - Exterior
Created By: Colin Cribling
Checked By: JACOB TUCKER

## Wall Footings for Exterior




90 mm clay face brick

From CISC,

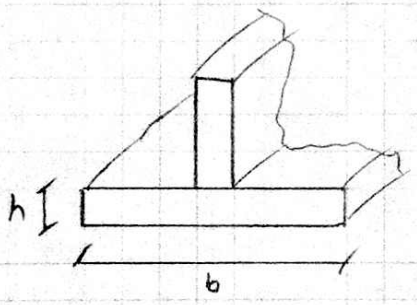
Force = 19.6 KN/m³ ✓

Line load due to brick facing

$P = 19.6\ kN/m^3 \times 4.78\ m \times 0.090\ m = 8.43\ kN/m$ ✓

use 10 kN/m

$P_f = 10(1.25) = 12.5\ kN/m$ ✓




1.6 m foundation depth

$q_{pa} = 700\ kPa$

Assume $q_{su} = 500\ kPa$

Use 300 mm wall width ✓

## 1. Size of Footing

Assume $h = 200\ mm$

$q_{sa(net)} = 200 - 0.2(24)_{footing} - (1.6 - 0.2)(17)_{soil} = 171.4\ kN/m^2$ ✓

$b = \frac{P}{q_{sa(net)}} = \frac{12.5 \times 1000}{171.4} = 80\ mm$

Choose practical width:

Using No. 15M bars, developmental length:

$l_d = 0.45(0.8)\frac{400}{\sqrt{30}}(16.0) = 421\ mm$ ✓

$421 \times 2 + 300_{wall} + 75 \times 2_{cover} = 1292\ mm$ use $b = 1300\ mm$ ✓

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Footing size is more than adequate

∴ Use minimum required reinforcement

$A_{s,min} = 0.002 \times 1000 \times 200 = 400\ mm^2$ ✓

Use 2 No. 15M bars per m, $A_s = 400\ mm^2$

$s = \frac{1000}{2} = 500\ mm$

$s_{max} = \begin{cases} 3h = 600 \\ 500 \end{cases}$ use ∴ OK ✓

CONSIDER 3×15M
↳ > min steel
↳ smaller spacing

## Secondary Reinforcement

$A_{s,min} = 0.002 \times 1300 \times 200 = 520\ mm^2$ ✓

Use 3 No. 15M bars, $A_s = 600\ mm^2$ ✓

$s = \frac{1300}{3} = 433\ mm^2$

$s_{max} = \begin{cases} 600 \\ 500 \end{cases}$ ∴ OK ✓

## Wall Footing Connection

$A_{s,min} = 0.0015 A_g = 0.0015(300 \times 1000) = 450\ mm^2$

Use 3 No. 15M ∴ $A_s = 600\ mm^2$ ✓

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# Pier Foundation Design

Design by Colin Gibling
Checked by Jacob Tucker

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 26, 2013


Calculation: Pier Design
Created By: Colin Gibling
Checked By: JACOB TUCKER

## Pier Design

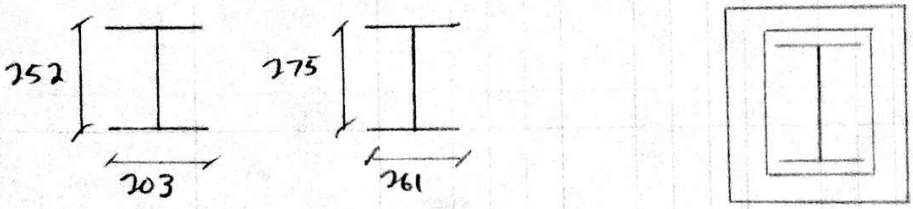
Interior $P_f$ = 2086 kN ✓
Exterior $P_f$ = 712 kN

$f'_c$ = 30 MPa ✓
$f_y$ = 400 MPa

## Interior

Columns range from 529 - 532 → W250x58 - W250x131

W250x58 W250x131




Choose max pier size of 400 mm x 400 mm based on base plate requirements ✓

$A_g$ = 160000 mm²

Table 7.1.2: choose $\rho_t$ = 1% = 0.01 ✓ $P_{r\,max}$ = 2.5 MN ✓

## Reinforcement

$A_s = \rho_t A_g = 0.01(160000\ mm^2) = 1600\ mm^2$ ✓

Choose 9 No. 15M bars (longitudinal)

$A_{s\,total}$ = 1800 mm² ✓

## Ties:

Use No. 10M ties

Cl. 7.6.5.2 { 16 (16.0) = 256 ; 48 (11.3) = 542.4 ; 400 } use Spacing shall not exceed ✓

Use spacing of 240 mm ✓

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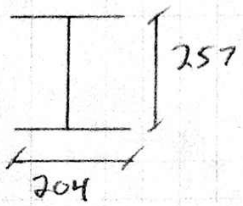
Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 26, 2013


Calculation: Pier Design
Created By: Colin Gibling
Checked By: JACOB TUCKER

## Exterior Pier

Columns range from S 27 - S30 → W250 x 33 - W250 x 67

W250 x 33 W250 x 67




Choose max pier size of 350mm x 350mm ✓

$A_g = 122500\ mm^2$ ✓

Table 7.1.7 Choose $\rho_t = 1\% = 0.01$ ✓ $P_{r\,max} = 1.75\ MN$

## Reinforcement

$A_s = \rho_t A_g = 0.01(122500\ mm^2) = 1225\ mm^2$ ✓

Choose 8 No. 15M bars (longitudinal)

$A_{s\,total} = 1600\ mm^2$ ✓

## Ties

Use No. 10M ties

Cl. 7.6.5.7 $\begin{cases} 16(16.0) = 256 \\ 48(11.3) = 542.4 \\ 350 \end{cases}$ use ∴ use spacing of 240mm ✓

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# Spread Footing Design

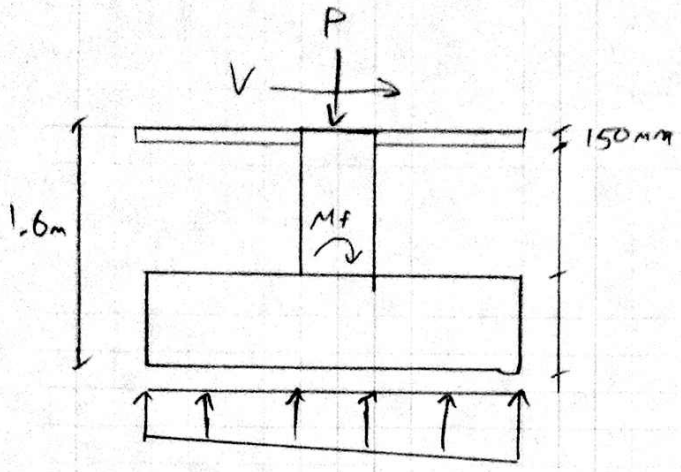
Design by Colin Gibling
Checked by Jacob Tucker

STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 27, 2013


Calculation: Exterior Spread Footing
Created By: Colin Gibling
Checked By: JACOB TUCKER

## Exterior Spread Footing Design




V = 50 kN ✓

Serviced loads
DL = 710 kN ✓
LL = 730 kN ✓
SL = 80 kN ✓

Factored Loads
All = 712 kN ✓

$q_{sa}$ = 200 kPa (provided by client)
$q_{su}$ = 500 kPa (assumed)
$M_f$ = 1.075 m (50 kN) = 53.75 kN ✓

Pier size = 350mm x 350 mm
f'c = 30 MPa
$f_y$ = 400 MPa ✓

### 1. Size of Footing

Estimate Footing thickness: h = 1.5(350) = 525 mm ✓

Fill thickness = 1600 − 525 − 150 = 925 mm ✓

$\Sigma w = w_1^{LL} + w_2^{slab} + w_3^{soil} + w_4^{footing}$ = 4.8 + 0.15(24.0) + 0.925(17.0) + 0.525(24.0)
= 36.73 kPa ✓

$q_{sa(net)} = q_{sa} - \Sigma w$ = 200 − 36.73 = 163 kPa ✓

$P_s$ = 710 + 730 + 80 = 520 kPa ✓

$A = \frac{P_s}{q_{sa(net)}} = \frac{520}{163} = 3.19\ m^2$ Use 1.8 m x 1.8 m footings ✓

∴ $A = 3.24\ m^2$ ✓

275 kPa = 0.275 MPa

$q_{sf\ max} = \frac{P_f}{A} + \frac{M_f}{S} = \frac{712}{3.24} + \frac{53.8}{\cancel{(1.7)(1.7)^2/6}}$ = ~~285.5 kPa~~ = ~~0.286 MPa~~

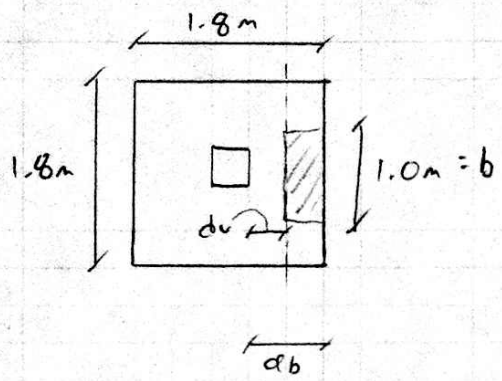
$S = \frac{(1.8)\times(1.8)^2}{6} = 0.972\ m^3$

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## 2. Footing Thickness

### a) One way Shear

$a_b = 725$ mm ✓




$V_f = q_{sf\,max}(a_b - d_v)b \leq V_r = \phi_c \lambda \beta \sqrt{f'_c}\, b\, d_v$

Equate and find $d_v$:

$\Rightarrow \frac{0.275}{0.386}(725 - d_v)(1000) = 0.65(1.0)(0.21)\sqrt{30}(1000)d_v$

$\Rightarrow d_v =$ ~~201 mm~~ 195 mm

Check $a_b < 3d_v \Rightarrow 3d_v =$ ~~603~~ 585 mm $< a_b$ ∴ Not ok

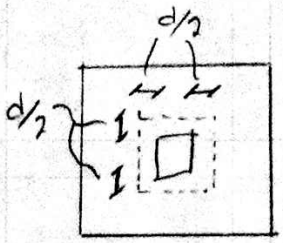
Use $\beta = \frac{230}{(1000 + d_v)}$ in above equation

∴ $d_v =$ ~~216 mm~~ 210 mm

$d = \frac{d_v}{0.9} =$ ~~240 mm~~ 233 mm = d

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b) Two-way Shear




$C_x = C_y = 350\text{ mm}$

$b_o = 2(C_x + C_y + 2d)$ ✓

$V_f = q_{sf}(A - (C_x + d)(C_y + d)) = 0.786(1800^2 - (350+d)^2)$ ✓

$V_r = v_r b_o d$ ✓

Assume $v_r = 0.38 \lambda \phi_c \sqrt{f'_c}$

$\therefore V_r = 0.38(1.0)(0.65)\sqrt{30}[2(700+2d)]d$ ✓

Equate $V_f$ and $V_r$ and find $d$

$d = \cancel{252\text{ mm}}$ 246 mm

Check 3 possible shear stresses to ensure assumed $v_r$ is correct:

1) $v_{r1} = 0.38 \lambda \phi_c \sqrt{f'_c} = 0.38(1.0)(0.65)\sqrt{30} = 1.353$ ✓

2) $v_{r2} = \left(1 + \frac{2}{\beta_c}\right) 0.19 \lambda \phi_c \sqrt{f'_c} = \left(1 + \frac{2}{1}\right) 0.19(1.0)(0.65)\sqrt{30} = 2.029$ ✓

3) $v_{r3} = \left(\frac{\alpha_s}{b_o/d} + 0.19\right) \lambda \phi_c \sqrt{f'_c} = \left(\frac{3}{2408/252} + 0.19\right)(1.0)(0.65)\sqrt{30} = \cancel{1.794}$ 1.78 ✓

$v_{r1}$ is smallest $\therefore$ Assumption is correct ✓

Check $a_o > 3d \Rightarrow 3d = \cancel{756}$ 738 mm $\quad a = 725 < 3d = \cancel{756}$ 738 $\therefore$ OK ✓

$d = \cancel{252\text{ mm}}$ 246 mm 2 way shear governs. use $d = \cancel{260\text{ mm}}$ 250 mm

Thickness: $h = \cancel{260\text{ mm}}$ 250 mm $+ 75\text{ mm} + 25\text{ mm} = \cancel{360\text{ mm}}$ 350 mm use 400 mm ✓ OK

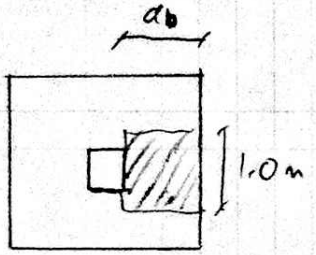
$\therefore d = 300\text{ mm}$ ✓

$d_{longitudinal} = 400 - 75 - 25 - 25/2 = 288\text{ mm}$ ✓

$d_{transverse} = 400 - 75 - 25/2 = 313\text{ mm}$ ✓

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## 3. Reinforcement




$d_b = 725\,mm$ ✓
Design for 1m strip ✓

$$M_f = q_{st}\, b\, \frac{d_b^2}{2} = \frac{0.786}{0.275}(1000)\frac{(775)^2}{2} = \frac{72.3\times10^6}{75.2\times10^6}\ N\cdot mm\ per\ m$$

$$M_r = K_r b d^2 \times 10^{-6}$$

$$\Rightarrow K_r = \frac{72.3}{75.2}\times\frac{10^6}{1000(788)^2} = \frac{0.87}{0.91}$$

$\rho = 0.27\%$ ✓, $\rho_{max} = 2.63\%$ ✓

$A_s = \rho b d = 0.0027(1800)(788) = 1400\ mm^2$ ✓

$A_{s,min} = 0.002 A_g = 0.002(1800)(400) = 1440\ mm^2$ ✓

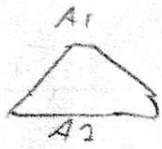
∴ use $A_{s,min} = 1440\ mm^2$

Select 5 No 20M bars, $A_s = 1500\ mm^2$ ✓

Spacing, $s = \frac{1800}{5} = 360\ mm$ check $\begin{cases} 500\ mm \\ 3h = 1200\ mm \end{cases}$ ∴ OK ✓

Check development length: Table 9.10, $l_d = 530\ mm < d_b = 725\ mm$ ✓
∴ OK

## 4. Column - Footing Joint




a) Footing Bearing: $B_{r,f} = 0.85\phi_c f'_c A_1 \sqrt{A_2/A_1} + \phi_s f_y A_{dowel}$

$A_1 = 350^2$
$A_2 = 1800^2$
$\sqrt{\frac{A_2}{A_1}} = 5.1 \le 2.0$ use 2.0

∴ $B_r = 0.85(0.65)(30)(350^2)(2.0) = 4061\ kN$ ✓ $> P_f = 712\ kN$ ∴ OK ✓

b) Column Bearing: $B_{r,column} = 0.85\phi_c f'_c A_1 + \phi_s f_y A_{dowel}$
$= 0.85(0.65)(30)(350^2) = 2030\ kN > P_f = 712\ kN$
∴ OK ✓

* Recommended to provide dowels at connection to match the pier reinforcement. ✓

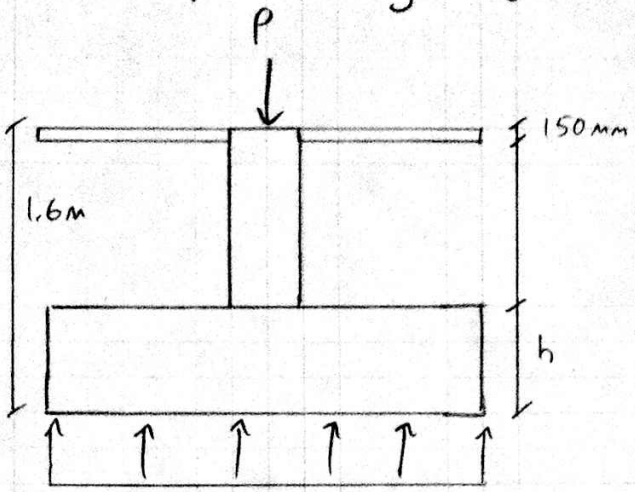
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STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 26, 2013

Page: 1 of 5
Calculation: Interior Spread Footing
Created By: Colin Gibling
Checked By: JACOB TUCKER

# Interior Spread Footing Design




Serviced Loads
DL = 501 kN
LL = 886 kN ✓
SL = 253 kN

Factored Load
Total = 2086 kN ✓

$q_{sa}$ = 200 kPa (Provided by client)
$q_{su}$ = 500 kPa (Assumed) ✓

$f'_c$ = 30 MPa
$F_y$ = 400 MPa ✓

Pier Size = 400mm × 400mm ✓

## 1. Size of Footing

Estimate footing thickness: $h = 1.5(400) = 600$ mm ✓

Fill thickness: $1660 - 600 - 150 = 850$ mm ✓

$\Sigma w = \overset{LL}{w_1} + \overset{Slab}{w_2} + \overset{Soil}{w_3} + \overset{footing}{w_4} = 4.8 + 0.15(24.0) + 0.85(17.0) + 0.6(24.0)$
$= 37.25$ kPa ✓

$q_{sa(net)} = q_{sa} - \Sigma w = 200 - 37.25 = 163$ kPa ✓

$P_s = 501 + 886 + 253 = 1640$ kN ✓

$A = \frac{P_s}{q_{sa(net)}} = \frac{1640}{163} = 10.06\ m^2$ Use 3.2 m × 3.2 m footings

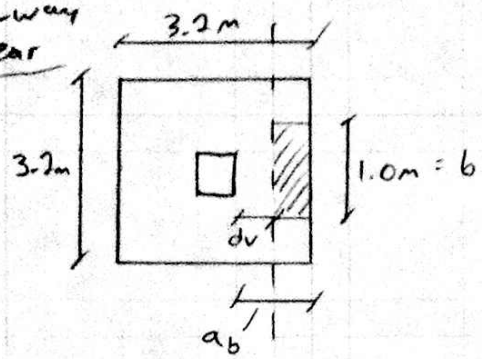
$\therefore A = 10.24\ m^2$ ✓

$q_{sf} = \frac{P_f}{A} = \frac{2086}{10.24} = 203.7$ kPa $= 0.204$ MPa ✓

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## 2. Footing Thickness

a) One-way Shear




$a_b = 1400\ mm$ ✓

$V_f = q_{sf}(a_b - d_v)b \leq V_r = \phi_c \lambda \beta \sqrt{f'_c} b d_v$

Equate and find $d_v$:

$\Rightarrow 0.204(1400 - d_v)(1000) = 0.65(1.0)(0.21)\sqrt{30}(1000)d_v$

$\Rightarrow d_v = 300\ mm$ ✓

Check $a_b < 3d_v \Rightarrow 3d_v = 900\ mm < a_b$ ∴ Not OK ✓

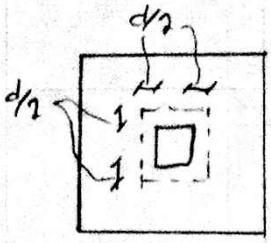
Use $\beta = \frac{730}{(1000 + d_v)}$ in above equation

$\therefore d_v = 353\ mm$ ✓

$d = \frac{d_v}{0.9} = 392\ mm$ ✓

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b) Two Way Shear




$c_x = c_y = 400\ mm$

$b_o = 2(c_x + c_y + 2d)$

$V_f = q_{sf}(A - ((c_x+d)(c_y+d))) = 0.204(3200^2 - (400+d)^2)$ ✓

$V_r = v_r b_o d$

Assume $v_r = 0.38\lambda\phi_c\sqrt{f'_c}$

$\therefore V_r = 0.38(1.0)(0.65)\sqrt{30}[2(800+2d)]d$ ✓

Equate $V_f$ and $V_r$ and find $d$

$d = 432\ mm$ ✓

Check the 3 possible shear stresses to ensure assumed $v_r$ is correct:

1) $v_{r1} = 0.38\lambda\phi_c\sqrt{f'_c} = 0.38(1.0)(0.65)\sqrt{30} = 1.353$ ✓

2) $v_{r2} = \left(1 + \frac{2}{\beta_c}\right)0.19\lambda\phi_c\sqrt{f'_c} = \left(1 + \frac{2}{1}\right)0.19(1.0)(0.65)\sqrt{30} = 2.029$ ✓

3) $v_{r3} = \left(\frac{d_s}{b_o/d} + 0.19\right)\lambda\phi_c\sqrt{f'_c} = \left(\frac{3}{3328/432} + 0.19\right)(1.0)(0.65)\sqrt{30} = 2.063$ ✓

$v_{r1}$ is smallest $\therefore$ Assumption is correct

Check $a_b > 3d \Rightarrow 3d = 1296$ $\quad a_b = 1400 > 3d = 1296$ ✓

$\therefore$ New $V_r = \frac{1300}{(1000+d)} v_r = 0.9078(1.353) = 1.228$ ✓

$\therefore V_r = 1.228[2(800+2d)]d$ Equate $V_r$ and $V_f$, New $d = 459\ mm$ ✓

Two way shear governs, use $d = 459\ mm \approx 460\ mm$ ✓

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Thickness:

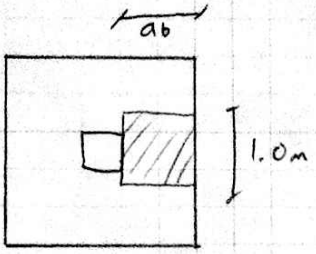
$h = 460\,mm + 75\,mm + 25\,mm = 560\,mm$ (dv + cover + bars) use 600mm ✓

$\therefore$ use $d_v = 500\,mm$ ✓

$d_{longitudinal} = 600 - 75 - 25 - 25/2 = 488\,mm$

$d_{transverse} = 600 - 75 - 25/2 = 513\,mm$ ✓

## 3. Reinforcement




$a_b = 1400\,mm$ ✓

Design for 1m strip ✓

$M_f = q_{sf}\, b\, \frac{a_b^2}{2} = 0.204(1000)(1400)^2/2 = 199.9 \times 10^6\ N{\cdot}mm$ per m ✓

$M_r = K_r b d^2 \times 10^{-6}$

$K_r = \frac{199.9 \times 10^6}{1000(488)^2} = 0.84$ ✓ $\rho = 0.25\%$ $\rho_{max} = 2.63\%$ ✓

$A_s = \rho b d = 0.0025(3200)(488) = 3904\,mm^2$ ✓

$A_{s,min} = 0.002\,A_g = 0.002(3200)(600) = 3840\,mm^2$ ✓

Select 8 No. 25M bars, $A_s = 4000\,mm^2$ ✓

Spacing, $s = \frac{3200}{8} = 400\,mm$ check $\begin{cases} 500mm \\ 3h = 1800 \end{cases}$ $\therefore$ OK ✓

Check development length: Table 9.10, $l_d = 820\,mm$ $< a_b = 1400mm$ ✓
$\therefore$ OK

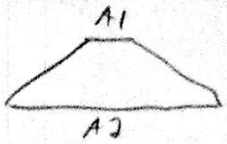
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STRATA SOLUTIONS

Client: Morrison Hershfield
Project: Orthodontic Clinic
Date: March 26, 2007


Calculation: Interior Spread Footing
Created By: Colin Gibling
Checked By: JACOB TUCKER

## 4. Column - Footing Joint




a) Footing bearing:

$$B_{r,f} = 0.85 \phi_c f'_c A_1 \sqrt{\frac{A_2}{A_1}} + \phi_s f_y A_{dowel}$$

$A_1 = 400^2 = 0.16 \times 10^6 \, mm^2$

$A_2 = 3200^2 = 10.24 \times 10^6 \, mm^2$

$\sqrt{A_2/A_1} = 8.0 \leq 2.0$ use 2.0

$\therefore B_r = 0.85(0.65)(30)(0.16 \times 10^6)(2.0) = 5304^{KN} > P_f = 2086^{KN}$ ∴ OK ✓

b) Column bearing:

$B_{r,column} = 0.85 \phi_c f'_c A_1 + \phi_s f_y A_{dowel}$
$= 0.85(0.65)(30)(0.16 \times 10^6) = 2652 \, KN > P_f = 2086 \, KN$ ∴ OK ✓

Note, though reinforcement is not required it is recommended to provide dowels at the connection to match the pier reinforcement. ✓

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STRATA SOLUTIONS

# Appendix E

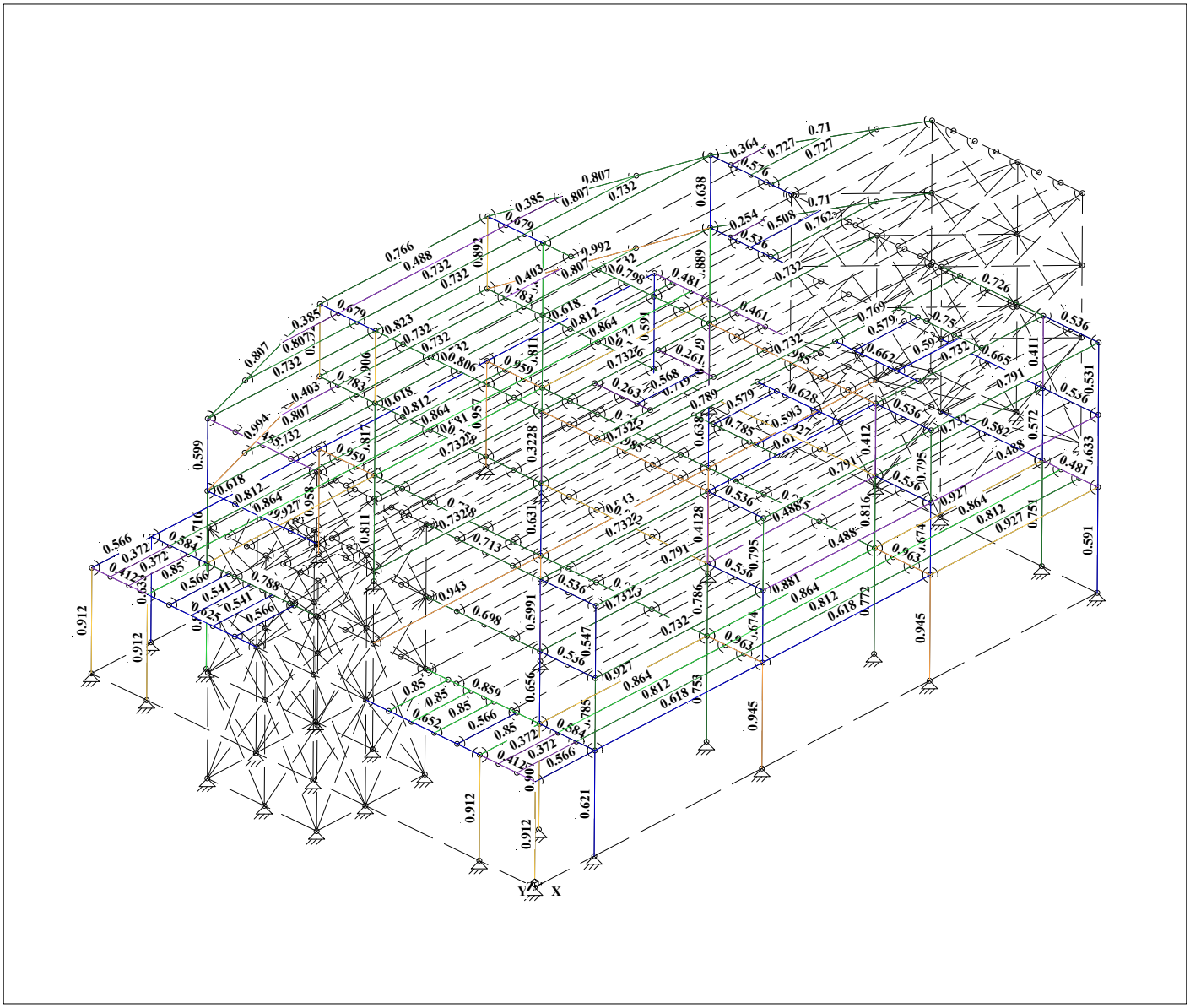
# S-Frame/S-Steel Results

S-Steel Key Results- All load cases
S-Steel Key Results – Downward load cases
Rendered View of Beams and Columns
S-Frame – Columns
S-Frame – Moments'
S-Frame – Shear Forces




# S-Steel Key Results- All Load Cases

**1.1**




## 2. Summary of Governing Members for Each Group

| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 373 | Section 33 | W460X113 * | Comb 12, 1.25D + 1.4Wnorth + 0.5L | Beam-column stability | 0.994 | Pass |
| 208 | Section 37 | W530X123 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.985 | Pass |
| 14 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.978 | Pass |



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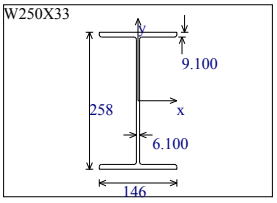
| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 63 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 11 | Section 28 | W200X59 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Beam-column stability | 0.958 | Pass |
| 12 | Section 30 | W250X67 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column stability | 0.945 | Pass |
| 71 | Section 22 | W360X72 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.943 | Pass |
| 46 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.927 | Pass |
| 212 | Section 17 | W530X150 * | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-tension strength | 0.927 | Pass |
| 1 | Section 27 | W250X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.912 | Pass |
| 22 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.907 | Pass |
| 37 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.906 | Pass |
| 35 | Section 35 | W250X45 | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-column stability | 0.889 | Pass |
| 179 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.859 | Pass |
| 44 | Section 21 | W310X21 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.85 | Pass |
| 304 | Section 7 | W410X100 * | Comb 12, 1.25D + 1.4Wnorth + 0.5L | Beam-column stability | 0.823 | Pass |
| 376 | Section 11 | W410X60 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.807 | Pass |
| 504 | Section 10 | W360X45 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.807 | Pass |
| 209 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.806 | Pass |
| 192 | Section 8 | W410X54 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.791 | Pass |
| 455 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.789 | Pass |
| 24 | Section 34 | W200X46 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column strength | 0.785 | Pass |
| 567 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.785 | Pass |
| 305 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 530 | Section 9 | W360X33 | Comb 17, 1.25D + 1.4Wsouth + 0.5S | Slenderness | 0.727 | Pass |
| 190 | Section 3 | W530X82 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.713 | Pass |
| 210 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.638 | Pass |
| 574 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 189 | Section 13 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 74 | Section 12 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |

## 3. Code Details For Governing Members for Each Group

**Member: 1** S-FRAME Section is W250X33
Member is part of group: Section 27
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

**Load Combination 27 0.9D + 1.4Wwest + 0.5S (Bending + Compression)**

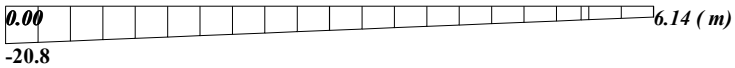
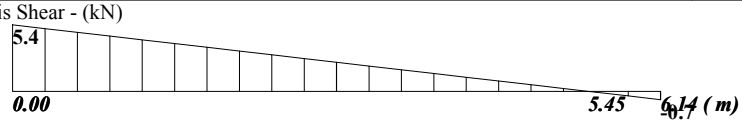
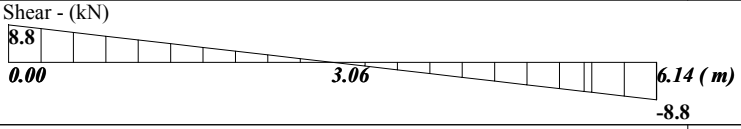
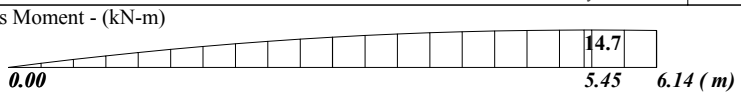
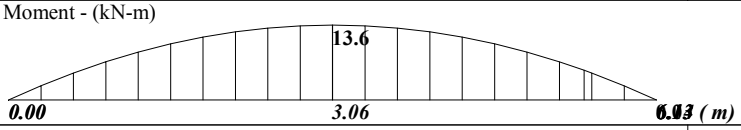
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| **Governing geometrical slenderness ratio** $k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=56.7; | $\frac{k_y L/r_y}{200} = \frac{182}{200} =$ | **0.912** |




Clause 11

**Clause 10.4.2.1**


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| | | |
|---|---|---|
| Axial Load - (kN)<br>  <br> | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.428 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (56\ MPa)} = \frac{21}{209} =$ | **0.100** |
| Strong Axis Shear - (kN)<br>  <br> | | |
| Strong axis shear strength check<br>$A_w$= 1574 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{5}{327} =$ | **0.016** |
| Weak Axis Shear - (kN)<br>  <br> | | |
| Weak axis shear strength check<br>$A_w$= 1771 mm$^2$; | $\frac{V_{fx}}{\phi\ A_w\ F_s} = \frac{V_{fx}}{\phi\ A_w\ 0.66F_y} = \frac{9}{368} =$ | **0.024** |
| Strong Axis Moment - (kN-m)<br>  <br> | | |
| Bending Stability Check<br>$L_u$=6.14 m; $\omega_2$=1.245; | $\frac{M_{fx}}{M_{rx}} = \frac{15}{60} =$ | **0.247** |
| Weak Axis Moment - (kN-m)<br>  <br> | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi\ F_y\ Z_y} = \frac{14}{31} =$ | **0.433** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.01; $U_{1y}$=1.09; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.393** |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.01; $U_{1y}$=1.09;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} + \frac{\beta\ U_{1y}\ M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.595** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi\ Z_x\ F_y} + \frac{M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.543** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=1.01; $U_{1y}$=1.09;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} + \frac{\beta\ U_{1y}\ M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.712** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.679** |

Clause 13.3.1

Clause 13.4.1.1(a)

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2

Clause 13.8.2(c)

Clause 13.8.2

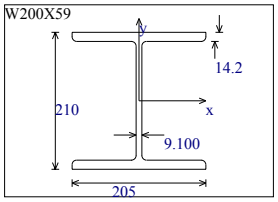

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**Member: 11** S-FRAME Section is W200X59

Member is part of group: Section 28

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 19 1.25D + 1.4Wwest + 0.5S (Bending + Compression)**

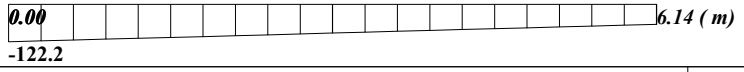
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=68.3; | $\frac{k_y L/r_y}{200} = \frac{118}{200} =$ | **0.591** |

Clause 10.4.2.1

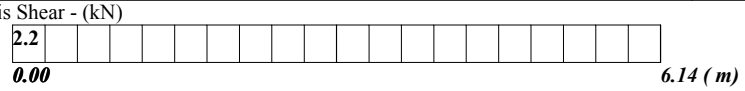
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.574 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (116\ MPa)} = \frac{122}{792} =$ | **0.154** |

Clause 13.3.1

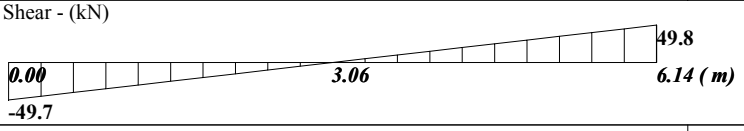
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1911 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{2}{397} =$ | **0.005** |

Clause 13.4.1.1(a)

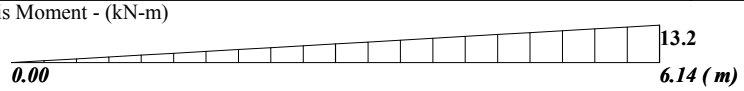
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3881 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66 F_y} = \frac{50}{807} =$ | **0.062** |

Clause 13.4.1.1(a)

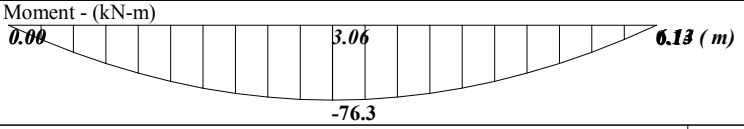
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=6.14 m; $\omega_2$=1.750; | $\frac{M_{fx}}{M_{rx}} = \frac{13}{198} =$ | **0.067** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{76}{95} =$ | **0.800** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=0.60; $\omega_{1y}$=1.00; $U_{1x}$=1.00; $U_{1y}$=1.13; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.648** |

Clause 13.8.2(a)


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| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=0.62; $U_{1y}$=1.13;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\,U_{1x}\,M_{fx}}{\phi\,Z_x\,F_y} + \frac{\beta\,U_{1y}\,M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.956** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi\,Z_x\,F_y} + \frac{M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.864** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=0.62; $U_{1y}$=1.13;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\,U_{1x}\,M_{fx}}{M_{rx}} + \frac{\beta\,U_{1y}\,M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.958** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.867** |

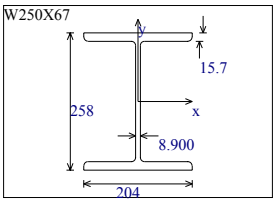
Clause 13.8.2(b)

Clause 13.8.2

**Clause 13.8.2(c)**

Clause 13.8.2

**Member: 12** S-FRAME Section is W250X67
Member is part of group: Section 30
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 15 1.25D + 1.4Wwest + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=55.7; | $\frac{k_y\,L/r_y}{200} = \frac{120}{200} =$ | **0.602** |
| Axial Load - (kN)<br>***0.00*** ***6.14 ( m)***<br>**-174.9** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.605 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (113\ MPa)} = \frac{175}{869} =$ | **0.201** |
| Strong Axis Shear - (kN)<br>**7.3**<br>***0.00*** ***6.14 ( m)*** | | |
| Strong axis shear strength check<br>$A_w$= 2296 mm$^2$; | $\frac{V_{fy}}{\phi\,A_w\,F_s} = \frac{V_{fy}}{\phi\,A_w\,0.66F_y} = \frac{7}{477} =$ | **0.015** |
| Weak Axis Shear - (kN)<br>**47.1**<br>***0.00*** ***2.90*** ***6.14 ( m)***<br>**-52.4** | | |
| Weak axis shear strength check<br>$A_w$= 4270 mm$^2$; | $\frac{V_{fx}}{\phi\,A_w\,F_s} = \frac{V_{fx}}{\phi\,A_w\,0.66F_y} = \frac{52}{888} =$ | **0.059** |
| Strong Axis Moment - (kN-m)<br>**44.7**<br>***0.00*** ***6.14 ( m)*** | | |

Clause 11

Clause 10.4.2.1

Clause 13.3.1

Clause 13.4.1.1(a)

Clause 13.4.1.1(a)


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| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=6.14 m; $\omega_2$=1.750; | $\frac{M_{fx}}{M_{rx}} = \frac{45}{267} =$ | **0.168** |
| Weak Axis Moment - (kN-m)<br>68.5<br>0.00 2.90 5.81 6.14 ( m)<br>-16.2 | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{68}{105} =$ | **0.655** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=0.60; $\omega_{1y}$=1.00; $U_{1x}$=1.00; $U_{1y}$=1.18; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.661** |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=0.62; $U_{1y}$=1.18;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.939** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.812** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=0.62; $U_{1y}$=1.18;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.945** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.823** |

Clause 13.6(a)

Clause 13.5(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2

**Clause 13.8.2(c)**

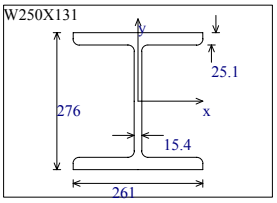
Clause 13.8.2

**Member: 14** S-FRAME Section is W250X131

Member is part of group: Section 32

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=53.4; | $\frac{k_y L/r_y}{200} = \frac{92}{200} =$ | **0.460** |
| Axial Load - (kN)<br>0.00 6.14 ( m)<br>-2087.1 | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.224 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (166\ MPa)} = \frac{2087}{2493} =$ | **0.837** |
| Weak Axis Shear - (kN)<br>5.7<br>0.00 6.14 ( m) | | |

Clause 11

Clause 10.4.2.1

Clause 13.3.1


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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 8735 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{6}{1816} =$ | **0.003** |
| Weak Axis Moment - (kN-m)<br>35.2<br>*0.00* *6.14 ( m)* | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{35}{274} =$ | **0.128** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=0.60; $U_{1x}$=1.22; $U_{1y}$=1.29; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.496** |
| **Axial Compression and Bending overall member Strength Check**<br>**$U_{1x}$=1.22; $U_{1y}$=1.29;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.978** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.22; $U_{1y}$=1.29;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.978** |

Clause 13.4.1.1(a)

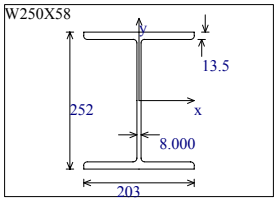
Clause 13.5(a)

Clause 13.8.2(a)

**Clause 13.8.2(b)**

**Clause 13.8.2(c)**

**Member: 22** S-FRAME Section is W250X58
Member is part of group: Section 29
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Compression)**

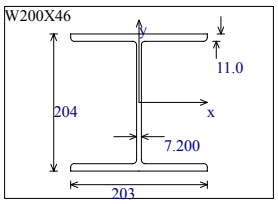
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=56.6; | $\frac{k_y L/r_y}{200} = \frac{122}{200} =$ | **0.610** |
| Axial Load - (kN)<br>*0.00* *6.14 ( m)*<br>-671.2 | | |
| **Factored Compressive Resistance Check**<br>**n=1.34; $\lambda_y$=1.624** | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi AF_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (111\ MPa)} = \frac{671}{740} =$ | **0.907** |

Clause 11

Clause 10.4.2.1

**Clause 13.3.1**

**Member: 24** S-FRAME Section is W200X46
Member is part of group: Section 34
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 15 1.25D + 1.4Wwest + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |

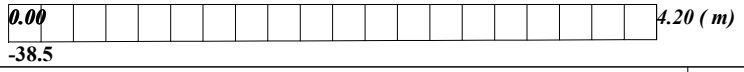
Clause 11


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| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=47.7; | $\frac{k_y L/r_y}{200} = \frac{82}{200} =$ | **0.411** |

Clause 10.4.2.1

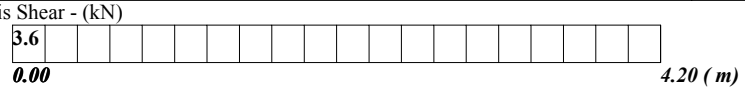
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.095 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (190\ MPa)} = \frac{38}{1000} =$ | **0.038** |

Clause 13.3.1

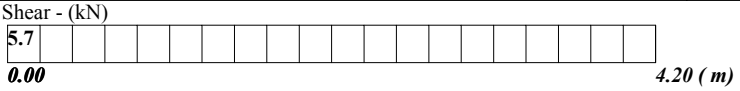
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1469 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{4}{305} =$ | **0.012** |

Clause 13.4.1.1(a)

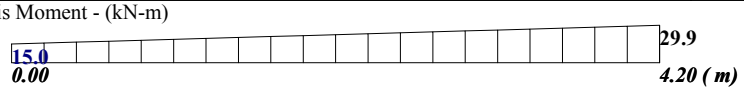
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 2977 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66 F_y} = \frac{6}{619} =$ | **0.009** |

Clause 13.4.1.1(a)

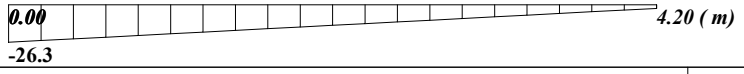
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=4.20 m; $\omega_2$=1.300; | $\frac{M_{fx}}{M_{rx}} = \frac{30}{139} =$ | **0.215** |

Clause 13.6(b)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y S_y} = \frac{26}{48} =$ | **0.553** |

Clause 13.5(b)

| | | |
|---|---|---|
| **Axial Compression and Bending cross-sectional Strength Check**<br>**$\omega_{1x}$=0.80; $\omega_{1y}$=0.64; $U_{1x}$=1.00; $U_{1y}$=1.00;** | $\frac{C_f}{\phi A F_y} + \frac{U1_x M_{fx}}{\phi S_x F_y} + \frac{U1_y M_{fy}}{\phi S_y F_y} =$ | **0.785** |

**Clause 13.8.3(a)**

| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=0.80; $\omega_{1y}$=0.64; $U_{1x}$=0.81; $U_{1y}$=0.65; | $\frac{C_f}{C_{ry}} + \frac{U_{1x} M_{fx}}{\phi S_x F_y} + \frac{U_{1y} M_{fy}}{\phi S_y F_y} =$ | **0.570** |

Clause 13.8.3(b)

| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=0.80; $\omega_{1y}$=0.64; $U_{1x}$=0.81; $U_{1y}$=0.65; | $\frac{C_f}{C_{ry}} + \frac{U_{1x} M_{fx}}{M_{rx}} + \frac{U_{1y} M_{fy}}{\phi S_y F_y} =$ | **0.572** |

Clause 13.8.3(c)

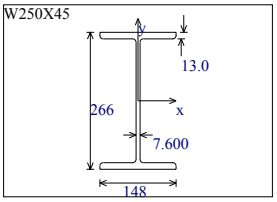

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**Member: 35** S-FRAME Section is W250X45

Member is part of group: Section 35

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 14 1.25D + 1.4Weast + 0.5L (Bending + Compression)**

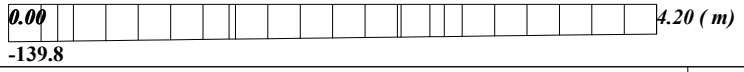
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=37.7; | $\frac{k_y L/r_y}{200} = \frac{120}{200} =$ | **0.599** |

Clause 10.4.2.1

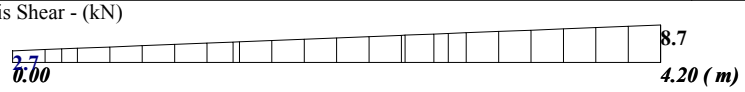
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.595 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (114\ MPa)} = \frac{140}{587} =$ | **0.238** |

Clause 13.3.1

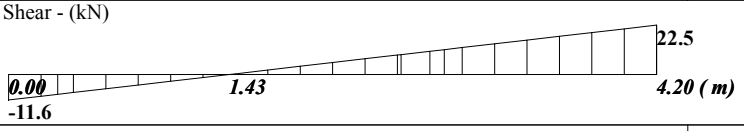
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2022 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{9}{420} =$ | **0.021** |

Clause 13.4.1.1(a)

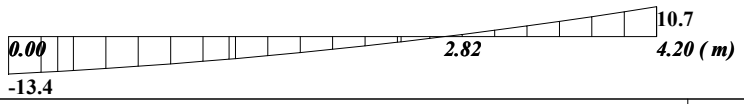
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 2565 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66 F_y} = \frac{22}{533} =$ | **0.042** |

Clause 13.4.1.1(a)

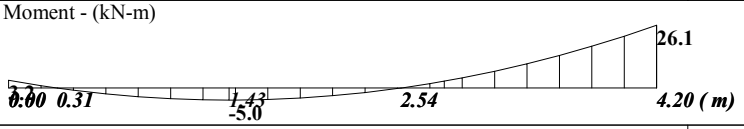
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=4.20 m; $\omega_2$=1.990; | $\frac{M_{fx}}{M_{rx}} = \frac{13}{178} =$ | **0.075** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{26}{46} =$ | **0.567** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.02; $U_{1y}$=1.22; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.552** |

Clause 13.8.2(a)


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| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.02; $U_{1y}$=1.22;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} + \frac{\beta\ U_{1y}\ M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.885** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi\ Z_x\ F_y} + \frac{M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.637** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.02; $U_{1y}$=1.22;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} + \frac{\beta\ U_{1y}\ M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.889** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi\ Z_y\ F_y} =$ | **0.642** |

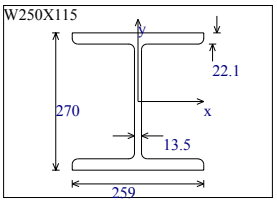
Clause 13.8.2(b)

Clause 13.8.2

**Clause 13.8.2(c)**

Clause 13.8.2

**Member: 37** S-FRAME Section is W250X115
Member is part of group: Section 31
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=36.9; | $\frac{k_y\ L/r_y}{200} = \frac{63}{200} =$ | **0.317** |
| Axial Load - (kN)<br>**0.00** … **4.20 ( m)**<br>**-327.7** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=0.844 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (243\ MPa)} = \frac{328}{3187} =$ | **0.103** |
| Strong Axis Shear - (kN)<br>**4.0**<br>**0.00** … **4.20 ( m)** | | |
| Strong axis shear strength check<br>$A_w$= 3645 $mm^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{4}{758} =$ | **0.005** |
| Weak Axis Shear - (kN)<br>**97.2**<br>**0.00** … **4.20 ( m)** | | |
| Weak axis shear strength check<br>$A_w$= 7632 $mm^2$; | $\frac{V_{fx}}{\phi\ A_w\ F_s} = \frac{V_{fx}}{\phi\ A_w\ 0.66F_y} = \frac{97}{1587} =$ | **0.061** |
| Strong Axis Moment - (kN-m)<br>**0.00** … **4.20 ( m)**<br>**-16.8** | | |

Clause 11

Clause 10.4.2.1

Clause 13.3.1

Clause 13.4.1.1(a)

Clause 13.4.1.1(a)


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| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=4.20 m; $\omega_2$=1.751; | $\frac{M_{fx}}{M_{rx}} = \frac{17}{504} =$ | **0.033** |
| Weak Axis Moment - (kN-m)<br>**201.4**<br>***0.00*** ***2.13*** ***4.20 ( m)***<br>**-206.9** | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{207}{237} =$ | **0.872** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=0.60; $\omega_{1y}$=0.40; $U_{1x}$=1.00; $U_{1y}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.623** |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=0.61; $U_{1y}$=0.42;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.431** |
| **Biaxial bending strength check** | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.906** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=0.61; $U_{1y}$=0.42;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.431** |
| **Biaxial bending stability check** | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.906** |

Clause 13.6(a)

Clause 13.5(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

**Clause 13.8.2**

Clause 13.8.2(c)

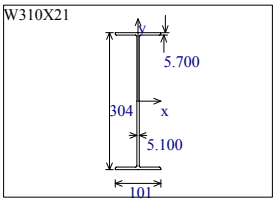
**Clause 13.8.2**

**Member: 44** S-FRAME Section is W310X21 *

Member is part of group: Section 21

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 27 0.9D + 1.4Wwest + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=27.7;** | $\frac{k_y L/r_y}{200} = \frac{170}{200} =$ | **0.850** |
| Axial Load - (kN)<br>***0.00*** ***3.25 ( m)***<br>**-10.7** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.262 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (63\ MPa)} = \frac{11}{153} =$ | **0.070** |
| Strong Axis Shear - (kN)<br>**5.1**<br>***0.00*** ***1.64*** ***3.25 ( m)***<br>**-5.4** | | |

Clause 11

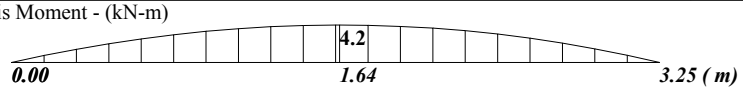
**Clause 10.4.2.1**

Clause 13.3.1


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| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1550 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{5}{322} =$ | **0.017** |

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=3.25 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{4}{35} =$ | **0.122** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.053** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.053** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.174** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

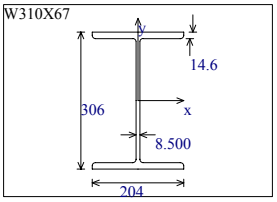
Clause 13.8.2(c)

**Member: 46** S-FRAME Section is W310X67

Member is part of group: Section 20

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



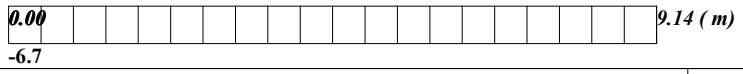

**Load Combination 27 0.9D + 1.4Wwest + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=70.1;** | $\frac{k_y L/r_y}{200} = \frac{185}{200} =$ | **0.927** |

Clause 11

**Clause 10.4.2.1**

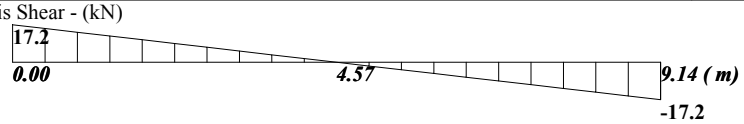
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.469 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (54\ MPa)} = \frac{7}{413} =$ | **0.016** |

Clause 13.3.1

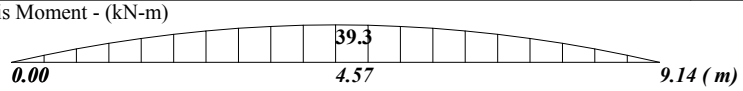
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2601 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{17}{541} =$ | **0.032** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)





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| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{39}{163} =$ | **0.241** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.103** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.104** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.222** |

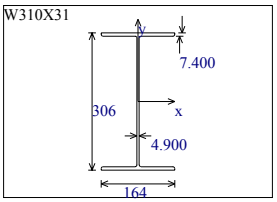
Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2(c)

**Member: 63** S-FRAME Section is W310X31
Member is part of group: Section 23
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **4** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=23.5; | $\frac{k_y L/r_y}{200} = \frac{82}{200} =$ | **0.412** |
| Equivalent slenderness parameter based on buckling stress Fe<br>$F_e$=290 MPa; | $\lambda_e = \left[\frac{F_y}{F_e}\right]^{1/2} =$ | **1.098** |
| Axial Load - (kN)<br>***0.00*** ***3.05 ( m)***<br>**-2.4** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_e$=1.098 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A_{eff} F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A_{eff}\,(189\ MPa)} = \frac{2}{567} =$ | **0.004** |
| Effective area for class 4 sections<br>$A_{gross}$=3990 $mm^2$; | $A_{eff}\,(mm^2)$ = | **3337** |
| Strong Axis Shear - (kN)<br>**118.8** ***0.00*** ***2.03*** ***3.05 ( m)***<br>**-121.2** | | |
| Strong axis shear strength check<br>$A_w$= 1499 $mm^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w\ 0.66F_y} = \frac{121}{312} =$ | **0.389** |
| Strong Axis Moment - (kN-m)<br>**123.0** ***0.00*** ***2.03*** ***3.05 ( m)*** | | |

Clause 11

Clause 10.4.2.1

Clause 13.3.2

Clause 13.3.2

Clause 13.3.3(a)

Clause 13.4.1.1(a)


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| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.01 m; $\omega_2$=1.142; | $\frac{M_{fx}}{M_{rx}} = \frac{123}{128} =$ | **0.959** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi A_{eff} F_y} + \frac{M_{fx}}{M_{rx}} =$ | **0.893** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{U_{1x} M_{fx}}{M_{rx}} =$ | **0.894** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$\omega_{1x}$=1.00; $U_{1x}$=1.00;** | $\frac{C_f}{C_{ry}} + \frac{U_{1x} M_{fx}}{M_{rx}} =$ | **0.963** |

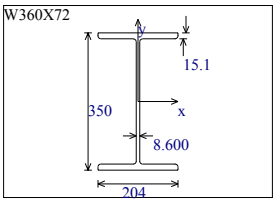
Clause 13.6(b)

Clause 13.8.3(a)

Clause 13.8.3(b)

**Clause 13.8.3(c)**

**Member: 71** S-FRAME Section is W360X72
Member is part of group: Section 22
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*



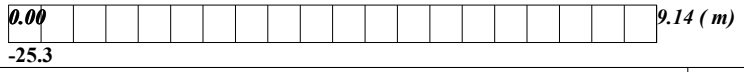

**Load Combination 26 0.9D + 1.4Weast + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=61.6;** | $\frac{k_y L/r_y}{200} = \frac{189}{200} =$ | **0.943** |

Clause 11

**Clause 10.4.2.1**

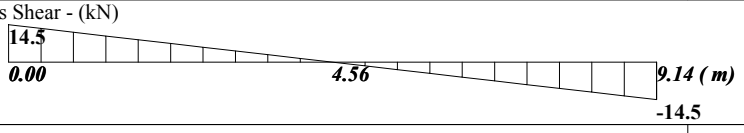
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.512 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (52\ MPa)} = \frac{25}{428} =$ | **0.059** |

Clause 13.3.1

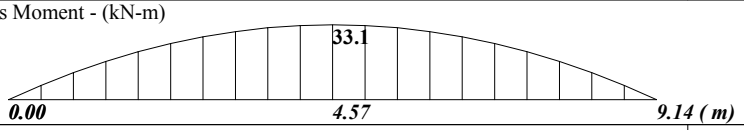
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 3010 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w\ 0.66 F_y} = \frac{14}{626} =$ | **0.023** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{33}{178} =$ | **0.186** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.01; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} =$ | **0.079** |

Clause 13.6(a)

Clause 13.8.2(a)


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| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.01; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.083** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.01; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.218** |

Clause 13.8.2(b)

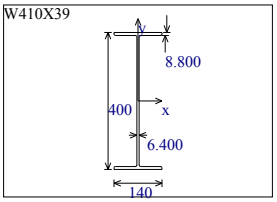
Clause 13.8.2(c)

**Member: 74** S-FRAME Section is W410X39

Member is part of group: Section 12

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



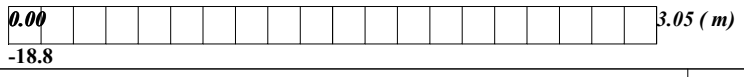

**Load Combination 25 0.9D + 1.4Wsouth + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=19.1;** | $\frac{k_y\ L/r_y}{200} = \frac{107}{200} =$ | **0.536** |

Clause 11

**Clause 10.4.2.1**

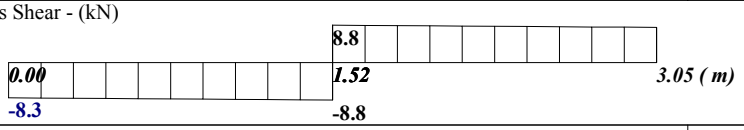
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.426 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (135\ MPa)} = \frac{19}{606} =$ | **0.031** |

Clause 13.3.1

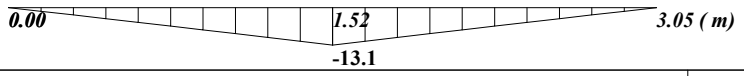
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2560 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{9}{532} =$ | **0.017** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=3.05 m; $\omega_2$=1.269; | $\frac{M_{fx}}{M_{rx}} = \frac{13}{185} =$ | **0.070** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.060** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.060** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.091** |

Clause 13.6(a)

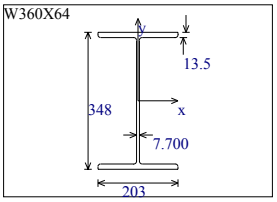
Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2(c)


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**Member: 179** S-FRAME Section is W360X64
Member is part of group: Section 24
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

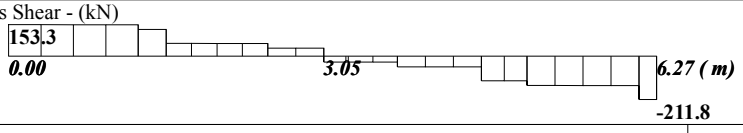



**Load Combination 2 1.25D + 1.5L + 0.5S (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

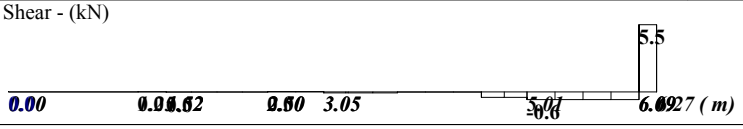
Strong Axis Shear - (kN)



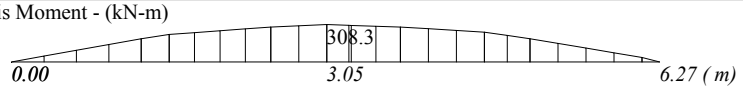

| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2680 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{212}{557} =$ | **0.380** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)



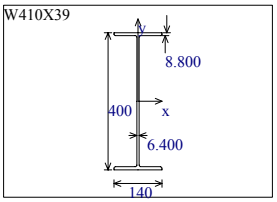

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=1.57 m; $\omega_2$=1.140;** | $\frac{M_{fx}}{M_{rx}} = \frac{308}{359} =$ | **0.859** |

**Clause 13.6(a)**

**Member: 189** S-FRAME Section is W410X39
Member is part of group: Section 13
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 25 0.9D + 1.4Wsouth + 0.5S (Bending + Compression)**

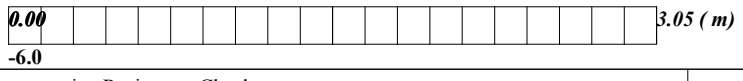
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=19.1;** | $\frac{k_y L/r_y}{200} = \frac{107}{200} =$ | **0.536** |

**Clause 10.4.2.1**

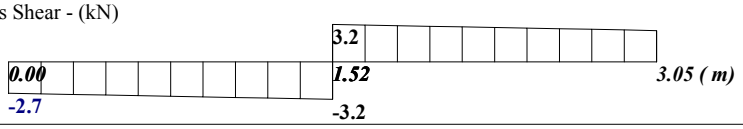
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.426 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (135\ MPa)} = \frac{6}{606} =$ | **0.010** |

Clause 13.3.1

Strong Axis Shear - (kN)

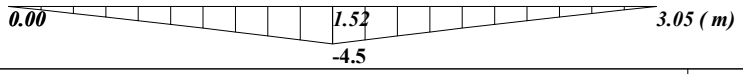




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| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2560 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{3}{532} =$ | **0.006** |

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=3.05 m; $\omega_2$=1.276; | $\frac{M_{fx}}{M_{rx}} = \frac{5}{186} =$ | **0.024** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.021** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.021** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.031** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

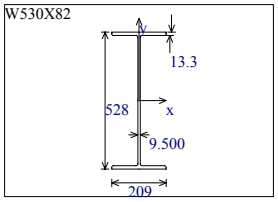
Clause 13.8.2(c)

**Member: 190** S-FRAME Section is W530X82

Member is part of group: Section 3

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



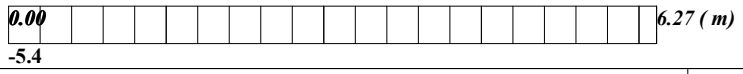

**Load Combination 25 0.9D + 1.4Wsouth + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=29.3;** | $\frac{k_y L/r_y}{200} = \frac{143}{200} =$ | **0.713** |

Clause 11

**Clause 10.4.2.1**

Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.898 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (86\ MPa)} = \frac{5}{812} =$ | **0.007** |

Clause 13.3.1

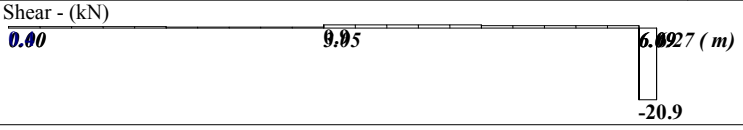
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 5016 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{14}{1043} =$ | **0.013** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)



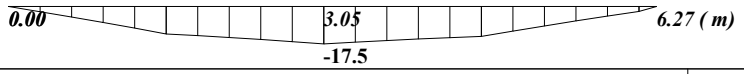


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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3706 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{21}{771} =$ | **0.027** |

Clause 13.4.1.1(a)

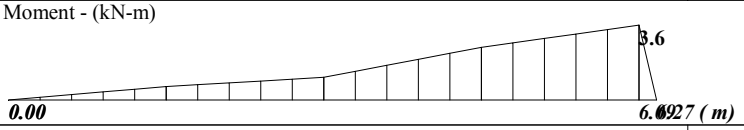
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=6.27 m; $\omega_2$=1.145; | $\frac{M_{fx}}{M_{rx}} = \frac{17}{342} =$ | **0.051** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{4}{95} =$ | **0.037** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.00; $U_{1y}$=1.01; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.047** |

Clause 13.8.2(a)

| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.00; $U_{1y}$=1.01;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.061** |

Clause 13.8.2(b)

| | | |
|---|---|---|
| Biaxial bending strength check | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.064** |

Clause 13.8.2

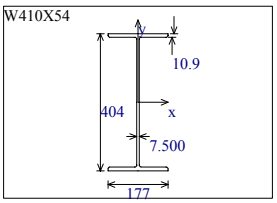
| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=1.00; $U_{1y}$=1.01;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.082** |

Clause 13.8.2(c)

| | | |
|---|---|---|
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.088** |

Clause 13.8.2

**Member: 192** S-FRAME Section is W410X54
Member is part of group: Section 8
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 27 0.9D + 1.4Wwest + 0.5S (Bending + Tension)**

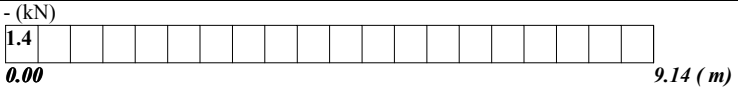
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{237}{300} =$ | **0.791** |

**Clause 10.4.2.2**

Axial Load - (kN)





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| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=6810 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{1}{2145} =$ | **0.001** |
| Strong Axis Shear - (kN)<br>1.6 at 0.00; 4.57; 9.14 ( m); -1.6 | | |
| Strong axis shear strength check<br>$A_w$= 3030 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{2}{630} =$ | **0.002** |
| Strong Axis Moment - (kN-m)<br>0.00; 4.57; 9.14 ( m); -3.6 | | |
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{4}{81} =$ | **0.044** |
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} =$ | **0.011** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.041** |

Clause 13.2 a (i)

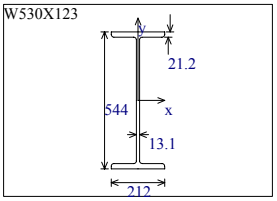
Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.9(a)

Clause 13.9(b)

**Member: 208** S-FRAME Section is W530X123
Member is part of group: Section 37
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 25 0.9D + 1.4Wsouth + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=41.5;** | $\frac{k_y L/r_y}{200} = \frac{197}{200} =$ | **0.985** |
| Axial Load - (kN)<br>0.00; 4.57; 9.15 ( m); -4.8; -4.8 | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.624 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (48\ MPa)} = \frac{5}{680} =$ | **0.007** |
| Strong Axis Shear - (kN)<br>13.0; 0.00; 1.52; 3.05; 4.57; 7.62; 9.15 ( m); -13.6; -15.2 | | |
| Strong axis shear strength check<br>$A_w$= 7126 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{15}{1482} =$ | **0.010** |

Clause 11

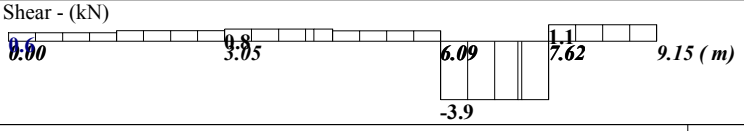
**Clause 10.4.2.1**

Clause 13.3.1

Clause 13.4.1.1(a)

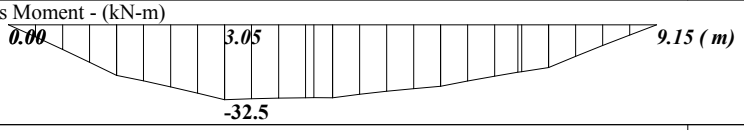

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Weak Axis Shear - (kN)



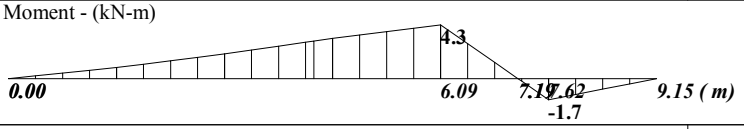

| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 5993 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{4}{1246} =$ | **0.003** |

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.15 m; $\omega_2$=1.142; | $\frac{M_{fx}}{M_{rx}} = \frac{32}{403} =$ | **0.081** |

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{4}{157} =$ | **0.027** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.00; $U_{1y}$=1.01; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.045** |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.00; $U_{1y}$=1.01;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.058** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.059** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=1.00; $U_{1y}$=1.01;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{M_{rx}} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.099** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.108** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2

Clause 13.8.2(c)

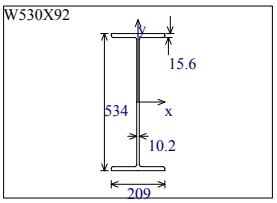
Clause 13.8.2

**Member: 209** S-FRAME Section is W530X92

Member is part of group: Section 18

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*

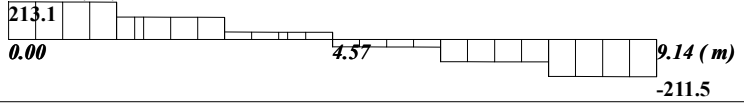



**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

Strong Axis Shear - (kN)



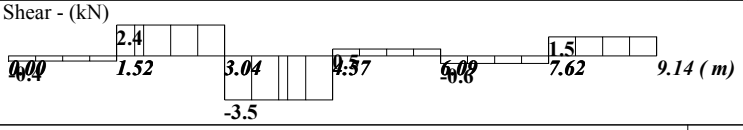


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| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 5447 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{213}{1132} =$ | **0.188** |

Clause 13.4.1.1(a)

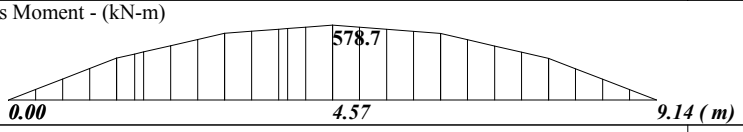
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 4347 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{3}{904} =$ | **0.004** |

Clause 13.4.1.1(a)

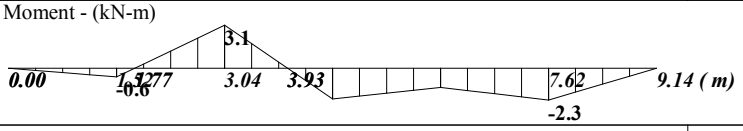
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.55 m; $\omega_2$=1.146; | $\frac{M_{fx}}{M_{rx}} = \frac{579}{743} =$ | **0.779** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{3}{112} =$ | **0.028** |

Clause 13.5(a)

| | | |
|---|---|---|
| **Biaxial bending stability check** | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.806** |

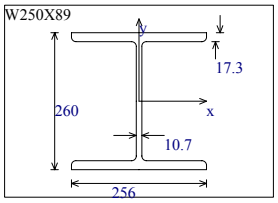
**Clause 13.6(f)**

**Member: 210** S-FRAME Section is W250X89

Member is part of group: Section 36

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

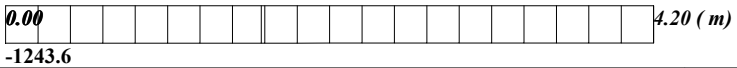
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=37.5; | $\frac{k_y L/r_y}{200} = \frac{64}{200} =$ | **0.322** |

Clause 10.4.2.1

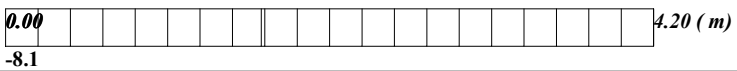
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=0.858 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (239\ MPa)} = \frac{1244}{2456} =$ | **0.506** |

Clause 13.3.1

Weak Axis Shear - (kN)





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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 5905 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{8}{1228} =$ | **0.007** |
| Weak Axis Moment - (kN-m)<br>**35.2** ***0.00*** ***4.20 ( m)*** | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{35}{181} =$ | **0.195** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=0.61; $U_{1x}$=1.08; $U_{1y}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.463** |
| **Axial Compression and Bending overall member Strength Check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.79;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.638** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.79;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.638** |

Clause 13.4.1.1(a)

Clause 13.5(a)

Clause 13.8.2(a)

**Clause 13.8.2(b)**

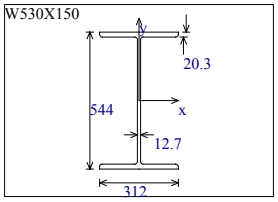
**Clause 13.8.2(c)**

**Member: 212** S-FRAME Section is W530X150 *

Member is part of group: Section 17

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 14 1.25D + 1.4Weast + 0.5L (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{125}{300} =$ | **0.416** |
| Axial Load - (kN)<br>**76.0** ***0.00*** ***9.15 ( m)*** | | |
| Factored Tensile Resistance Check<br>$A_g$=19200 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{76}{6048} =$ | **0.013** |
| Strong Axis Shear - (kN)<br>**179.3** ***0.00*** ***4.57*** ***9.15 ( m)*** **-179.3** | | |
| Strong axis shear strength check<br>$A_w$= 6909 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{179}{1436} =$ | **0.125** |
| Weak Axis Shear - (kN)<br>22.8 ***0.00*** **38.9** ***4.57*** ***6.09*** ***9.15 ( m)*** **-90.3** | | |

Clause 11

Clause 10.4.2.2

Clause 13.2 a (i)

Clause 13.4.1.1(a)


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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 8445 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{90}{1756} =$ | **0.051** |
| Strong Axis Moment - (kN-m)<br>**488.1**<br>***0.00*** ***4.57*** ***9.15 ( m)*** | | |
| Bending Stability Check<br>$L_u$=1.55 m; $\omega_2$=1.146; | $\frac{M_{fx}}{M_{rx}} = \frac{488}{1307} =$ | **0.373** |
| Weak Axis Moment - (kN-m)<br>**172.1**<br>***0.00*** ***6.09*** ***9.15 ( m)*** | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{172}{318} =$ | **0.541** |
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.927** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.902** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

**Clause 13.9(a)**

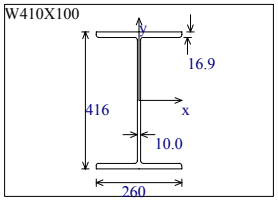
Clause 13.9(b)

**Member: 304** S-FRAME Section is W410X100 *

Member is part of group: Section 7

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 12 1.25D + 1.4Wnorth + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=51.7; | $\frac{k_y L/r_y}{200} = \frac{146}{200} =$ | **0.732** |
| Axial Load - (kN)<br>***0.00*** ***9.14 ( m)***<br>**-723.0** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.950 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (82\ MPa)} = \frac{723}{937} =$ | **0.771** |
| Strong Axis Shear - (kN)<br>**9.4**<br>***0.00*** ***4.56*** ***9.14 ( m)***<br>**-9.4** | | |
| Strong axis shear strength check<br>$A_w$= 4160 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{9}{865} =$ | **0.011** |

Clause 11

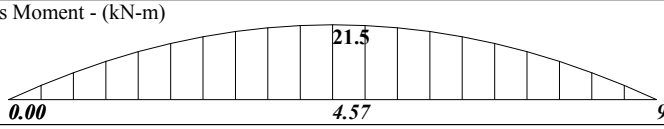
Clause 10.4.2.1

Clause 13.3.1

Clause 13.4.1.1(a)


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Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{21}{386} =$ | **0.056** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.08; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.210** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.08; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.258** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$\omega_{1x}$=1.00; $U_{1x}$=1.08;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.823** |

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

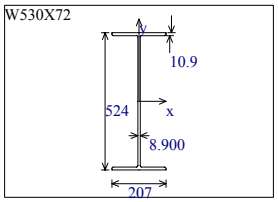
**Clause 13.8.2(c)**

**Member: 305** S-FRAME Section is W530X72

Member is part of group: Section 19

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



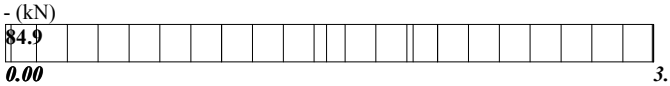

**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{72}{300} =$ | **0.242** |

Clause 11

Clause 10.4.2.2

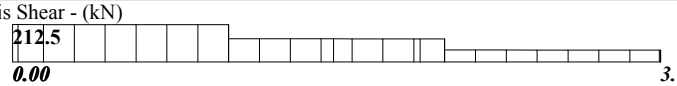
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=9160 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{85}{2885} =$ | **0.029** |

Clause 13.2 a (i)

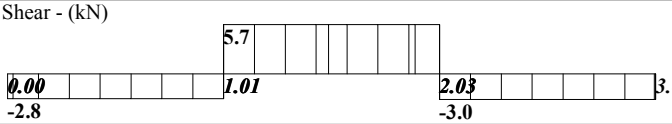
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 4664 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{213}{970} =$ | **0.219** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3008 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{6}{625} =$ | **0.009** |

Clause 13.4.1.1(a)


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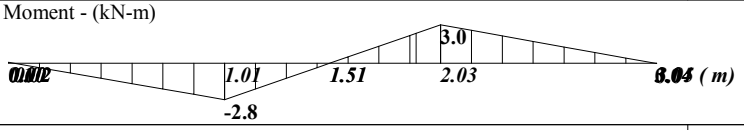
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.01 m; $\omega_2$=2.500; | $\frac{M_{fx}}{M_{rx}} = \frac{334}{482} =$ | **0.693** |

Clause 13.6(b)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y S_y} = \frac{3}{49} =$ | **0.061** |

Clause 13.5(b)

| | | |
|---|---|---|
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi S_x F_y} + \frac{M_{fy}}{\phi S_y F_y} =$ | **0.783** |

**Clause 13.9(a)**

| | | |
|---|---|---|
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f S_x}{M_{rx} A} =$ | **0.724** |

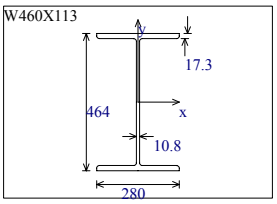
Clause 13.9(b)

**Member: 373** S-FRAME Section is W460X113 *

Member is part of group: Section 33

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 12 1.25D + 1.4Wnorth + 0.5L (Bending + Compression)**

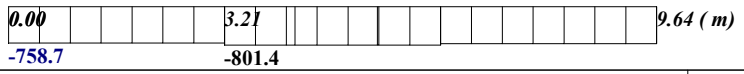
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_x L/r_x$=49.1; | $\frac{k_y L/r_y}{200} = \frac{145}{200} =$ | **0.727** |

Clause 10.4.2.1

Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.936 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (83\ MPa)} = \frac{801}{1076} =$ | **0.745** |

Clause 13.3.1

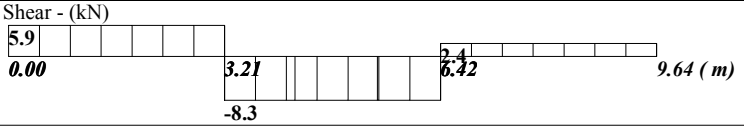
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 5011 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{13}{1042} =$ | **0.013** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)





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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 6459 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{8}{1343} =$ | **0.006** |
| Strong Axis Moment - (kN-m)<br>**34.2**<br>***0.00*** ***4.25*** ***9.64 ( m)*** | | |
| Bending Stability Check<br>$L_u$=9.64 m; $\omega_2$=1.140; | $\frac{M_{fx}}{M_{rx}} = \frac{34}{473} =$ | **0.072** |
| Weak Axis Moment - (kN-m)<br>**18.9**<br>***0.00*** ***3.21*** ***5.48*** ***6.42*** ***9.64 ( m)***<br>**-7.8** | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{19}{218} =$ | **0.087** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.07; $U_{1y}$=2.47; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.343** |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.07; $U_{1y}$=2.47;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.965** |
| Biaxial bending strength check | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.128** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.07; $U_{1y}$=2.47;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.994** |
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.159** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2

**Clause 13.8.2(c)**

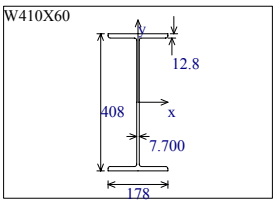
Clause 13.8.2

**Member: 376** S-FRAME Section is W410X60

Member is part of group: Section 11

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 27 0.9D + 1.4Wwest + 0.5S (Tension)**

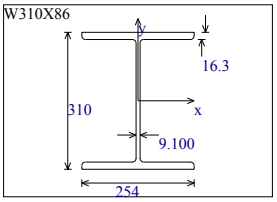
| | | |
|---|---|---|
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{242}{300} =$ | **0.807** |
| Axial Load - (kN)<br>**66.3** **67.2**<br>***0.00*** ***3.21*** ***9.64 ( m)*** | | |
| Factored Tensile Resistance Check<br>$A_g$=7580 mm$^2$; $F_y$=350 MPa; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{67}{2388} =$ | **0.028** |

**Clause 10.4.2.2**

Clause 13.2 a (i)


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**Member: 455** S-FRAME Section is W310X86
Member is part of group: Section 6
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

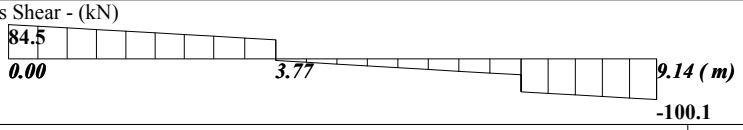



**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

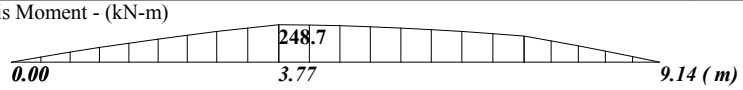
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2821 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{100}{586} =$ | **0.171** |

Clause 13.4.1.1(a)

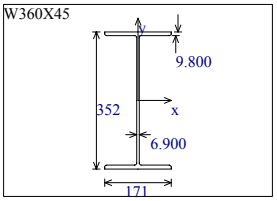
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=9.14 m; $\omega_2$=1.168;** | $\frac{M_{fx}}{M_{rx}} = \frac{249}{315} =$ | **0.789** |

**Clause 13.6(a)**

**Member: 504** S-FRAME Section is W360X45
Member is part of group: Section 10
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 26 0.9D + 1.4Weast + 0.5S (Bending + Compression)**

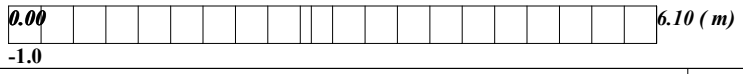
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=41.8;** | $\frac{k_y L/r_y}{200} = \frac{161}{200} =$ | **0.807** |

**Clause 10.4.2.1**

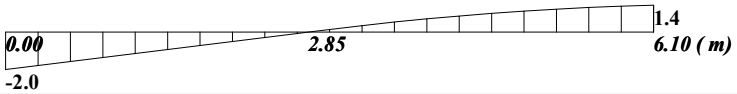
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.148 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (69\ MPa)} = \frac{1}{357} =$ | **0.003** |

Clause 13.3.1

Strong Axis Shear - (kN)

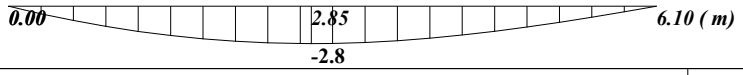



| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2429 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{2}{505} =$ | **0.004** |

Clause 13.4.1.1(a)


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Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=6.10 m; $\omega_2$=1.146; | $\frac{M_{fx}}{M_{rx}} = \frac{3}{108} =$ | **0.026** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.010** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi Z_x F_y} =$ | **0.010** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.025** |

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

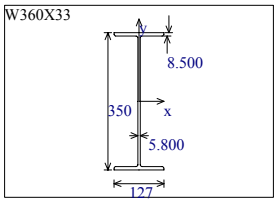
Clause 13.8.2(c)

**Member: 530** S-FRAME Section is W360X33

Member is part of group: Section 9

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



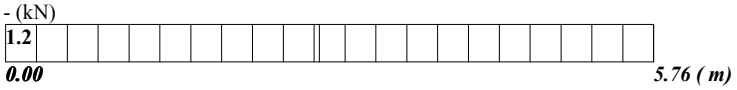

**Load Combination 17 1.25D + 1.4Wsouth + 0.5S (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{218}{300} =$ | **0.727** |

Clause 11

**Clause 10.4.2.2**

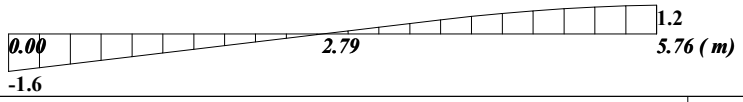
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=4170 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{1}{1314} =$ | **0.001** |

Clause 13.2 a (i)

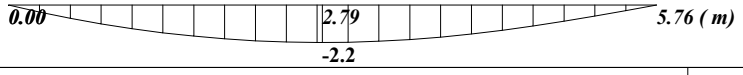
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2030 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w\ 0.66 F_y} = \frac{2}{422} =$ | **0.004** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=5.76 m; $\omega_2$=1.143; | $\frac{M_{fx}}{M_{rx}} = \frac{2}{46} =$ | **0.048** |

Clause 13.6(a)

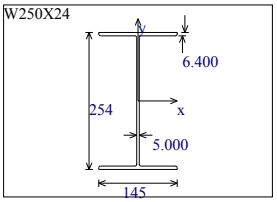

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| | | |
|---|---|---|
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} =$ | **0.014** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.044** |

Clause 13.9(a)

Clause 13.9(b)

**Member: 567** S-FRAME Section is W250X24
Member is part of group: Section 5
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




Clause 11

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **4** |

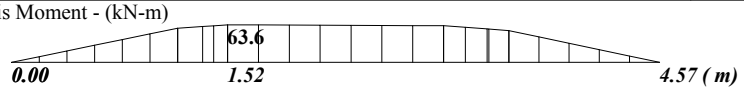
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1270 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{51}{264} =$ | **0.192** |

Clause 13.4.1.1(a)

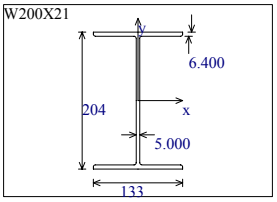
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=1.51 m; $\omega_2$=1.068;** | $\frac{M_{fx}}{M_{rx}} = \frac{64}{81} =$ | **0.785** |

**Clause 13.6(b)**

**Member: 574** S-FRAME Section is W200X21
Member is part of group: Section 4
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

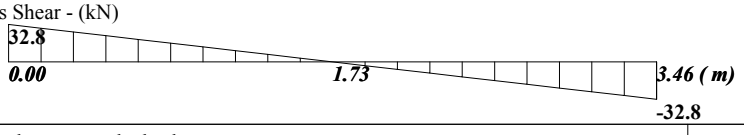



Clause 11

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |

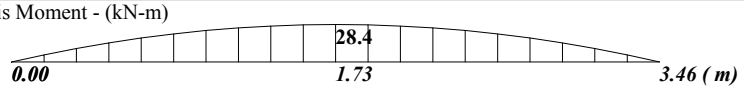
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1020 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{33}{212} =$ | **0.155** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)





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| **Bending Stability Check** | | |
|---|---|---|
| $L_u$=3.46 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{28}{48} =$ | **0.590** |

Clause 13.6(b)

## 4. Summary of Governing Load Cases for Each Member

| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 373 | Section 33 | W460X113 * | Comb 12, 1.25D + 1.4Wnorth + 0.5L | Beam-column stability | 0.994 | Pass |
| 374 | Section 33 | W460X113 * | Comb 12, 1.25D + 1.4Wnorth + 0.5L | Beam-column stability | 0.992 | Pass |
| 208 | Section 37 | W530X123 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.985 | Pass |
| 215 | Section 37 | W530X123 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.985 | Pass |
| 14 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.978 | Pass |
| 9 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.971 | Pass |
| 63 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 65 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 47 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.959 | Pass |
| 51 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.959 | Pass |
| 58 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.584 | Pass |
| 45 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.584 | Pass |
| 67 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.481 | Pass |
| 53 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.481 | Pass |
| 43 | Section 23 | W310X31 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.412 | Pass |
| 55 | Section 23 | W310X31 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.412 | Pass |
| 11 | Section 28 | W200X59 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Beam-column stability | 0.958 | Pass |
| 16 | Section 28 | W200X59 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Beam-column stability | 0.957 | Pass |
| 303 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.892 | Pass |
| 306 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.892 | Pass |
| 18 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.751 | Pass |
| 4 | Section 28 | W200X59 | Comb 18, 1.25D + 1.4Weast + 0.5S | Beam-column stability | 0.633 | Pass |
| 21 | Section 28 | W200X59 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column stability | 0.621 | Pass |
| 17 | Section 28 | W200X59 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.591 | Pass |
| 20 | Section 28 | W200X59 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.591 | Pass |
| 12 | Section 30 | W250X67 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column stability | 0.945 | Pass |
| 7 | Section 30 | W250X67 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column stability | 0.945 | Pass |
| 27 | Section 30 | W250X67 | Comb 3, 1.25D + 1.5L + 0.4Wnorth | Beam-column strength | 0.816 | Pass |
| 25 | Section 30 | W250X67 | Comb 3, 1.25D + 1.5L + 0.4Wnorth | Beam-column strength | 0.786 | Pass |
| 19 | Section 30 | W250X67 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.699 | Pass |
| 203 | Section 30 | W250X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.412 | Pass |
| 202 | Section 30 | W250X67 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Slenderness | 0.412 | Pass |
| 71 | Section 22 | W360X72 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.943 | Pass |
| 312 | Section 22 | W360X72 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.943 | Pass |
| 381 | Section 22 | W360X72 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.943 | Pass |
| 62 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.927 | Pass |
| 66 | Section 20 | W310X67 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.927 | Pass |
| 61 | Section 20 | W310X67 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.927 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 46 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.927 | Pass |
| 54 | Section 20 | W310X67 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.927 | Pass |
| 64 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 49 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 481 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 500 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 498 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 483 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 485 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 496 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 499 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 501 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 482 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 479 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 484 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 497 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 48 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.618 | Pass |
| 50 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.618 | Pass |
| 60 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.618 | Pass |
| 59 | Section 20 | W310X67 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.618 | Pass |
| 52 | Section 20 | W310X67 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.618 | Pass |
| 212 | Section 17 | W530X150 * | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-tension strength | 0.927 | Pass |
| 83 | Section 17 | W530X150 * | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-tension strength | 0.902 | Pass |
| 70 | Section 17 | W530X150 * | Comb 5, 1.25D + 1.5L + 0.4Weast | Beam-tension strength | 0.815 | Pass |
| 68 | Section 17 | W530X150 * | Comb 5, 1.25D + 1.5L + 0.4Weast | Beam-tension strength | 0.813 | Pass |
| 84 | Section 17 | W530X150 * | Comb 3, 1.25D + 1.5L + 0.4Wnorth | Beam-tension strength | 0.758 | Pass |
| 211 | Section 17 | W530X150 * | Comb 3, 1.25D + 1.5L + 0.4Wnorth | Beam-tension strength | 0.746 | Pass |
| 72 | Section 17 | W530X150 * | Comb 5, 1.25D + 1.5L + 0.4Weast | Beam-tension strength | 0.742 | Pass |
| 69 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.738 | Pass |
| 2 | Section 27 | W250X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.912 | Pass |
| 1 | Section 27 | W250X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.912 | Pass |
| 6 | Section 27 | W250X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.912 | Pass |
| 3 | Section 27 | W250X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.912 | Pass |
| 22 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.907 | Pass |
| 5 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.877 | Pass |
| 37 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.906 | Pass |
| 38 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.879 | Pass |
| 15 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.818 | Pass |
| 33 | Section 31 | W250X115 | Comb 4, 1.25D + 1.5L + 0.4Wsouth | Beam-column strength | 0.817 | Pass |
| 34 | Section 31 | W250X115 | Comb 4, 1.25D + 1.5L + 0.4Wsouth | Beam-column strength | 0.811 | Pass |
| 10 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.811 | Pass |
| 13 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.772 | Pass |
| 8 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.753 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 35 | Section 35 | W250X45 | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-column stability | 0.889 | Pass |
| 191 | Section 35 | W250X45 | Comb 26, 0.9D + 1.4Weast + 0.5S | Beam-column stability | 0.795 | Pass |
| 194 | Section 35 | W250X45 | Comb 26, 0.9D + 1.4Weast + 0.5S | Beam-column stability | 0.795 | Pass |
| 32 | Section 35 | W250X45 | Comb 6, 1.25D + 1.5L + 0.4Wwest | Beam-column stability | 0.716 | Pass |
| 26 | Section 35 | W250X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Beam-column stability | 0.674 | Pass |
| 28 | Section 35 | W250X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Beam-column stability | 0.674 | Pass |
| 23 | Section 35 | W250X45 | Comb 5, 1.25D + 1.5L + 0.4Weast | Beam-column stability | 0.656 | Pass |
| 39 | Section 35 | W250X45 | Comb 22, 0.9D + 1.4Weast + 0.5L | Beam-tension strength | 0.638 | Pass |
| 188 | Section 35 | W250X45 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Slenderness | 0.599 | Pass |
| 36 | Section 35 | W250X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.599 | Pass |
| 179 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.859 | Pass |
| 181 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.788 | Pass |
| 178 | Section 24 | W360X64 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.652 | Pass |
| 182 | Section 24 | W360X64 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.625 | Pass |
| 183 | Section 24 | W360X64 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.582 | Pass |
| 171 | Section 24 | W360X64 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.461 | Pass |
| 488 | Section 21 | W310X21 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.85 | Pass |
| 489 | Section 21 | W310X21 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.85 | Pass |
| 487 | Section 21 | W310X21 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.85 | Pass |
| 44 | Section 21 | W310X21 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.85 | Pass |
| 56 | Section 21 | W310X21 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.85 | Pass |
| 486 | Section 21 | W310X21 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.566 | Pass |
| 42 | Section 21 | W310X21 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.566 | Pass |
| 57 | Section 21 | W310X21 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.566 | Pass |
| 493 | Section 21 | W310X21 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.566 | Pass |
| 490 | Section 21 | W310X21 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.566 | Pass |
| 491 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 492 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 495 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 494 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 480 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 478 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 304 | Section 7 | W410X100 * | Comb 12, 1.25D + 1.4Wnorth + 0.5L | Beam-column stability | 0.823 | Pass |
| 204 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 96 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 75 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 216 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 206 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 88 | Section 7 | W410X100 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.732 | Pass |
| 85 | Section 7 | W410X100 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.732 | Pass |
| 81 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 92 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 90 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 89 | Section 7 | W410X100 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.732 | Pass |
| 502 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 380 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 73 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 517 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.732 | Pass |
| 516 | Section 7 | W410X100 * | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.732 | Pass |
| 379 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 310 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 217 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 311 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.732 | Pass |
| 378 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.71 | Pass |
| 375 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.71 | Pass |
| 205 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.614 | Pass |
| 503 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.488 | Pass |
| 77 | Section 7 | W410X100 * | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.488 | Pass |
| 80 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.488 | Pass |
| 78 | Section 7 | W410X100 * | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.488 | Pass |
| 376 | Section 11 | W410X60 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.807 | Pass |
| 377 | Section 11 | W410X60 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.807 | Pass |
| 93 | Section 11 | W410X60 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.766 | Pass |
| 518 | Section 10 | W360X45 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.807 | Pass |
| 521 | Section 10 | W360X45 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.807 | Pass |
| 504 | Section 10 | W360X45 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.807 | Pass |
| 507 | Section 10 | W360X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.807 | Pass |
| 588 | Section 10 | W360X45 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.762 | Pass |
| 589 | Section 10 | W360X45 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.508 | Pass |
| 519 | Section 10 | W360X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.403 | Pass |
| 522 | Section 10 | W360X45 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.403 | Pass |
| 590 | Section 10 | W360X45 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.254 | Pass |
| 209 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.806 | Pass |
| 214 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.798 | Pass |
| 180 | Section 18 | W530X92 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.698 | Pass |
| 185 | Section 18 | W530X92 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.669 | Pass |
| 193 | Section 8 | W410X54 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.791 | Pass |
| 192 | Section 8 | W410X54 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.791 | Pass |
| 195 | Section 8 | W410X54 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.791 | Pass |
| 199 | Section 8 | W410X54 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.726 | Pass |
| 94 | Section 8 | W410X54 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.679 | Pass |
| 91 | Section 8 | W410X54 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.679 | Pass |
| 169 | Section 8 | W410X54 | Comb 24, 0.9D + 1.4Wnorth + 0.5S | Slenderness | 0.576 | Pass |
| 455 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.789 | Pass |
| 460 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.769 | Pass |
| 456 | Section 6 | W310X86 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.719 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 24 | Section 34 | W200X46 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column strength | 0.785 | Pass |
| 30 | Section 34 | W200X46 | Comb 14, 1.25D + 1.4Weast + 0.5L | Beam-column strength | 0.633 | Pass |
| 29 | Section 34 | W200X46 | Comb 15, 1.25D + 1.4Wwest + 0.5L | Beam-column strength | 0.572 | Pass |
| 187 | Section 34 | W200X46 | Comb 18, 1.25D + 1.4Weast + 0.5S | Beam-column stability | 0.547 | Pass |
| 196 | Section 34 | W200X46 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Beam-column stability | 0.531 | Pass |
| 197 | Section 34 | W200X46 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.411 | Pass |
| 567 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.785 | Pass |
| 570 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.75 | Pass |
| 569 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.662 | Pass |
| 568 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.628 | Pass |
| 571 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.263 | Pass |
| 572 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.261 | Pass |
| 305 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 302 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 184 | Section 19 | W530X72 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.665 | Pass |
| 170 | Section 19 | W530X72 | Comb 3, 1.25D + 1.5L + 0.4Wnorth | Beam-column strength | 0.536 | Pass |
| 530 | Section 9 | W360X33 | Comb 17, 1.25D + 1.4Wsouth + 0.5S | Slenderness | 0.727 | Pass |
| 531 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 505 | Section 9 | W360X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.385 | Pass |
| 508 | Section 9 | W360X33 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.385 | Pass |
| 532 | Section 9 | W360X33 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Slenderness | 0.364 | Pass |
| 190 | Section 3 | W530X82 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.713 | Pass |
| 186 | Section 3 | W530X82 | Comb 27, 0.9D + 1.4Wwest + 0.5S | Slenderness | 0.455 | Pass |
| 210 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.638 | Pass |
| 31 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.631 | Pass |
| 207 | Section 36 | W250X89 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Slenderness | 0.322 | Pass |
| 213 | Section 36 | W250X89 | Comb 19, 1.25D + 1.4Wwest + 0.5S | Slenderness | 0.322 | Pass |
| 576 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 574 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 575 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.579 | Pass |
| 577 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.579 | Pass |
| 573 | Section 4 | W200X21 | Comb 26, 0.9D + 1.4Weast + 0.5S | Slenderness | 0.568 | Pass |
| 198 | Section 13 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 189 | Section 13 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 201 | Section 13 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 200 | Section 13 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 76 | Section 12 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 74 | Section 12 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 82 | Section 12 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |
| 79 | Section 12 | W410X39 | Comb 25, 0.9D + 1.4Wsouth + 0.5S | Slenderness | 0.536 | Pass |


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# S-Steel Key Results- Downward Load Cases

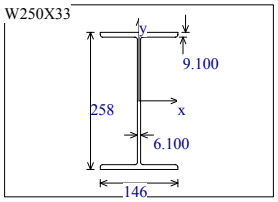
## 1. Summary of Governing Selected Members for Each Group

| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 14 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.978 | Pass |
| 63 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 71 | Section 22 | W360X72 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.943 | Pass |
| 1 | Section 27 | W250X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.912 | Pass |
| 22 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.907 | Pass |
| 37 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.906 | Pass |
| 303 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.892 | Pass |
| 46 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 179 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.859 | Pass |
| 376 | Section 11 | W410X60 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |
| 504 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |
| 209 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.806 | Pass |
| 455 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.789 | Pass |
| 567 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.785 | Pass |
| 305 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 27 | Section 30 | W250X67 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.776 | Pass |
| 84 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.746 | Pass |
| 90 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 530 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 373 | Section 33 | W460X113 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 215 | Section 37 | W530X123 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.723 | Pass |
| 94 | Section 8 | W410X54 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.679 | Pass |
| 35 | Section 35 | W250X45 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.667 | Pass |
| 210 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.638 | Pass |
| 574 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 486 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.556 | Pass |
| 186 | Section 3 | W530X82 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.455 | Pass |
| 79 | Section 12 | W410X39 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.452 | Pass |
| 24 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 201 | Section 13 | W410X39 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.281 | Pass |

## 2. Code Details For Governing Members for Each Group

**Member: 1** S-FRAME Section is W250X33
Member is part of group: Section 27
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

⇨ **Load Combination 7 1.25D + 1.5S + 0.5L (Compression)**





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| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **4** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=56.7;** | $\frac{k_y L/r_y}{200} = \frac{182}{200}$ = | **0.912** |
| Equivalent slenderness parameter based on buckling stress Fe<br>$F_e$=59 MPa; | $\lambda_e = \left[\frac{F_y}{F_e}\right]^{1/2}$ = | **2.428** |
| Axial Load - (kN)<br>***0.00*** ***6.14 ( m)***<br>**-40.9** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_e$=2.428 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A_{eff} F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A_{eff}\,(56\ MPa)} = \frac{41}{202}$ = | **0.202** |
| Effective area for class 4 sections<br>$A_{gross}$=4170 $mm^2$; | $A_{eff}\,(mm^2)$ = | **4040** |

Clause 11

**Clause 10.4.2.1**

Clause 13.3.2

Clause 13.3.2

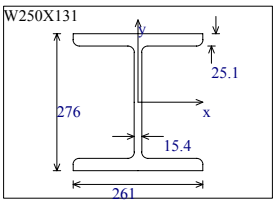
Clause 13.3.3(a)

**Member: 14** S-FRAME Section is W250X131

Member is part of group: Section 32

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=53.4; | $\frac{k_y L/r_y}{200} = \frac{92}{200}$ = | **0.460** |
| Axial Load - (kN)<br>***0.00*** ***6.14 ( m)***<br>**-2087.1** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.224 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (166\ MPa)} = \frac{2087}{2493}$ = | **0.837** |
| Weak Axis Shear - (kN)<br>**5.7**<br>***0.00*** ***6.14 ( m)*** | | |
| Weak axis shear strength check<br>$A_w$= 8735 $mm^2$; | $\frac{V_{fx}}{\phi\, A_w\, F_s} = \frac{V_{fx}}{\phi\, A_w\, 0.66 F_y} = \frac{6}{1816}$ = | **0.003** |
| Weak Axis Moment - (kN-m)<br>**35.2**<br>***0.00*** ***6.14 ( m)*** | | |

Clause 11

Clause 10.4.2.1

Clause 13.3.1

Clause 13.4.1.1(a)


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| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{35}{274} =$ | **0.128** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=0.60; $U_{1x}$=1.22; $U_{1y}$=1.29; | $\frac{C_f}{\phi A F_y} + \frac{0.85\, U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.496** |
| **Axial Compression and Bending overall member Strength Check**<br>**$U_{1x}$=1.22; $U_{1y}$=1.29;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\, U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.978** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.22; $U_{1y}$=1.29;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\, U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.978** |

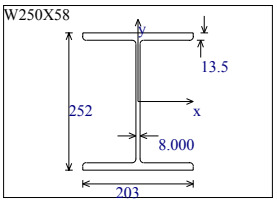
Clause 13.5(a)

Clause 13.8.2(a)

**Clause 13.8.2(b)**

**Clause 13.8.2(c)**

**Member: 22** S-FRAME Section is W250X58
Member is part of group: Section 29
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Compression)**

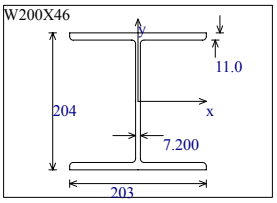
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=56.6; | $\frac{k_y L/r_y}{200} = \frac{122}{200} =$ | **0.610** |
| Axial Load - (kN)<br>***0.00*** ***6.14 ( m)***<br>**-671.2** | | |
| **Factored Compressive Resistance Check**<br>**n=1.34; $\lambda_y$=1.624** | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (111\ MPa)} = \frac{671}{740} =$ | **0.907** |

Clause 11

Clause 10.4.2.1

**Clause 13.3.1**

**Member: 24** S-FRAME Section is W200X46
Member is part of group: Section 34
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=47.7;** | $\frac{k_y L/r_y}{200} = \frac{82}{200} =$ | **0.411** |
| Axial Load - (kN)<br>***0.00*** ***4.20 ( m)***<br>**-112.8** | | |

Clause 11

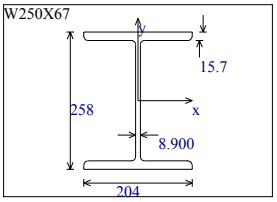
**Clause 10.4.2.1**


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| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.095 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (190\ MPa)} = \frac{113}{1000} =$ | **0.113** |

Clause 13.3.1

**Member: 27** S-FRAME Section is W250X67
Member is part of group: Section 30
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

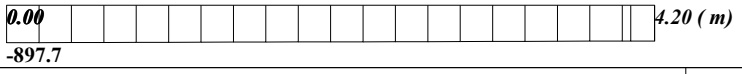
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=38.1; | $\frac{k_y L/r_y}{200} = \frac{82}{200} =$ | **0.412** |

Clause 10.4.2.1

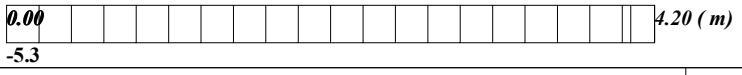
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.098 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (189\ MPa)} = \frac{898}{1454} =$ | **0.617** |

Clause 13.3.1

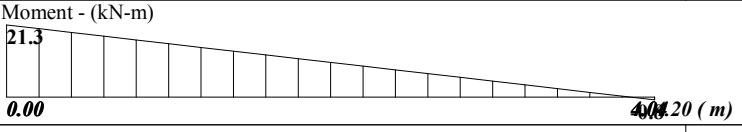
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 4270 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w\ 0.66F_y} = \frac{5}{888} =$ | **0.006** |

Clause 13.4.1.1(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{21}{105} =$ | **0.204** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=0.58; $U_{1x}$=1.08; $U_{1y}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.455** |

Clause 13.8.2(a)

| | | |
|---|---|---|
| **Axial Compression and Bending overall member Strength Check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.92;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.776** |

**Clause 13.8.2(b)**

| | | |
|---|---|---|
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.92;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{M_{rx}} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.776** |

**Clause 13.8.2(c)**

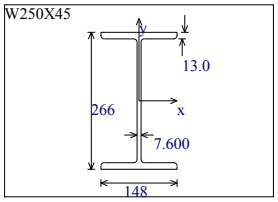

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**Member: 35** S-FRAME Section is W250X45

Member is part of group: Section 35

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=37.7; | $\frac{k_y L/r_y}{200} = \frac{120}{200} =$ | **0.599** |
| Axial Load - (kN)<br>**0.00** … **4.20 ( m)**<br>**-384.9** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.595 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (114\ MPa)} = \frac{385}{587} =$ | **0.656** |
| Strong Axis Shear - (kN)<br>**2.4**<br>**0.00** … **4.20 ( m)** | | |
| Strong axis shear strength check<br>$A_w$= 2022 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{2}{420} =$ | **0.006** |
| Strong Axis Moment - (kN-m)<br>**0.00** … **2.49** … **4.20 ( m)**<br>**4.1**<br>**-6.0** | | |
| Bending Stability Check<br>$L_u$=4.20 m; $\omega_2$=2.500; | $\frac{M_{fx}}{M_{rx}} = \frac{6}{186} =$ | **0.032** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=0.40; $U_{1x}$=1.00; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.241** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=0.40; $U_{1x}$=0.42; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.250** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$\omega_{1x}$=0.40; $U_{1x}$=0.42;** | $\mathbf{\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =}$ | **0.667** |

Clause 11

Clause 10.4.2.1

Clause 13.3.1

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

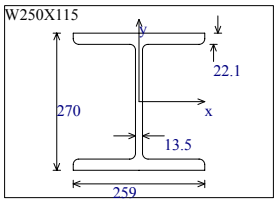
**Clause 13.8.2(c)**

**Member: 37** S-FRAME Section is W250X115

Member is part of group: Section 31

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**


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| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); Section Class = | **1** | Clause 11 |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=36.9; $\frac{k_y L/r_y}{200} = \frac{63}{200} =$ | **0.317** | Clause 10.4.2.1 |
| Axial Load - (kN)<br>0.00 … 4.20 ( m)<br>-327.7 | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=0.844 $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (243\ MPa)} = \frac{328}{3187} =$ | **0.103** | Clause 13.3.1 |
| Strong Axis Shear - (kN)<br>4.0<br>0.00 … 4.20 ( m) | | |
| Strong axis shear strength check<br>$A_w$= 3645 mm$^2$; $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{4}{758} =$ | **0.005** | Clause 13.4.1.1(a) |
| Weak Axis Shear - (kN)<br>97.2<br>0.00 … 4.20 ( m) | | |
| Weak axis shear strength check<br>$A_w$= 7632 mm$^2$; $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66 F_y} = \frac{97}{1587} =$ | **0.061** | Clause 13.4.1.1(a) |
| Strong Axis Moment - (kN-m)<br>0.00 … 4.20 ( m)<br>-16.8 | | |
| Bending Stability Check<br>$L_u$=4.20 m; $\omega_2$=1.751; $\frac{M_{fx}}{M_{rx}} = \frac{17}{504} =$ | **0.033** | Clause 13.6(a) |
| Weak Axis Moment - (kN-m)<br>201.4<br>0.00 … 2.13 … 4.20 ( m)<br>-206.9 | | |
| Weak axis section capacity in bending $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{207}{237} =$ | **0.872** | Clause 13.5(a) |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=0.60; $\omega_{1y}$=0.40; $U_{1x}$=1.00; $U_{1y}$=1.00; $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6 U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.623** | Clause 13.8.2(a) |
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=0.61; $U_{1y}$=0.42;β=0.85; $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.431** | Clause 13.8.2(b) |
| **Biaxial bending strength check** $\mathbf{\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =}$ | **0.906** | **Clause 13.8.2** |

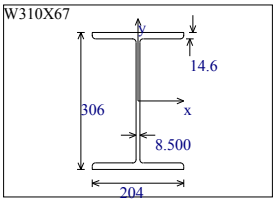

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| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=0.61; $U_{1y}$=0.42;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85\,U_{1x}\,M_{fx}}{M_{rx}} + \frac{\beta\,U_{1y}\,M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.431** |
| **Biaxial bending stability check** | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi\,Z_y\,F_y} =$ | **0.906** |

Clause 13.8.2(c)

**Clause 13.8.2**

**Member: 46** S-FRAME Section is W310X67
Member is part of group: Section 20
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{185}{300} =$ | **0.618** |
| Axial Load - (kN)<br>**3.2**<br>***0.00*** ***9.14 ( m)*** | | |
| Factored Tensile Resistance Check<br>$A_g$=8510 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{3}{2681} =$ | **0.001** |
| Strong Axis Shear - (kN)<br>**62.8**<br>***0.00*** ***4.57*** ***9.14 ( m)***<br>**-62.8** | | |
| Strong axis shear strength check<br>$A_w$= 2601 mm$^2$; | $\frac{V_{fy}}{\phi\,A_w\,F_s} = \frac{V_{fy}}{\phi\,A_w\,0.66F_y} = \frac{63}{541} =$ | **0.116** |
| Strong Axis Moment - (kN-m)<br>**143.5**<br>***0.00*** ***4.57*** ***9.14 ( m)*** | | |
| **Bending Stability Check**<br>**$L_u$=9.14 m; $\omega_2$=1.131;** | $\frac{M_{fx}}{M_{rx}} = \frac{143}{163} =$ | **0.881** |
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi\,Z_x\,F_y} =$ | **0.431** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} - \frac{T_f\,Z_x}{M_{rx}\,A} =$ | **0.879** |

Clause 11

Clause 10.4.2.2

Clause 13.2 a (i)

Clause 13.4.1.1(a)

**Clause 13.6(a)**

Clause 13.9(a)

Clause 13.9(b)

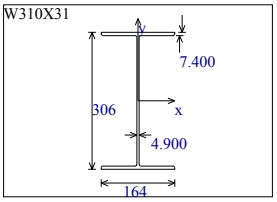

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**Member: 63** S-FRAME Section is W310X31

Member is part of group: Section 23

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **4** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=23.5; | $\frac{k_y L/r_y}{200} = \frac{82}{200} =$ | **0.412** |
| Equivalent slenderness parameter based on buckling stress Fe<br>$F_e$=290 MPa; | $\lambda_e = \left[\frac{F_y}{F_e}\right]^{1/2} =$ | **1.098** |
| Axial Load - (kN)<br>**0.00** … **3.05 ( m)**<br>**-2.4** | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_e$=1.098 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A_{eff} F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A_{eff}\,(189\ \text{MPa})} = \frac{2}{567} =$ | **0.004** |
| Effective area for class 4 sections<br>$A_{gross}$=3990 mm$^2$; | $A_{eff}$ (mm$^2$) = | **3337** |
| Strong Axis Shear - (kN)<br>**118.8**<br>**0.00** … **2.03** … **3.05 ( m)**<br>**-121.2** | | |
| Strong axis shear strength check<br>$A_w$= 1499 mm$^2$; | $\frac{V_{fy}}{\phi\, A_w\, F_s} = \frac{V_{fy}}{\phi\, A_w\, 0.66 F_y} = \frac{121}{312} =$ | **0.389** |
| Strong Axis Moment - (kN-m)<br>**123.0**<br>**0.00** … **2.03** … **3.05 ( m)** | | |
| Bending Stability Check<br>$L_u$=1.01 m; $\omega_2$=1.142; | $\frac{M_{fx}}{M_{rx}} = \frac{123}{128} =$ | **0.959** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi\, A_{eff}\, F_y} + \frac{M_{fx}}{M_{rx}} =$ | **0.893** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{U_{1x}\, M_{fx}}{M_{rx}} =$ | **0.894** |
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$\omega_{1x}$=1.00; $U_{1x}$=1.00;** | $\frac{C_f}{C_{ry}} + \frac{U_{1x}\, M_{fx}}{M_{rx}} =$ | **0.963** |

Clause 11

Clause 10.4.2.1

Clause 13.3.2

Clause 13.3.2

Clause 13.3.3(a)

Clause 13.4.1.1(a)

Clause 13.6(b)

Clause 13.8.3(a)

Clause 13.8.3(b)

**Clause 13.8.3(c)**

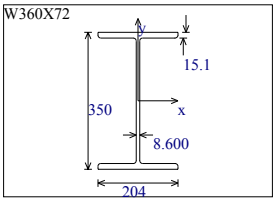

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**Member: 71** S-FRAME Section is W360X72

Member is part of group: Section 22

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*



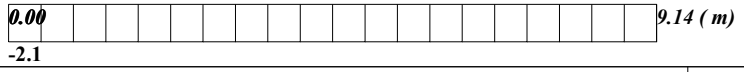

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=61.6;** | $\frac{k_y L/r_y}{200} = \frac{189}{200} =$ | **0.943** |

Clause 11

**Clause 10.4.2.1**

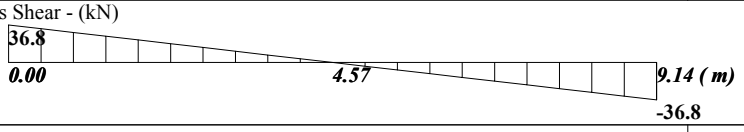
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.512 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (52\ MPa)} = \frac{2}{428} =$ | **0.005** |

Clause 13.3.1

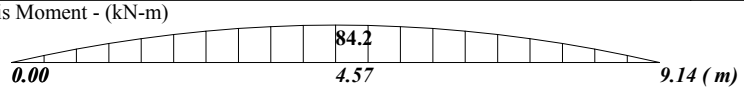
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 3010 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{37}{626} =$ | **0.059** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.131; | $\frac{M_{fx}}{M_{rx}} = \frac{84}{178} =$ | **0.473** |

Clause 13.6(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.178** |

Clause 13.8.2(a)

| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.179** |

Clause 13.8.2(b)

| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.407** |

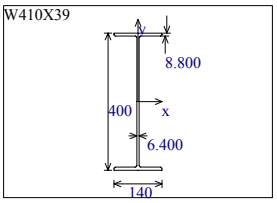
Clause 13.8.2(c)

**Member: 79** S-FRAME Section is W410X39

Member is part of group: Section 12

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**


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| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{107}{300} =$ | **0.357** |
| Axial Load - (kN)<br>**1.8** at ***0.00*** … ***3.05 ( m)*** | | |
| Factored Tensile Resistance Check<br>$A_g$=4990 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{2}{1572} =$ | **0.001** |
| Strong Axis Shear - (kN)<br>**68.4** at ***0.00*** … ***1.52*** … ***3.05 ( m)***<br>**-68.4** | | |
| Strong axis shear strength check<br>$A_w$= 2560 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{68}{532} =$ | **0.128** |
| Strong Axis Moment - (kN-m)<br>**103.6** at ***1.52***<br>***0.00*** … ***3.05 ( m)*** | | |
| Bending Stability Check<br>$L_u$=1.52 m; $\omega_2$=1.264; | $\frac{M_{fx}}{M_{rx}} = \frac{104}{230} =$ | **0.451** |
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} =$ | **0.452** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.449** |

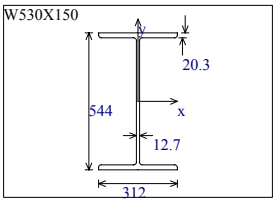
Clause 11
Clause 10.4.2.2
Clause 13.2 a (i)
Clause 13.4.1.1(a)
Clause 13.6(a)
**Clause 13.9(a)**
Clause 13.9(b)

**Member: 84** S-FRAME Section is W530X150 *

Member is part of group: Section 17

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{125}{300} =$ | **0.416** |
| Axial Load - (kN)<br>**15.1** at ***0.00*** … ***9.14 ( m)*** | | |

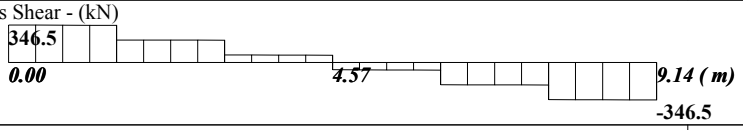
Clause 11
Clause 10.4.2.2


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| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=19200 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{15}{6048} =$ | **0.002** |

Clause 13.2 a (i)

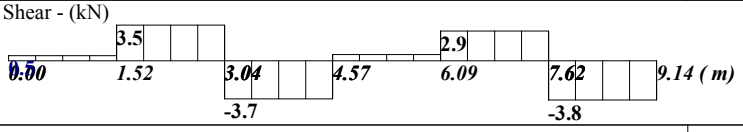
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 6909 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{346}{1436} =$ | **0.241** |

Clause 13.4.1.1(a)

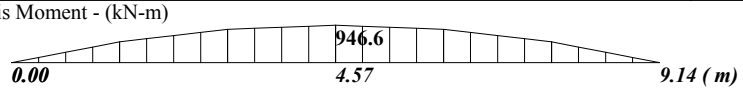
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 8445 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{4}{1756} =$ | **0.002** |

Clause 13.4.1.1(a)

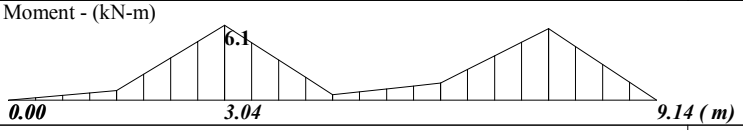
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.55 m; $\omega_2$=1.146; | $\frac{M_{fx}}{M_{rx}} = \frac{947}{1307} =$ | **0.724** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{6}{318} =$ | **0.019** |

Clause 13.5(a)

| | | |
|---|---|---|
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.746** |

**Clause 13.9(a)**

| | | |
|---|---|---|
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.741** |

Clause 13.9(b)

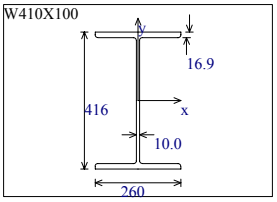
**Member: 90** S-FRAME Section is W410X100 *

Member is part of group: Section 7

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**



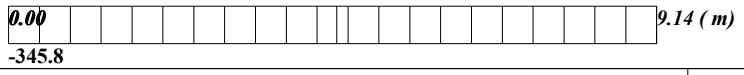
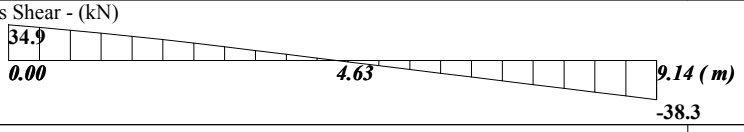
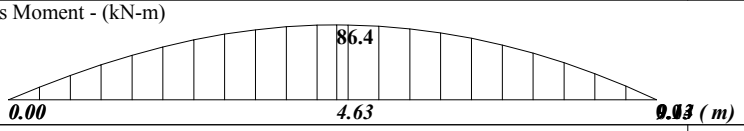

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=51.7;** | $\frac{k_y L/r_y}{200} = \frac{146}{200} =$ | **0.732** |

**Clause 10.4.2.1**


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| | | |
|---|---|---|
| Axial Load - (kN)<br>  <br> | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.950 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (82\ MPa)} = \frac{346}{937} =$ | **0.369** |
| Strong Axis Shear - (kN)<br>  <br> | | |
| Strong axis shear strength check<br>$A_w$= 4160 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66F_y} = \frac{38}{865} =$ | **0.044** |
| Strong Axis Moment - (kN-m)<br>  <br> | | |
| Bending Stability Check<br>$L_u$=9.14 m; $\omega_2$=1.136; | $\frac{M_{fx}}{M_{rx}} = \frac{86}{387} =$ | **0.223** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.04; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.200** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.04; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.223** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.04; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.566** |

Clause 13.3.1

Clause 13.4.1.1(a)

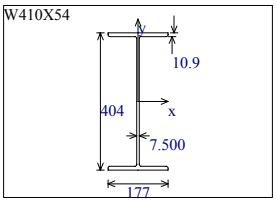
Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

Clause 13.8.2(c)

**Member: 94** S-FRAME Section is W410X54
Member is part of group: Section 8
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=18.4; | $\frac{k_y\ L/r_y}{200} = \frac{79}{200} =$ | **0.396** |
| Axial Load - (kN)<br>  <br> | | |
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.054 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (198\ MPa)} = \frac{97}{1211} =$ | **0.080** |

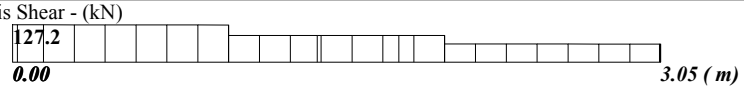
Clause 11

Clause 10.4.2.1

Clause 13.3.1


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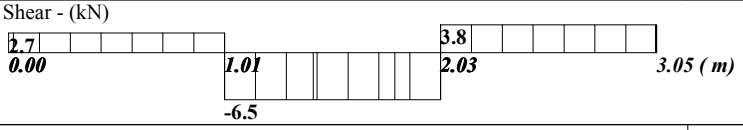
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 3030 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{127}{630} =$ | **0.202** |

Clause 13.4.1.1(a)

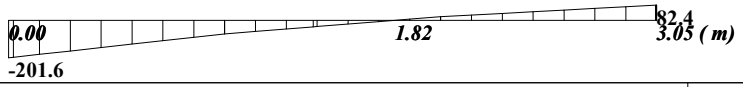
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 2572 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{6}{535} =$ | **0.012** |

Clause 13.4.1.1(a)

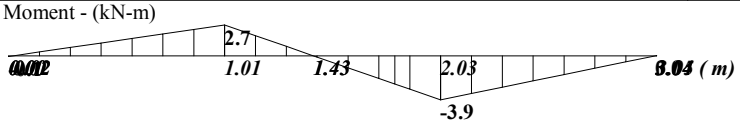
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.01 m; $\omega_2$=2.500; | $\frac{M_{fx}}{M_{rx}} = \frac{202}{331} =$ | **0.609** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{4}{56} =$ | **0.070** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.00; $U_{1y}$=1.05; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.608** |

Clause 13.8.2(a)

| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.00; $U_{1y}$=1.05;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.662** |

Clause 13.8.2(b)

| | | |
|---|---|---|
| **Biaxial bending strength check** | $\frac{\mathbf{M_{fx}}}{\phi \mathbf{Z_x F_y}} + \frac{\mathbf{M_{fy}}}{\phi \mathbf{Z_y F_y}} =$ | **0.679** |

**Clause 13.8.2**

| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=1.00; $U_{1y}$=1.05;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.662** |

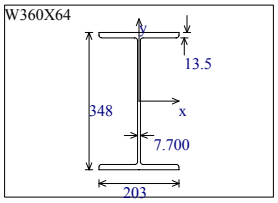
Clause 13.8.2(c)

| | | |
|---|---|---|
| **Biaxial bending stability check** | $\frac{\mathbf{M_{fx}}}{\mathbf{M_{rx}}} + \frac{\mathbf{M_{fy}}}{\phi \mathbf{Z_y F_y}} =$ | **0.679** |

**Clause 13.8.2**

**Member: 179** S-FRAME Section is W360X64
Member is part of group: Section 24
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

**Load Combination 2 1.25D + 1.5L + 0.5S (Bending)**



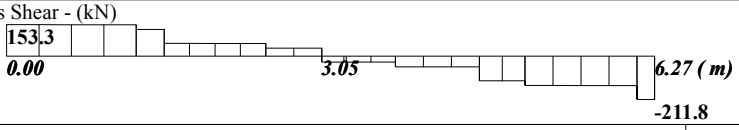


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| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

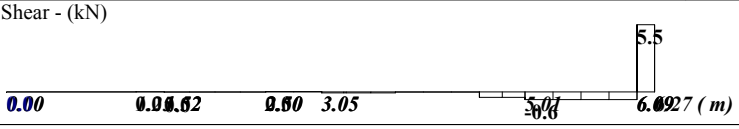
Strong Axis Shear - (kN)



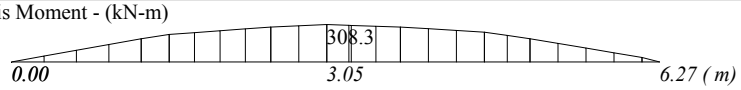

| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2680 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{212}{557} =$ | **0.380** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)




Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=1.57 m; $\omega_2$=1.140;** | $\frac{M_{fx}}{M_{rx}} = \frac{308}{359} =$ | **0.859** |

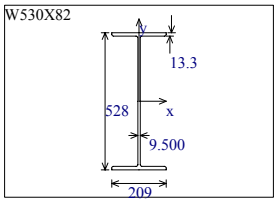
**Clause 13.6(a)**

**Member: 186** S-FRAME Section is W530X82

Member is part of group: Section 3

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Tension)**

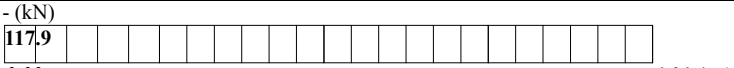
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{137}{300} =$ | **0.455** |

**Clause 10.4.2.2**

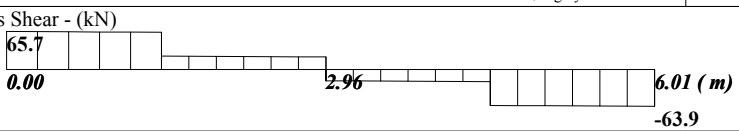
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=10500 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{118}{3308} =$ | **0.036** |

Clause 13.2 a (i)

Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 5016 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{66}{1043} =$ | **0.063** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)

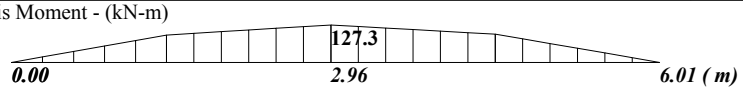




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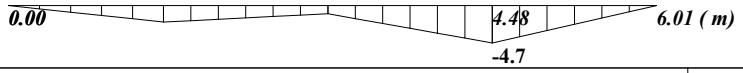
| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3706 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{3}{771} =$ | **0.004** |

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.50 m; $\omega_2$=1.139; | $\frac{M_{fx}}{M_{rx}} = \frac{127}{652} =$ | **0.195** |

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{5}{95} =$ | **0.049** |
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.280** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.208** |

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

Clause 13.9(a)

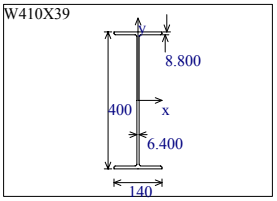
Clause 13.9(b)

**Member: 201** S-FRAME Section is W410X39

Member is part of group: Section 13

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*

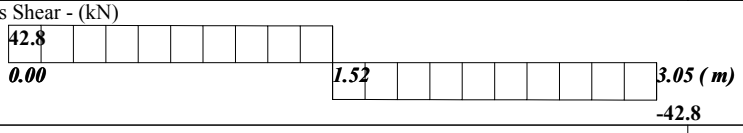



**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

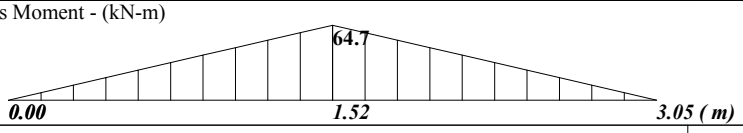
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2560 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{43}{532} =$ | **0.080** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=1.52 m; $\omega_2$=1.264;** | $\frac{M_{fx}}{M_{rx}} = \frac{65}{230} =$ | **0.281** |

**Clause 13.6(a)**

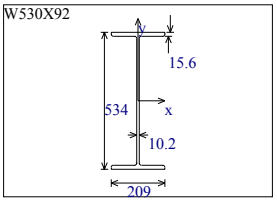

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**Member: 209** S-FRAME Section is W530X92

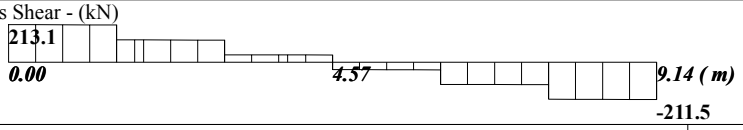
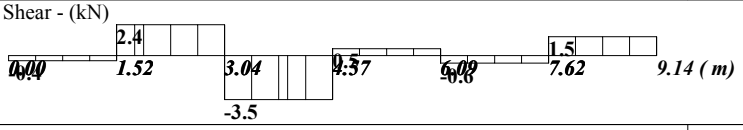
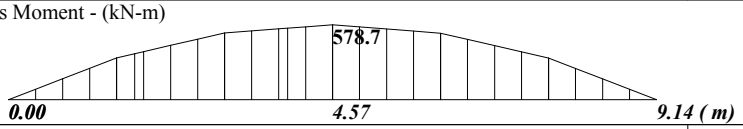
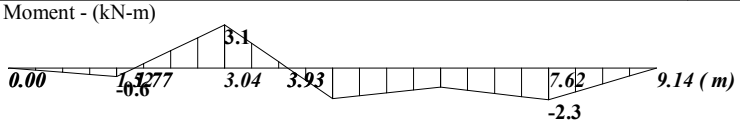
Member is part of group: Section 18

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| Strong Axis Shear - (kN)   | | |
| Strong axis shear strength check<br>$A_w$= 5447 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{213}{1132} =$ | **0.188** |
| Weak Axis Shear - (kN)   | | |
| Weak axis shear strength check<br>$A_w$= 4347 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{3}{904} =$ | **0.004** |
| Strong Axis Moment - (kN-m)   | | |
| Bending Stability Check<br>$L_u$=1.55 m; $\omega_2$=1.146; | $\frac{M_{fx}}{M_{rx}} = \frac{579}{743} =$ | **0.779** |
| Weak Axis Moment - (kN-m)   | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{3}{112} =$ | **0.028** |
| **Biaxial bending stability check** | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.806** |

Clause 11

Clause 13.4.1.1(a)

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.5(a)

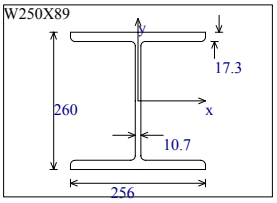
**Clause 13.6(f)**

**Member: 210** S-FRAME Section is W250X89

Member is part of group: Section 36

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

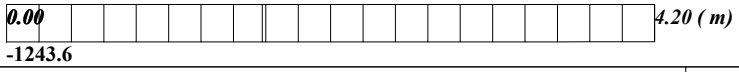
Clause 11


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| | | |
|---|---|---|
| Governing geometrical slenderness ratio<br>$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=37.5; | $\frac{k_y L/r_y}{200} = \frac{64}{200} =$ | **0.322** |

Clause 10.4.2.1

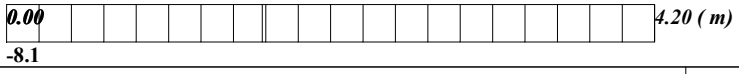
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=0.858 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y(1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (239\ MPa)} = \frac{1244}{2456} =$ | **0.506** |

Clause 13.3.1

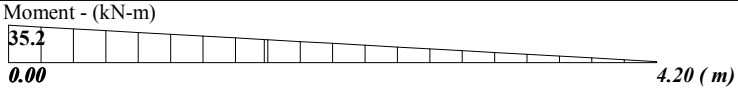
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 5905 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{8}{1228} =$ | **0.007** |

Clause 13.4.1.1(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{35}{181} =$ | **0.195** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=0.61; $U_{1x}$=1.08; $U_{1y}$=1.00; | $\frac{C_f}{\phi A F_y} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.463** |

Clause 13.8.2(a)

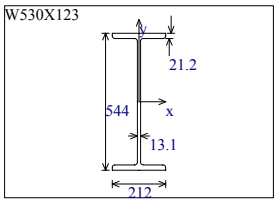
| | | |
|---|---|---|
| **Axial Compression and Bending overall member Strength Check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.79;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.638** |

**Clause 13.8.2(b)**

| | | |
|---|---|---|
| **Axial Compression and Bending lateral torsional buckling strength check**<br>**$U_{1x}$=1.08; $U_{1y}$=0.79;β=0.85;** | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x} M_{fx}}{M_{rx}} + \frac{\beta\ U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.638** |

**Clause 13.8.2(c)**

**Member: 215** S-FRAME Section is W530X123
Member is part of group: Section 37
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*

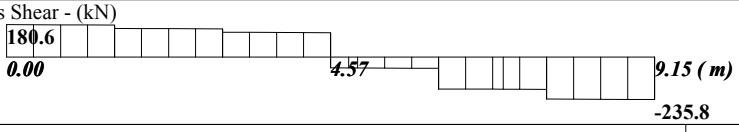



**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

Strong Axis Shear - (kN)

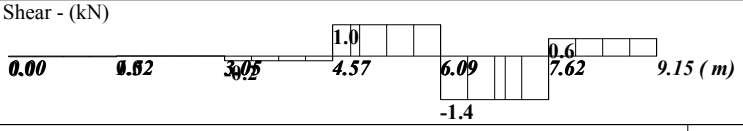



| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 7126 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{236}{1482} =$ | **0.159** |

Clause 13.4.1.1(a)


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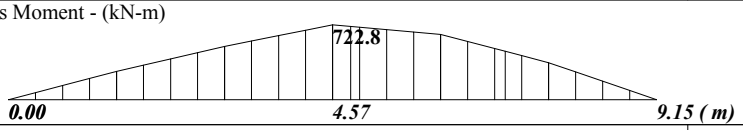
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 5993 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{1}{1246} =$ | **0.001** |

Clause 13.4.1.1(a)

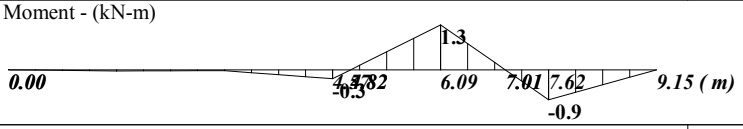
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.55 m; $\omega_2$=1.203; | $\frac{M_{fx}}{M_{rx}} = \frac{723}{1011} =$ | **0.715** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)



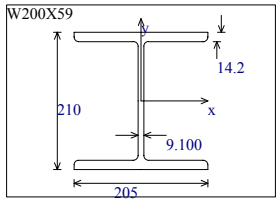

| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{1}{157} =$ | **0.008** |

Clause 13.5(a)

| | | |
|---|---|---|
| **Biaxial bending stability check** | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.723** |

**Clause 13.6(f)**

**Member: 303** S-FRAME Section is W200X59
Member is part of group: Section 28
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**

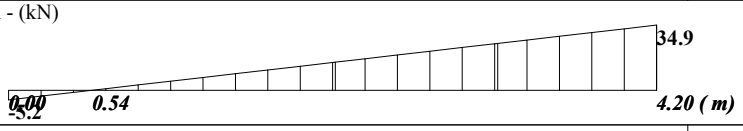
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{81}{300} =$ | **0.270** |

Clause 10.4.2.2

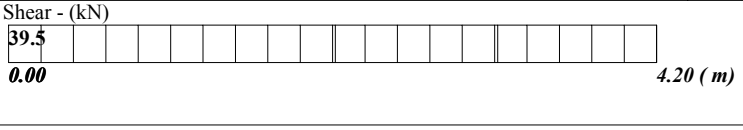
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=7560 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{35}{2381} =$ | **0.015** |

Clause 13.2 a (i)

Weak Axis Shear - (kN)





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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3881 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{40}{807} =$ | **0.049** |
| Weak Axis Moment - (kN-m)<br>**82.3**<br>***0.00*** ***2.12*** ***4.20 ( m)***<br>**-83.7** | | |
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{84}{95} =$ | **0.877** |
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.892** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.862** |

Clause 13.4.1.1(a)

Clause 13.5(a)

**Clause 13.9(a)**

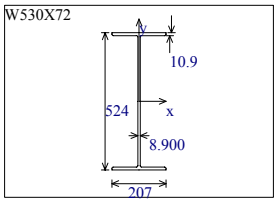
Clause 13.9(b)

**Member: 305** S-FRAME Section is W530X72

Member is part of group: Section 19

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 2 1.25D + 1.5L + 0.5S (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |
| Governing geometrical slenderness ratio | $\frac{L/r_y}{300} = \frac{72}{300} =$ | **0.242** |
| Axial Load - (kN)<br>**84.9**<br>***0.00*** ***3.05 ( m)*** | | |
| Factored Tensile Resistance Check<br>$A_g$=9160 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{85}{2885} =$ | **0.029** |
| Strong Axis Shear - (kN)<br>**212.5**<br>***0.00*** ***3.05 ( m)*** | | |
| Strong axis shear strength check<br>$A_w$= 4664 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{213}{970} =$ | **0.219** |
| Weak Axis Shear - (kN)<br>**5.7**<br>***0.00*** ***1.01*** ***2.03*** ***3.05 ( m)***<br>**-2.8** **-3.0** | | |
| Weak axis shear strength check<br>$A_w$= 3008 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{6}{625} =$ | **0.009** |

Clause 11

Clause 10.4.2.2

Clause 13.2 a (i)

Clause 13.4.1.1(a)

Clause 13.4.1.1(a)


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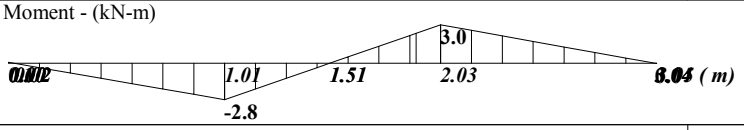
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=1.01 m; $\omega_2$=2.500; | $\frac{M_{fx}}{M_{rx}} = \frac{334}{482} =$ | **0.693** |

Clause 13.6(b)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y S_y} = \frac{3}{49} =$ | **0.061** |

Clause 13.5(b)

| | | |
|---|---|---|
| **Axial Tension and Bending Strength Check** | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi S_x F_y} + \frac{M_{fy}}{\phi S_y F_y} =$ | **0.783** |

**Clause 13.9(a)**

| | | |
|---|---|---|
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f S_x}{M_{rx} A} =$ | **0.724** |

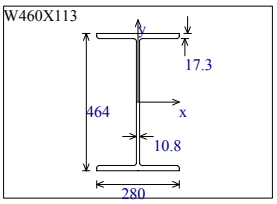
Clause 13.9(b)

**Member: 373** S-FRAME Section is W460X113 *

Member is part of group: Section 33

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**

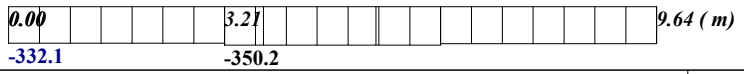
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=49.1;** | $\frac{k_y L/r_y}{200} = \frac{145}{200} =$ | **0.727** |

**Clause 10.4.2.1**

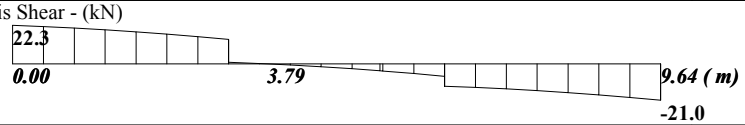
Axial Load - (kN)




| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=1.936 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (83\ MPa)} = \frac{350}{1076} =$ | **0.325** |

Clause 13.3.1

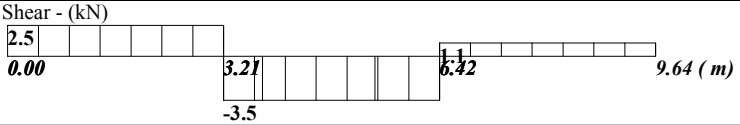
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 5011 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66 F_y} = \frac{22}{1042} =$ | **0.021** |

Clause 13.4.1.1(a)

Weak Axis Shear - (kN)



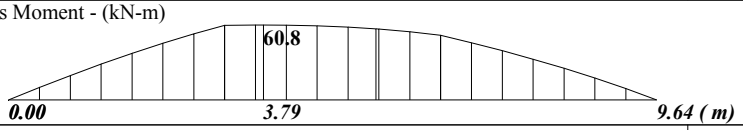


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| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 6459 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{4}{1343} =$ | **0.003** |

Clause 13.4.1.1(a)

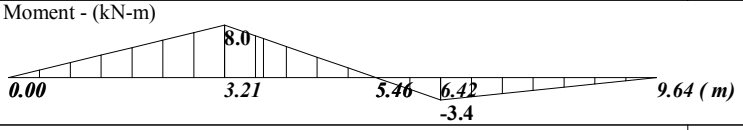
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.64 m; $\omega_2$=1.150; | $\frac{M_{fx}}{M_{rx}} = \frac{61}{477} =$ | **0.127** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{8}{218} =$ | **0.037** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $\omega_{1y}$=1.00; $U_{1x}$=1.03; $U_{1y}$=1.35; | $\frac{C_f}{\phi A F_y} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{0.6U_{1y}M_{fy}}{\phi Z_y F_y} =$ | **0.170** |

Clause 13.8.2(a)

| | | |
|---|---|---|
| Axial Compression and Bending overall member Strength Check<br>$U_{1x}$=1.03; $U_{1y}$=1.35;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{\phi Z_x F_y} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.431** |

Clause 13.8.2(b)

| | | |
|---|---|---|
| Biaxial bending strength check | $\frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.109** |

Clause 13.8.2

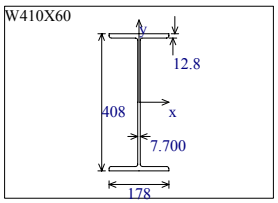
| | | |
|---|---|---|
| Axial Compression and Bending lateral torsional buckling strength check<br>$U_{1x}$=1.03; $U_{1y}$=1.35;β=0.85; | $\frac{C_f}{C_{ry}} + \frac{0.85 U_{1x} M_{fx}}{M_{rx}} + \frac{\beta U_{1y} M_{fy}}{\phi Z_y F_y} =$ | **0.479** |

Clause 13.8.2(c)

| | | |
|---|---|---|
| Biaxial bending stability check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.164** |

Clause 13.8.2

**Member: 376** S-FRAME Section is W410X60
Member is part of group: Section 11
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Tension)**

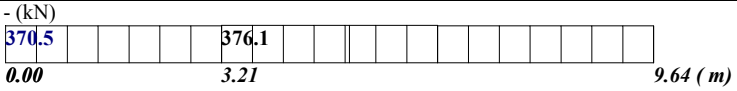
| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |

Clause 11

| | | |
|---|---|---|
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{242}{300} =$ | **0.807** |

**Clause 10.4.2.2**

Axial Load - (kN)



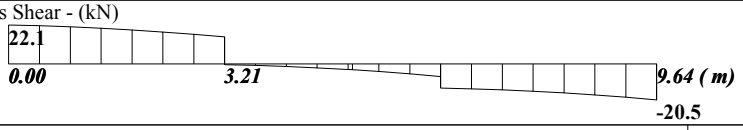


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| | | |
|---|---|---|
| Factored Tensile Resistance Check<br>$A_g$=7580 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{376}{2388} =$ | **0.158** |

Clause 13.2 a (i)

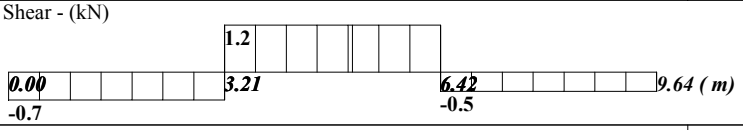
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 3142 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{22}{653} =$ | **0.034** |

Clause 13.4.1.1(a)

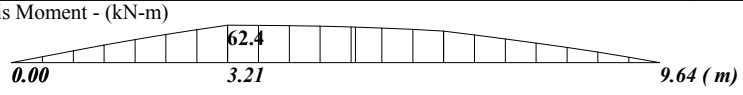
Weak Axis Shear - (kN)




| | | |
|---|---|---|
| Weak axis shear strength check<br>$A_w$= 3038 mm$^2$; | $\frac{V_{fx}}{\phi A_w F_s} = \frac{V_{fx}}{\phi A_w 0.66F_y} = \frac{1}{632} =$ | **0.002** |

Clause 13.4.1.1(a)

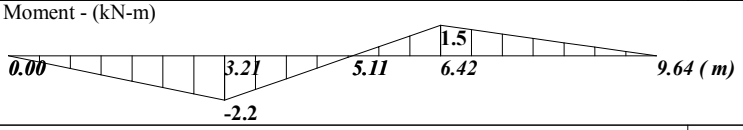
Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| Bending Stability Check<br>$L_u$=9.64 m; $\omega_2$=1.169; | $\frac{M_{fx}}{M_{rx}} = \frac{62}{100} =$ | **0.626** |

Clause 13.6(a)

Weak Axis Moment - (kN-m)




| | | |
|---|---|---|
| Weak axis section capacity in bending | $\frac{M_{fy}}{M_{ry}} = \frac{M_{fy}}{\phi F_y Z_y} = \frac{2}{66} =$ | **0.034** |

Clause 13.5(a)

| | | |
|---|---|---|
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} + \frac{M_{fy}}{\phi Z_y F_y} =$ | **0.358** |

Clause 13.9(a)

| | | |
|---|---|---|
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} + \frac{M_{fy}}{M_{ry}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.067** |

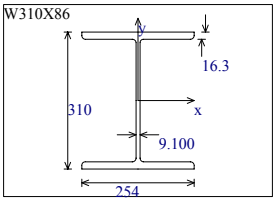
Clause 13.9(b)

**Member: 455** S-FRAME Section is W310X86

Member is part of group: Section 6

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*

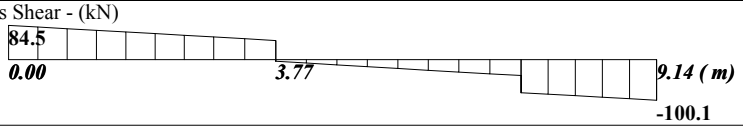



**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |

Clause 11

Strong Axis Shear - (kN)





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| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2821 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{100}{586} =$ | **0.171** |
| Strong Axis Moment - (kN-m)<br>**248.7**<br>***0.00*** ***3.77*** ***9.14 ( m)*** | | |
| **Bending Stability Check**<br>**$L_u$=9.14 m; $\omega_2$=1.168;** | $\frac{M_{fx}}{M_{rx}} = \frac{249}{315} =$ | **0.789** |

Clause 13.4.1.1(a)

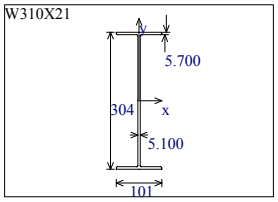
**Clause 13.6(a)**

**Member: 486** S-FRAME Section is W310X21 *

Member is part of group: Section 21

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




Clause 11

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| Strong Axis Shear - (kN)<br>**23.0**<br>***0.00*** ***1.65*** ***3.25 ( m)***<br>**-24.6** | | |
| Strong axis shear strength check<br>$A_w$= 1550 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{25}{322} =$ | **0.076** |
| Strong Axis Moment - (kN-m)<br>**19.3**<br>***0.00*** ***1.65*** ***3.25 ( m)*** | | |
| **Bending Stability Check**<br>**$L_u$=3.25 m; $\omega_2$=1.132;** | $\frac{M_{fx}}{M_{rx}} = \frac{19}{35} =$ | **0.556** |

Clause 13.4.1.1(a)

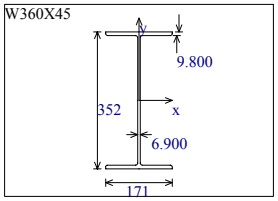
**Clause 13.6(a)**

**Member: 504** S-FRAME Section is W360X45

Member is part of group: Section 10

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




Clause 11

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Compression)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **2** |
| **Governing geometrical slenderness ratio**<br>**$k_x$=1.00; $k_y$=1.00; $k_xL/r_x$=41.8;** | $\frac{k_y L/r_y}{200} = \frac{161}{200} =$ | **0.807** |
| Axial Load - (kN)<br>***0.00*** ***6.10 ( m)***<br>**-5.9** | | |

**Clause 10.4.2.1**


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| | | |
|---|---|---|
| Factored Compressive Resistance Check<br>n=1.34; $\lambda_y$=2.148 | $\frac{C_f}{C_{ry}} = \frac{C_f}{\phi A F_y (1+\lambda^{2n})^{-1/n}} = \frac{C_f}{\phi A\ (69\ MPa)} = \frac{6}{357} =$ | **0.016** |
| Strong Axis Shear - (kN)<br>18.6<br>0.00 2.93 6.10 ( m)<br>-15.7 | | |
| Strong axis shear strength check<br>$A_w$= 2429 mm$^2$; | $\frac{V_{fy}}{\phi\ A_w\ F_s} = \frac{V_{fy}}{\phi\ A_w\ 0.66 F_y} = \frac{19}{505} =$ | **0.037** |
| Strong Axis Moment - (kN-m)<br>27.3<br>0.00 2.93 6.10 ( m) | | |
| Bending Stability Check<br>$L_u$=6.10 m; $\omega_2$=1.138; | $\frac{M_{fx}}{M_{rx}} = \frac{27}{107} =$ | **0.256** |
| Axial Compression and Bending cross-sectional Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{\phi\ A\ F_y} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.098** |
| Axial Compression and Bending overall member Strength Check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{rx}} + \frac{0.85\ U_{1x}\ M_{fx}}{\phi\ Z_x\ F_y} =$ | **0.099** |
| Axial Compression and Bending lateral torsional buckling strength check<br>$\omega_{1x}$=1.00; $U_{1x}$=1.00; | $\frac{C_f}{C_{ry}} + \frac{0.85\ U_{1x}\ M_{fx}}{M_{rx}} =$ | **0.234** |

Clause 13.3.1

Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.8.2(a)

Clause 13.8.2(b)

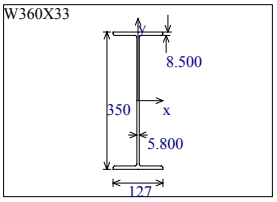
Clause 13.8.2(c)

**Member: 530** S-FRAME Section is W360X33

Member is part of group: Section 9

*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*

*Note: Member in braced frame(s).*




**Load Combination 7 1.25D + 1.5S + 0.5L (Bending + Tension)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **1** |
| **Governing geometrical slenderness ratio** | $\frac{L/r_y}{300} = \frac{218}{300} =$ | **0.727** |
| Axial Load - (kN)<br>2.7<br>0.00 5.76 ( m) | | |
| Factored Tensile Resistance Check<br>$A_g$=4170 mm$^2$; | $\frac{T_f}{T_r} = \frac{T_f}{\phi A_g F_y} = \frac{3}{1314} =$ | **0.002** |
| Strong Axis Shear - (kN)<br>19.1<br>0.00 2.83 5.76 ( m)<br>-16.7 | | |

Clause 11

**Clause 10.4.2.2**

Clause 13.2 a (i)


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| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 2030 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{19}{422} =$ | **0.045** |
| Strong Axis Moment - (kN-m)<br>27.0<br>0.00 2.83 5.76 ( m) | | |
| Bending Stability Check<br>$L_u$=5.76 m; $\omega_2$=1.138; | $\frac{M_{fx}}{M_{rx}} = \frac{27}{46} =$ | **0.588** |
| Axial Tension and Bending Strength Check | $\frac{T_f}{T_r} + \frac{M_{fx}}{\phi Z_x F_y} =$ | **0.160** |
| Axial Tension and Bending Stability Check | $\frac{M_{fx}}{M_{rx}} - \frac{T_f Z_x}{M_{rx} A} =$ | **0.580** |

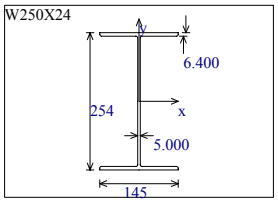
Clause 13.4.1.1(a)

Clause 13.6(a)

Clause 13.9(a)

Clause 13.9(b)

**Member: 567** S-FRAME Section is W250X24
Member is part of group: Section 5
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*




Clause 11

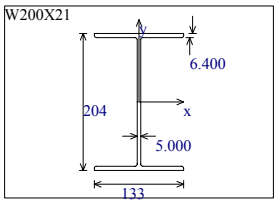
**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**

| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **4** |
| Strong Axis Shear - (kN)<br>49.6<br>0.00 1.52 4.57 ( m)<br>-50.8 | | |
| Strong axis shear strength check<br>$A_w$= 1270 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{51}{264} =$ | **0.192** |
| Strong Axis Moment - (kN-m)<br>63.6<br>0.00 1.52 4.57 ( m) | | |
| **Bending Stability Check**<br>**$L_u$=1.51 m; $\omega_2$=1.068;** | $\frac{M_{fx}}{M_{rx}} = \frac{64}{81} =$ | **0.785** |

Clause 13.4.1.1(a)

**Clause 13.6(b)**

**Member: 574** S-FRAME Section is W200X21
Member is part of group: Section 4
*Note: Neglecting: axial<1.0 kN, shear<1.0 kN, moment<1.0 kNm*
*Note: Member in braced frame(s).*



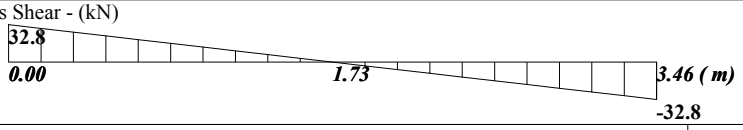

**Load Combination 7 1.25D + 1.5S + 0.5L (Bending)**


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| | | |
|---|---|---|
| Section classification ($f_y$=350 MPa); | Section Class = | **3** |

Clause 11

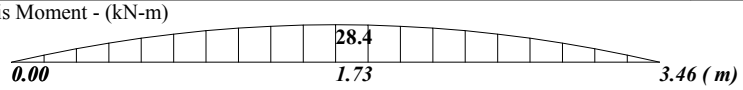
Strong Axis Shear - (kN)




| | | |
|---|---|---|
| Strong axis shear strength check<br>$A_w$= 1020 mm$^2$; | $\frac{V_{fy}}{\phi A_w F_s} = \frac{V_{fy}}{\phi A_w 0.66F_y} = \frac{33}{212} =$ | **0.155** |

Clause 13.4.1.1(a)

Strong Axis Moment - (kN-m)




| | | |
|---|---|---|
| **Bending Stability Check**<br>**$L_u$=3.46 m; $\omega_2$=1.131;** | $\frac{M_{fx}}{M_{rx}} = \frac{28}{48} =$ | **0.590** |

**Clause 13.6(b)**

## 3. Summary of Governing Load Cases for Each Selected Member

| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 14 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.978 | Pass |
| 9 | Section 32 | W250X131 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.971 | Pass |
| 63 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 65 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Beam-column stability | 0.963 | Pass |
| 47 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.959 | Pass |
| 51 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.959 | Pass |
| 58 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.584 | Pass |
| 45 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.584 | Pass |
| 67 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.481 | Pass |
| 53 | Section 23 | W310X31 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.481 | Pass |
| 43 | Section 23 | W310X31 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.13 | Pass |
| 55 | Section 23 | W310X31 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.13 | Pass |
| 71 | Section 22 | W360X72 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.943 | Pass |
| 312 | Section 22 | W360X72 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.943 | Pass |
| 381 | Section 22 | W360X72 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.943 | Pass |
| 2 | Section 27 | W250X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.912 | Pass |
| 1 | Section 27 | W250X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.912 | Pass |
| 6 | Section 27 | W250X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.912 | Pass |
| 3 | Section 27 | W250X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.912 | Pass |
| 22 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.907 | Pass |
| 5 | Section 29 | W250X58 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.877 | Pass |
| 37 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.906 | Pass |
| 38 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.879 | Pass |
| 15 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.818 | Pass |
| 10 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.811 | Pass |
| 13 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.772 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 8 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.753 | Pass |
| 33 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.687 | Pass |
| 34 | Section 31 | W250X115 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.678 | Pass |
| 303 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.892 | Pass |
| 306 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.892 | Pass |
| 18 | Section 28 | W200X59 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.751 | Pass |
| 16 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 11 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 4 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 20 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 21 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 17 | Section 28 | W200X59 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.591 | Pass |
| 62 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 64 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 66 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 46 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 49 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 54 | Section 20 | W310X67 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.881 | Pass |
| 496 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 481 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 500 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 498 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 483 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 485 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.864 | Pass |
| 501 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 499 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 484 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 479 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 482 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 497 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.812 | Pass |
| 50 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 48 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 60 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 61 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 52 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 59 | Section 20 | W310X67 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.419 | Pass |
| 179 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.859 | Pass |
| 181 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.788 | Pass |
| 183 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.504 | Pass |
| 171 | Section 24 | W360X64 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.283 | Pass |
| 178 | Section 24 | W360X64 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.252 | Pass |
| 182 | Section 24 | W360X64 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.235 | Pass |
| 376 | Section 11 | W410X60 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 377 | Section 11 | W410X60 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |
| 93 | Section 11 | W410X60 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.766 | Pass |
| 507 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |
| 504 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.807 | Pass |
| 588 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.762 | Pass |
| 518 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.538 | Pass |
| 521 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.538 | Pass |
| 522 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.403 | Pass |
| 519 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.403 | Pass |
| 589 | Section 10 | W360X45 | Comb 2, 1.25D + 1.5L + 0.5S | Slenderness | 0.339 | Pass |
| 590 | Section 10 | W360X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.169 | Pass |
| 209 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.806 | Pass |
| 214 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.798 | Pass |
| 185 | Section 18 | W530X92 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.669 | Pass |
| 180 | Section 18 | W530X92 | Comb 2, 1.25D + 1.5L + 0.5S | Biaxial Bending | 0.317 | Pass |
| 455 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.789 | Pass |
| 460 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.769 | Pass |
| 456 | Section 6 | W310X86 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.719 | Pass |
| 567 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.785 | Pass |
| 570 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.75 | Pass |
| 569 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.662 | Pass |
| 568 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.628 | Pass |
| 571 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.263 | Pass |
| 572 | Section 5 | W250X24 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.261 | Pass |
| 305 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 302 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.783 | Pass |
| 170 | Section 19 | W530X72 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.527 | Pass |
| 184 | Section 19 | W530X72 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.377 | Pass |
| 27 | Section 30 | W250X67 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.776 | Pass |
| 25 | Section 30 | W250X67 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.746 | Pass |
| 19 | Section 30 | W250X67 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.699 | Pass |
| 12 | Section 30 | W250X67 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.602 | Pass |
| 7 | Section 30 | W250X67 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.602 | Pass |
| 203 | Section 30 | W250X67 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.412 | Pass |
| 202 | Section 30 | W250X67 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.412 | Pass |
| 84 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.746 | Pass |
| 211 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.74 | Pass |
| 69 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.738 | Pass |
| 72 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.735 | Pass |
| 83 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.733 | Pass |
| 68 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.728 | Pass |
| 212 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.726 | Pass |
| 70 | Section 17 | W530X150 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.724 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 310 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 311 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 96 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 216 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 217 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 304 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 92 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 90 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 517 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 502 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 379 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 380 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.732 | Pass |
| 375 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.71 | Pass |
| 206 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.618 | Pass |
| 205 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.614 | Pass |
| 89 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.488 | Pass |
| 88 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.488 | Pass |
| 85 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.488 | Pass |
| 516 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.488 | Pass |
| 503 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.488 | Pass |
| 378 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.474 | Pass |
| 78 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.426 | Pass |
| 75 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.426 | Pass |
| 81 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.426 | Pass |
| 204 | Section 7 | W410X100 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.269 | Pass |
| 73 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.23 | Pass |
| 80 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.23 | Pass |
| 77 | Section 7 | W410X100 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.23 | Pass |
| 530 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 531 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 505 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.385 | Pass |
| 508 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.385 | Pass |
| 532 | Section 9 | W360X33 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.364 | Pass |
| 373 | Section 33 | W460X113 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 374 | Section 33 | W460X113 * | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.727 | Pass |
| 215 | Section 37 | W530X123 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.723 | Pass |
| 208 | Section 37 | W530X123 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.644 | Pass |
| 94 | Section 8 | W410X54 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.679 | Pass |
| 91 | Section 8 | W410X54 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.679 | Pass |
| 192 | Section 8 | W410X54 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.646 | Pass |
| 195 | Section 8 | W410X54 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.646 | Pass |
| 193 | Section 8 | W410X54 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.646 | Pass |
| 169 | Section 8 | W410X54 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.384 | Pass |


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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 199 | Section 8 | W410X54 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.261 | Pass |
| 35 | Section 35 | W250X45 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.667 | Pass |
| 32 | Section 35 | W250X45 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column stability | 0.616 | Pass |
| 23 | Section 35 | W250X45 | Comb 2, 1.25D + 1.5L + 0.5S | Compression | 0.615 | Pass |
| 26 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 28 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 191 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 194 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 188 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 36 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 39 | Section 35 | W250X45 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.599 | Pass |
| 210 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.638 | Pass |
| 31 | Section 36 | W250X89 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-column strength | 0.631 | Pass |
| 207 | Section 36 | W250X89 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.322 | Pass |
| 213 | Section 36 | W250X89 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.322 | Pass |
| 576 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 574 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.59 | Pass |
| 575 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.579 | Pass |
| 577 | Section 4 | W200X21 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.579 | Pass |
| 573 | Section 4 | W200X21 | Comb 2, 1.25D + 1.5L + 0.5S | Slenderness | 0.568 | Pass |
| 488 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.556 | Pass |
| 489 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.556 | Pass |
| 486 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.556 | Pass |
| 487 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.556 | Pass |
| 492 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 493 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 491 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 490 | Section 21 | W310X21 * | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.541 | Pass |
| 56 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.445 | Pass |
| 44 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.436 | Pass |
| 478 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 495 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 494 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 480 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.372 | Pass |
| 42 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.191 | Pass |
| 57 | Section 21 | W310X21 * | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.191 | Pass |
| 186 | Section 3 | W530X82 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.455 | Pass |
| 190 | Section 3 | W530X82 | Comb 7, 1.25D + 1.5S + 0.5L | Biaxial Bending | 0.236 | Pass |
| 79 | Section 12 | W410X39 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.452 | Pass |
| 74 | Section 12 | W410X39 | Comb 2, 1.25D + 1.5L + 0.5S | Beam-tension strength | 0.452 | Pass |
| 82 | Section 12 | W410X39 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.226 | Pass |
| 76 | Section 12 | W410X39 | Comb 2, 1.25D + 1.5L + 0.5S | Bending | 0.226 | Pass |
| 30 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |

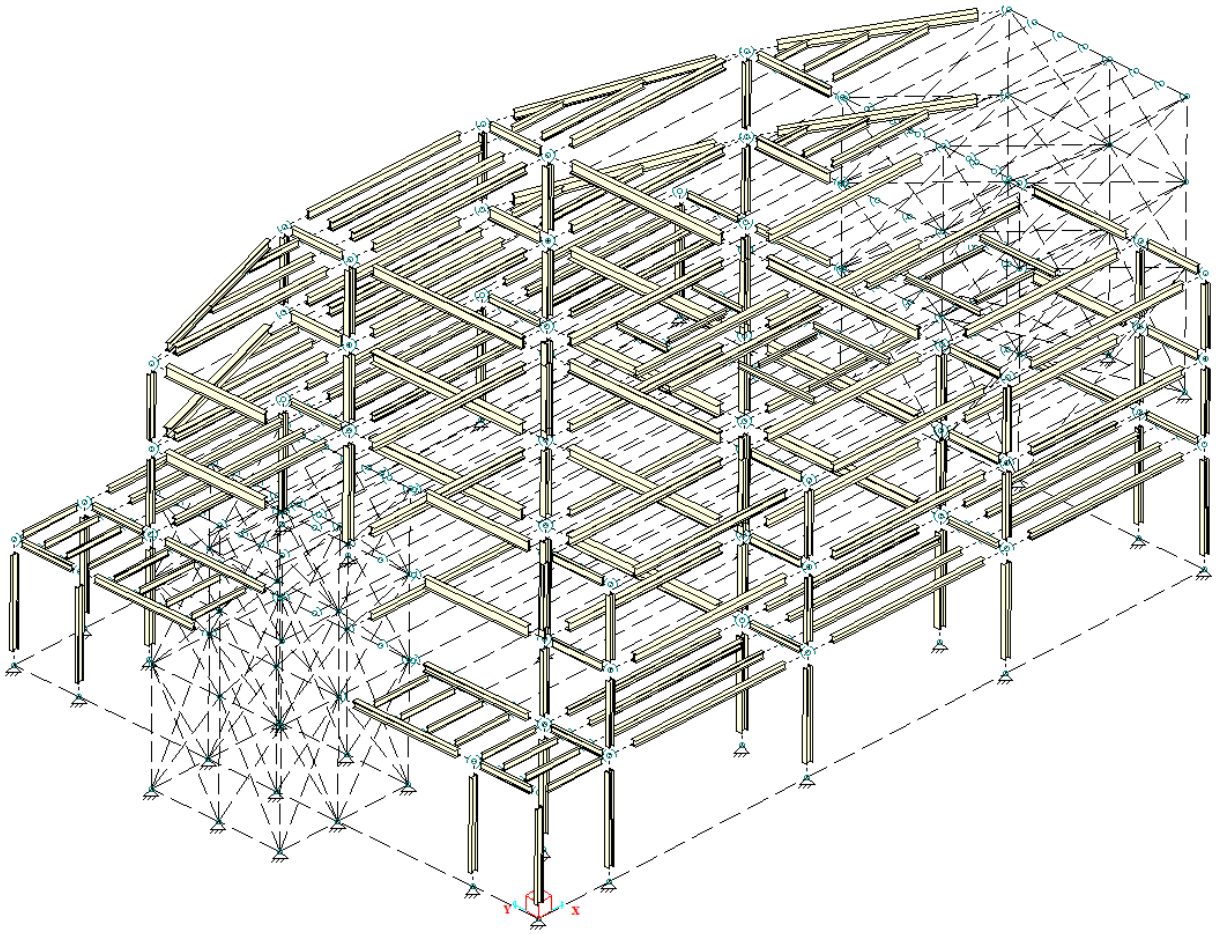

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| Member No. | Group Name | Steel Section | Governing Load Case/Comb | Governing Clause | Ratio | Pass/Fail Status |
|---|---|---|---|---|---|---|
| 29 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 24 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 197 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 196 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 187 | Section 34 | W200X46 | Comb 7, 1.25D + 1.5S + 0.5L | Slenderness | 0.411 | Pass |
| 201 | Section 13 | W410X39 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.281 | Pass |
| 200 | Section 13 | W410X39 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.277 | Pass |
| 198 | Section 13 | W410X39 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.141 | Pass |
| 189 | Section 13 | W410X39 | Comb 7, 1.25D + 1.5S + 0.5L | Bending | 0.139 | Pass |


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# Rendered View of Beams and Columns


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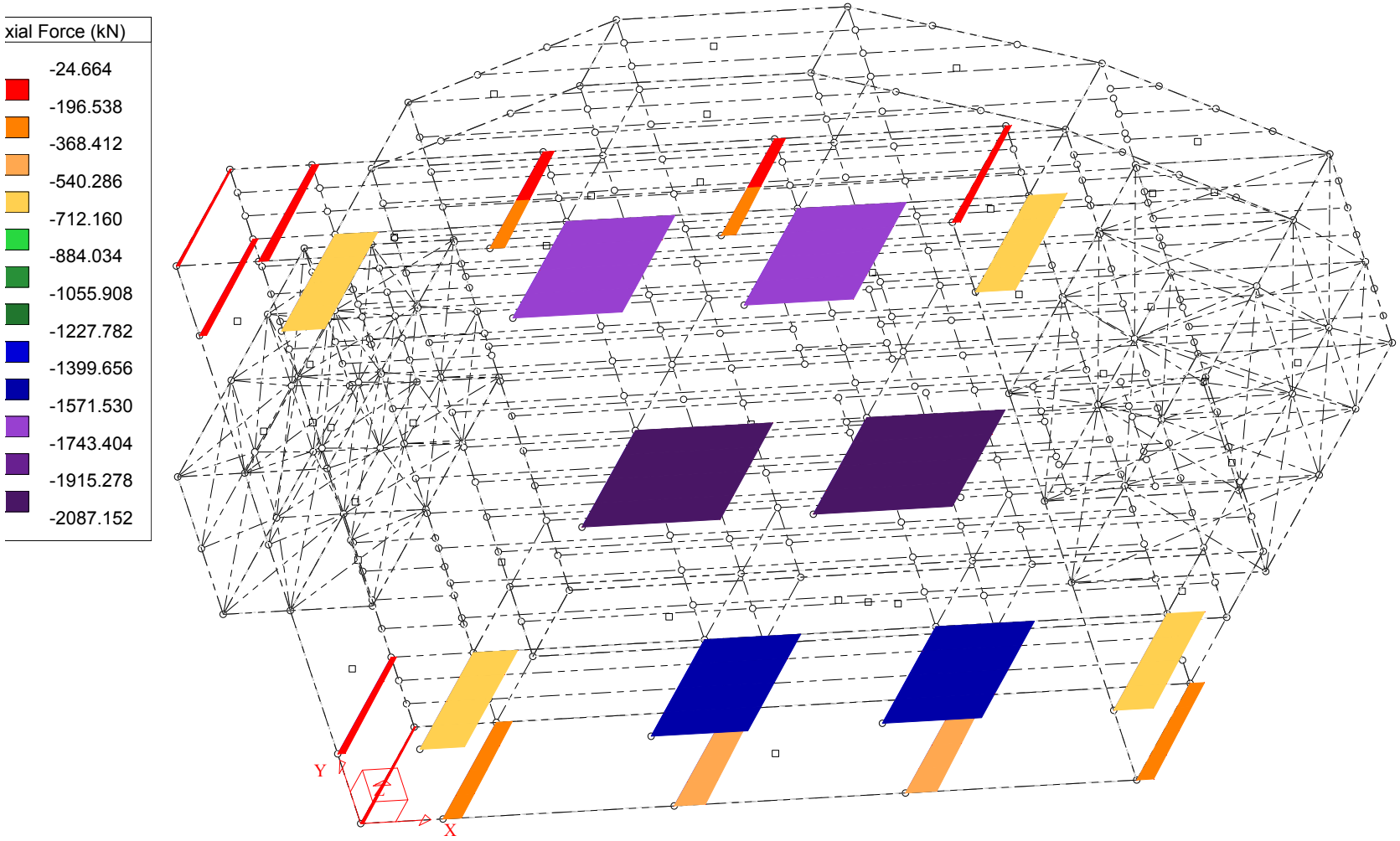
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# Morrison Hershfield Structural Design

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Engineer: Strata Solutions




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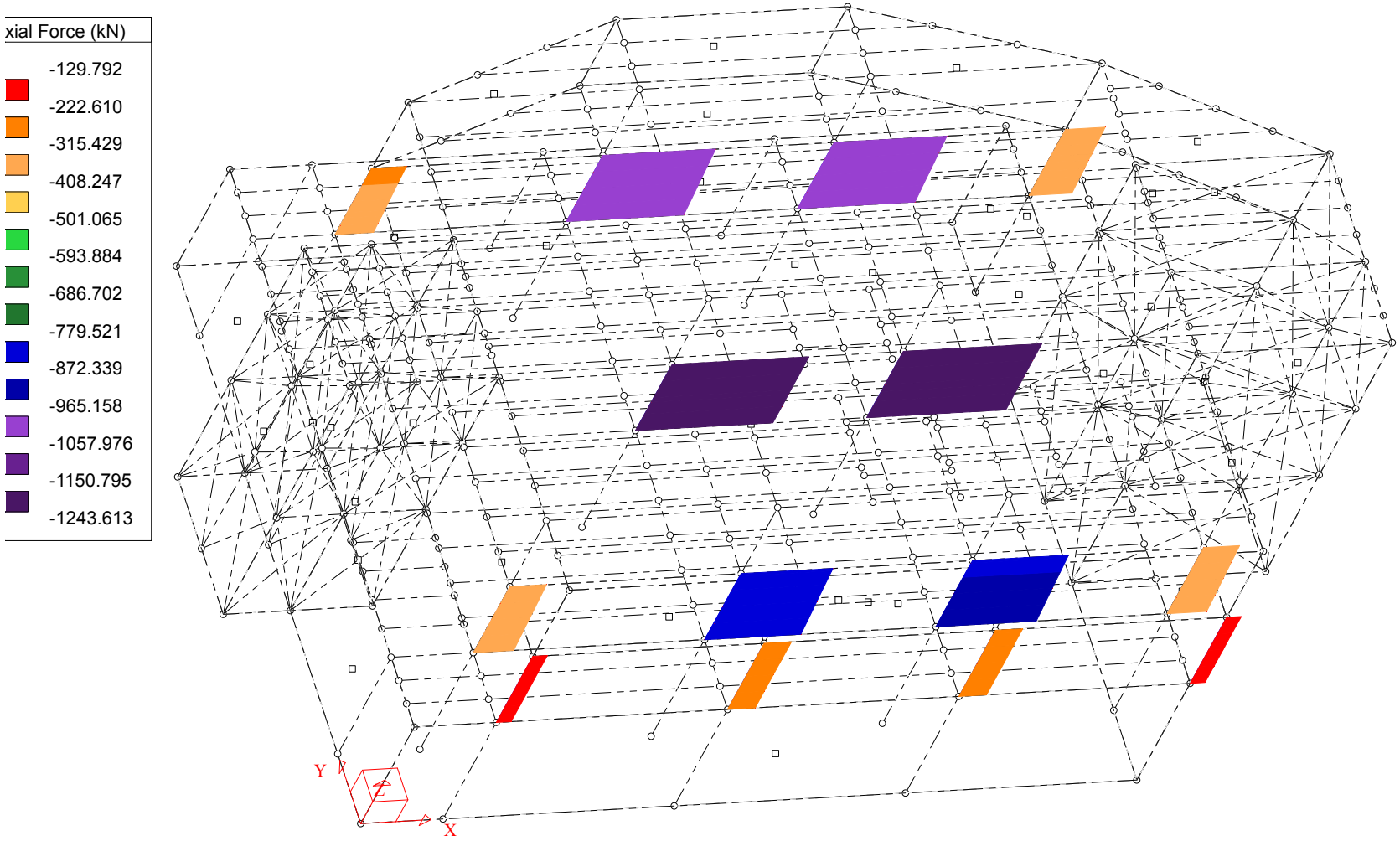
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Engineer: Strata Solutions




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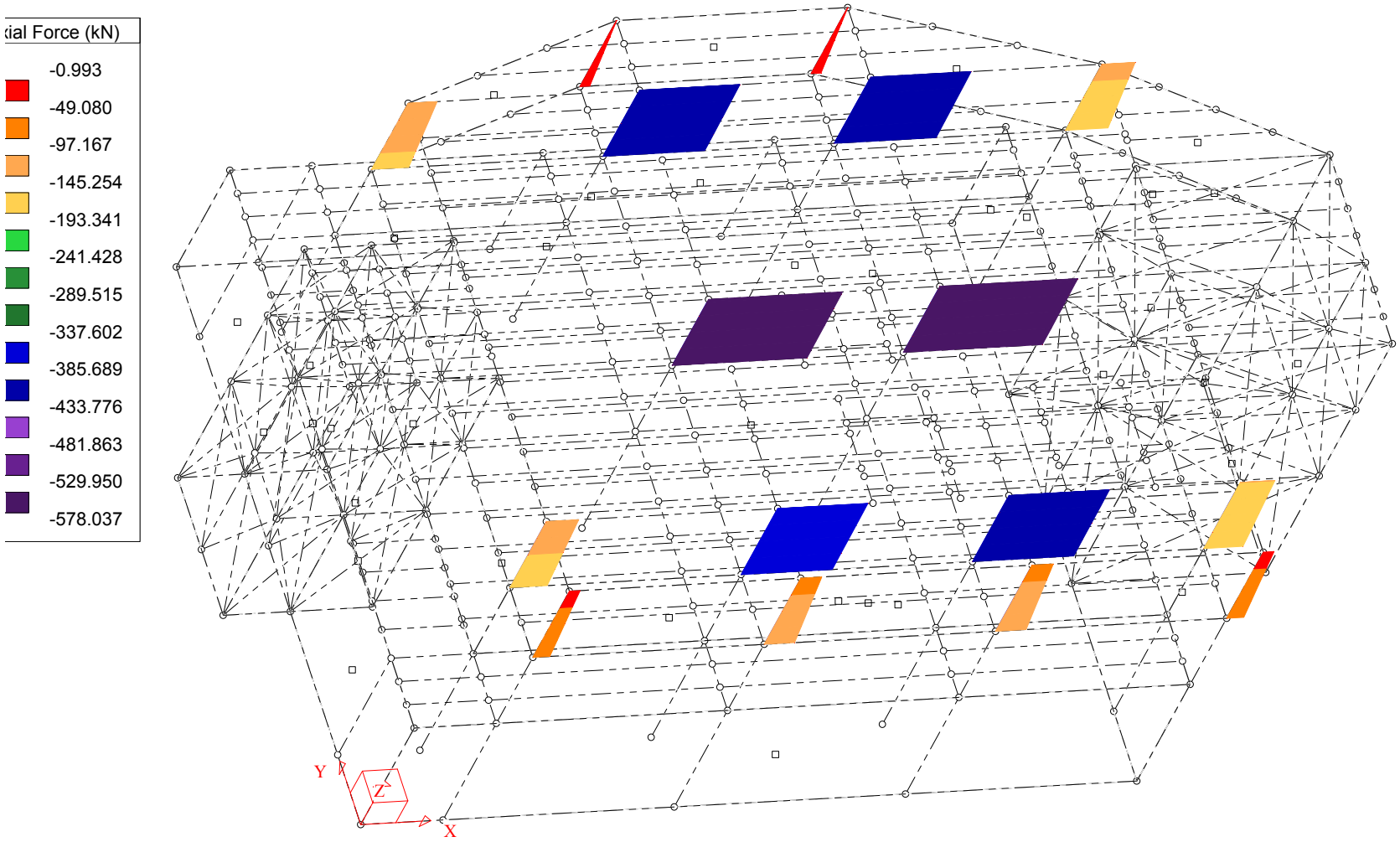
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Engineer: Strata Solutions




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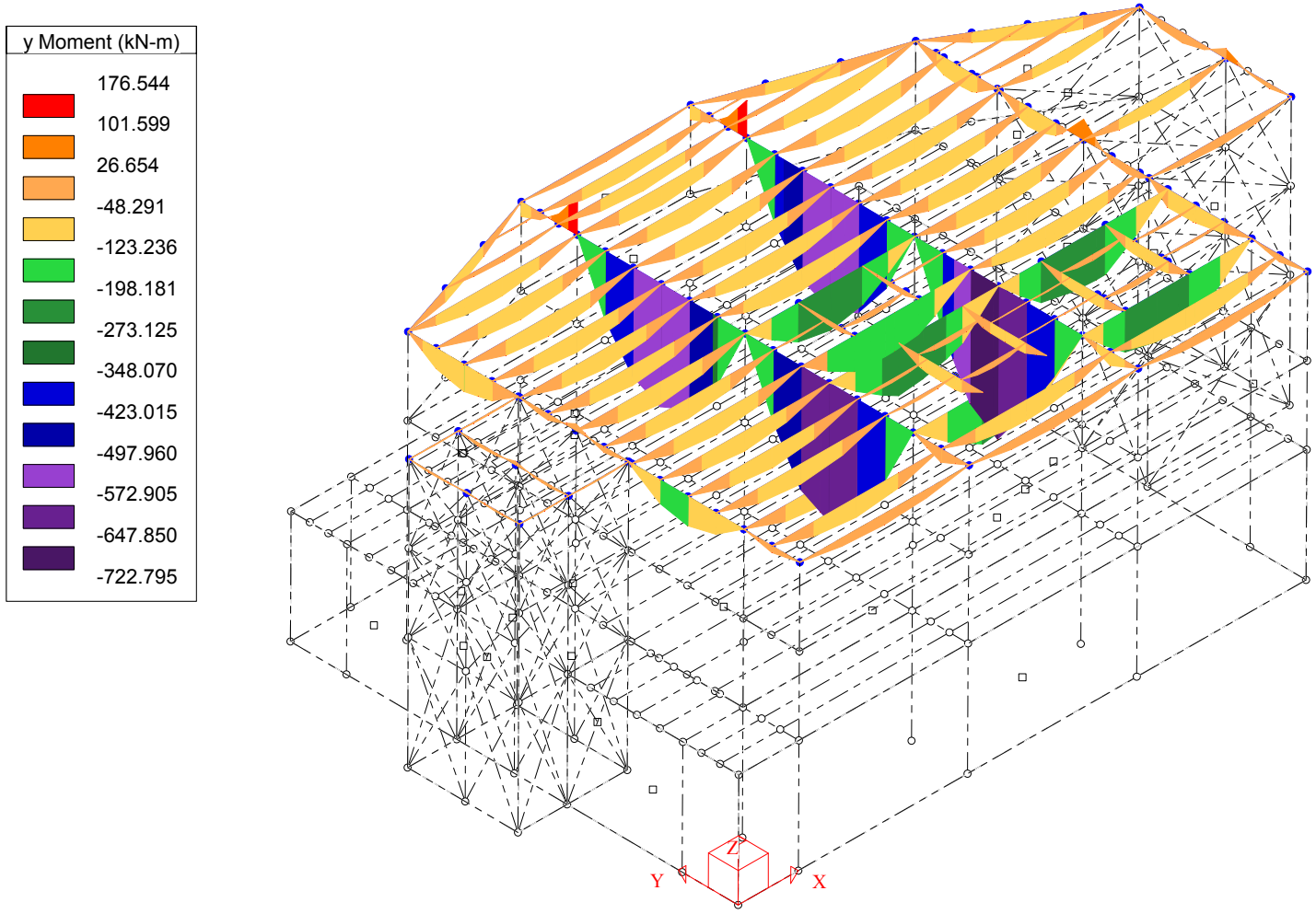
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Engineer: Strata Solutions




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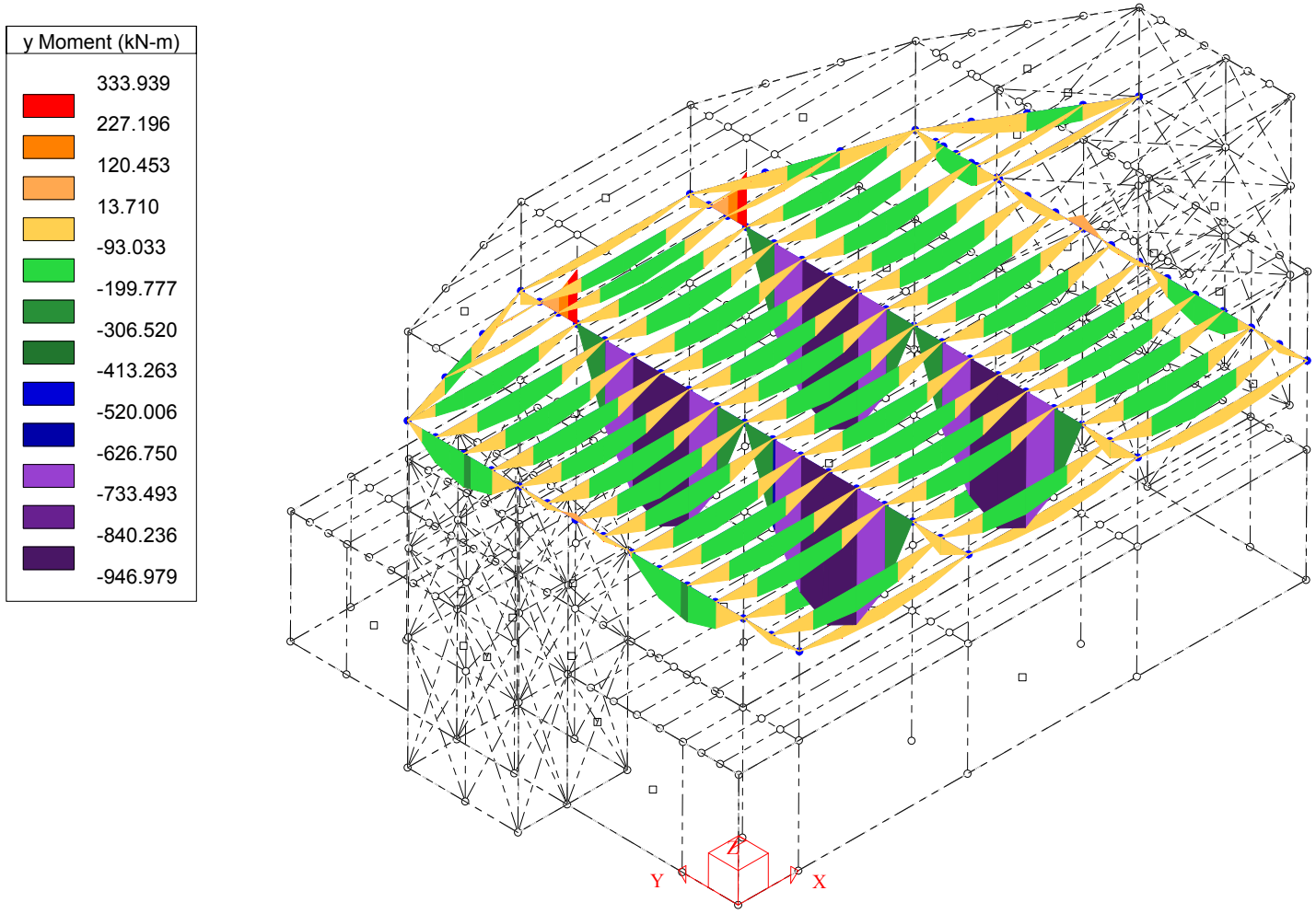
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Engineer: Strata Solutions




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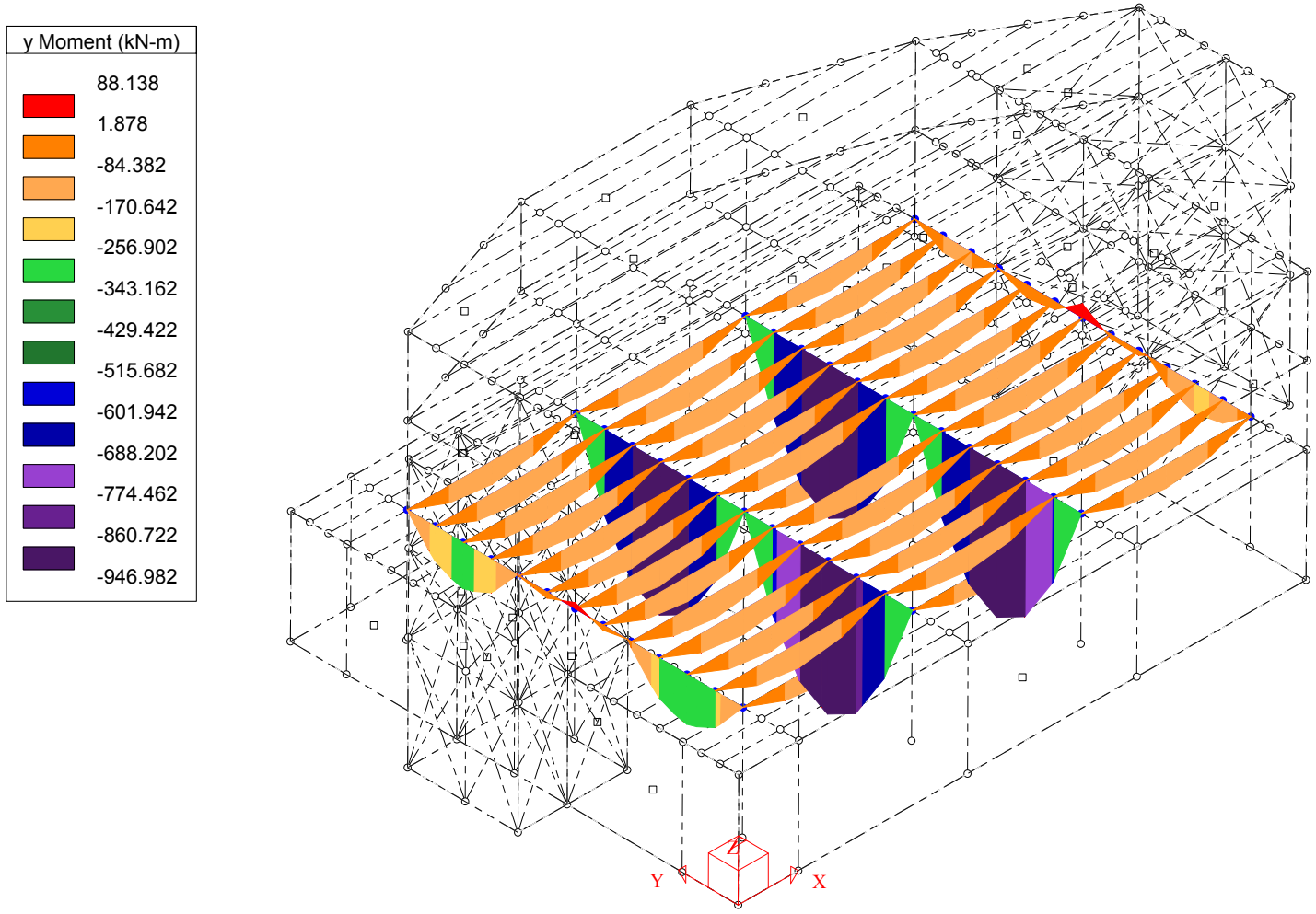
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Engineer: Strata Solutions




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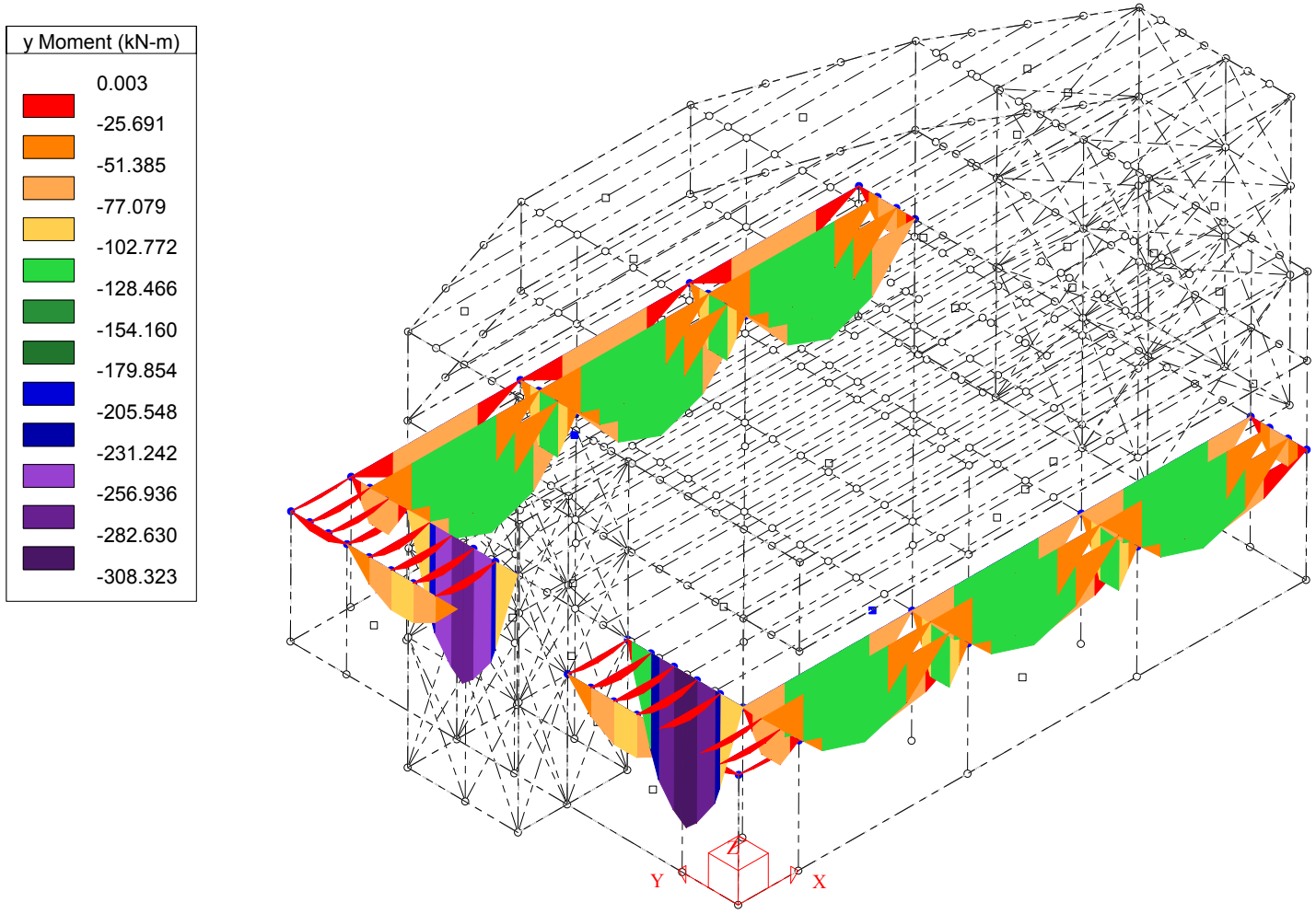
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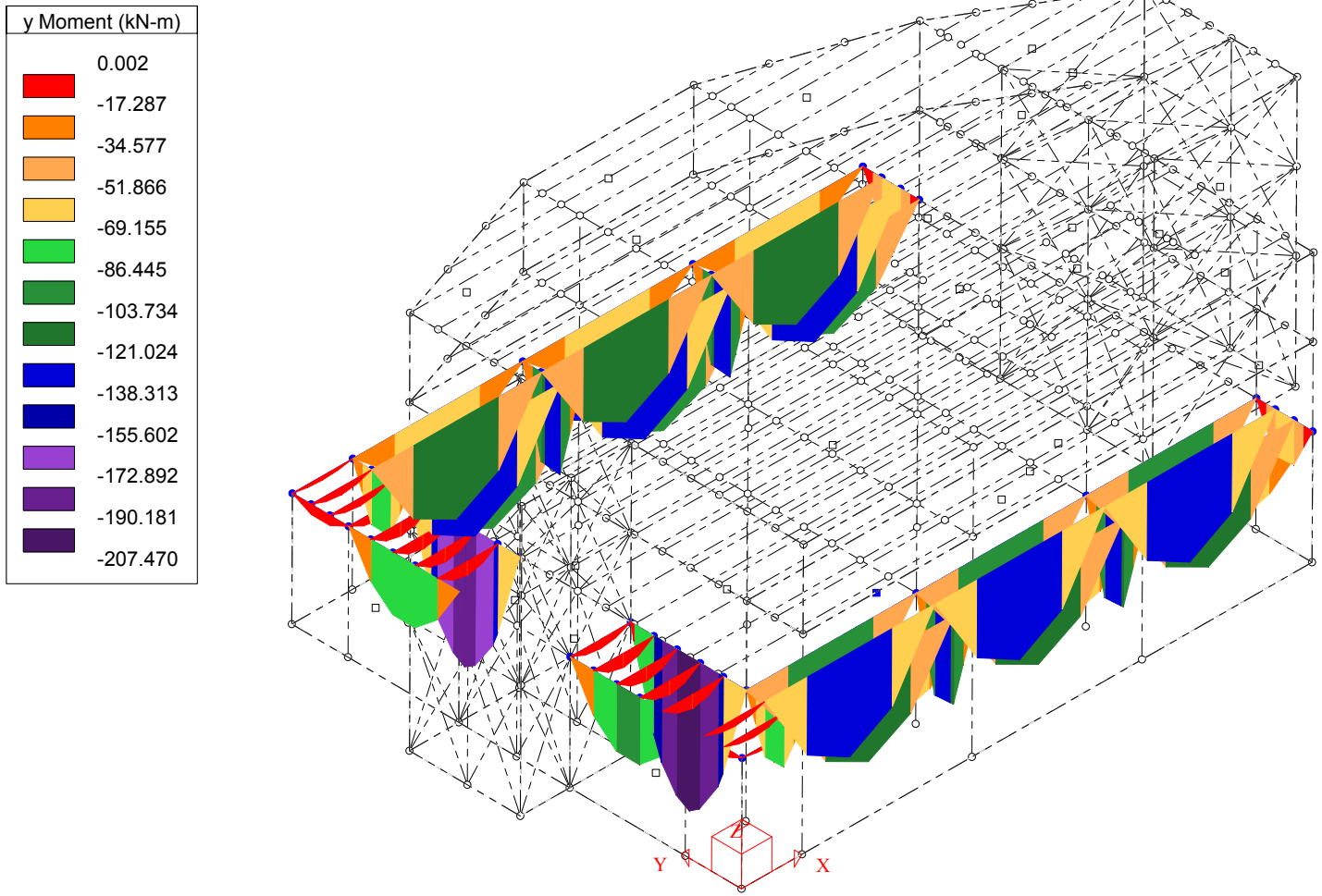
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Engineer: Strata Solutions




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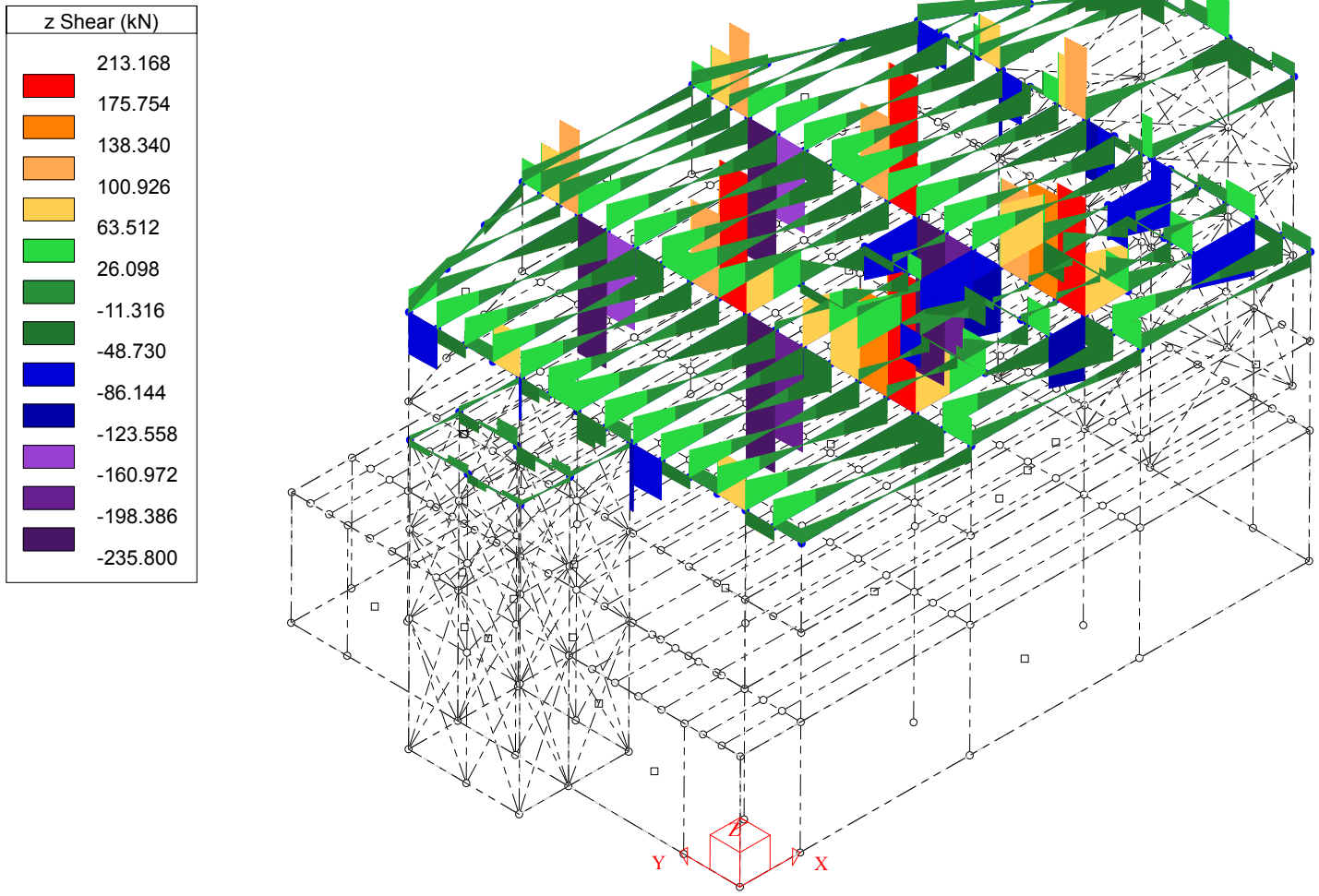




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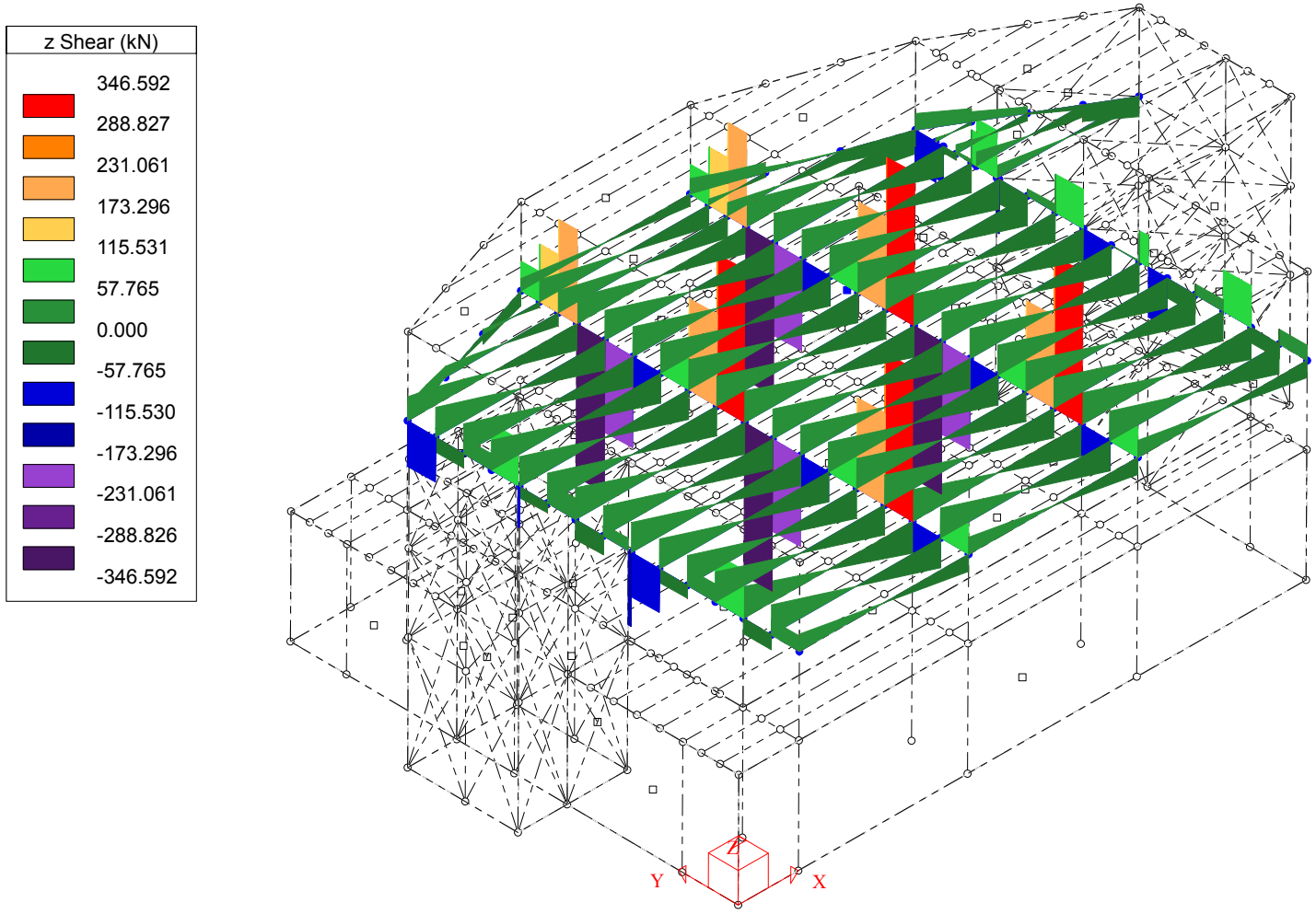
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GRAPHICAL RESULTS - Ld Comb 2 1.25D + 1.5L + 0.5S->z Shear (kN)
Engineer: Strata Solutions




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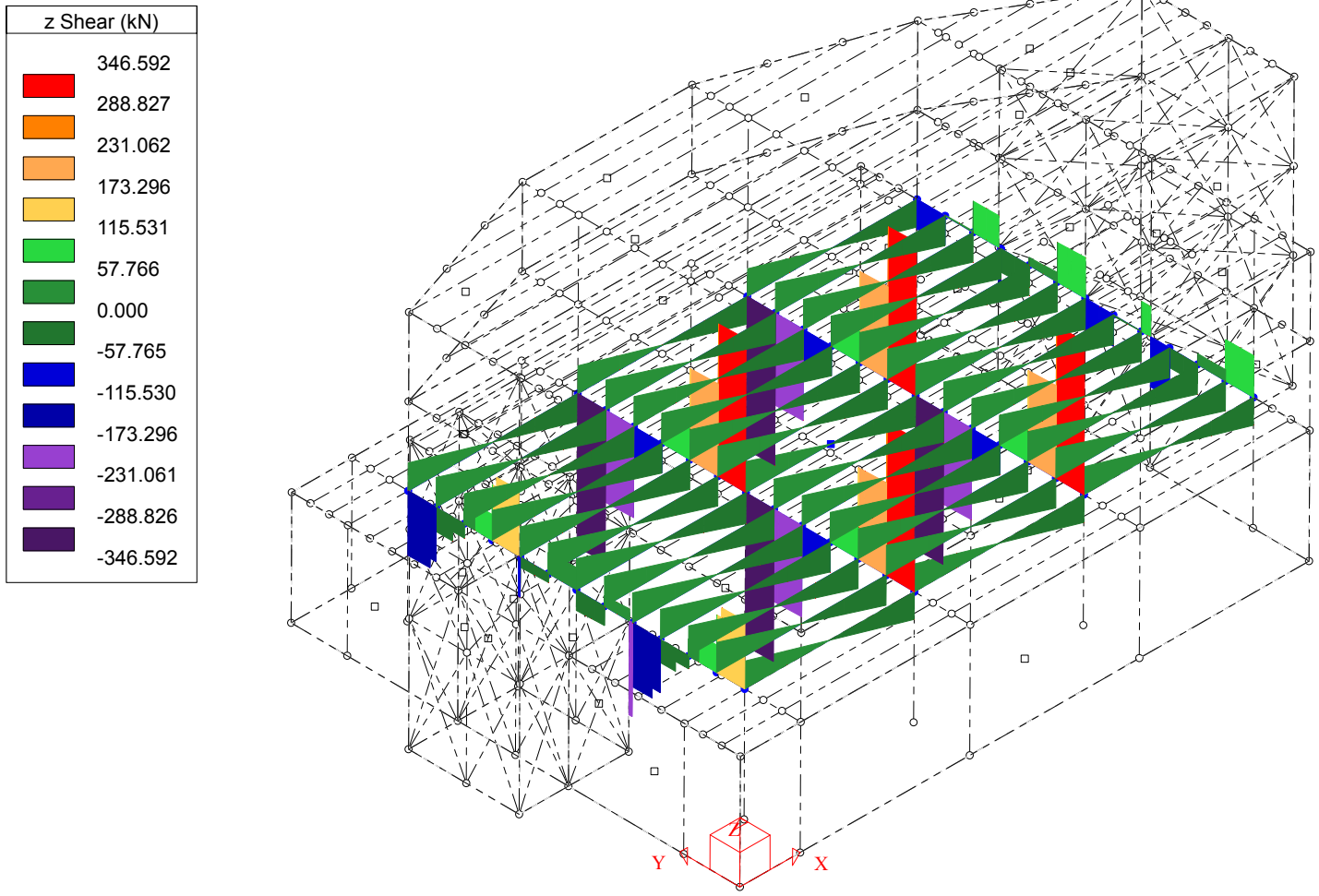
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**Memorial University of Newfoundland**

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# Morrison Hershfield Structural Design

Filename: E:\Civil Project\STRUCTUREV32_RoofGirders.TEL
GRAPHICAL RESULTS - Ld Comb 2 1.25D + 1.5L + 0.5S->z Shear (kN)
Engineer: Strata Solutions

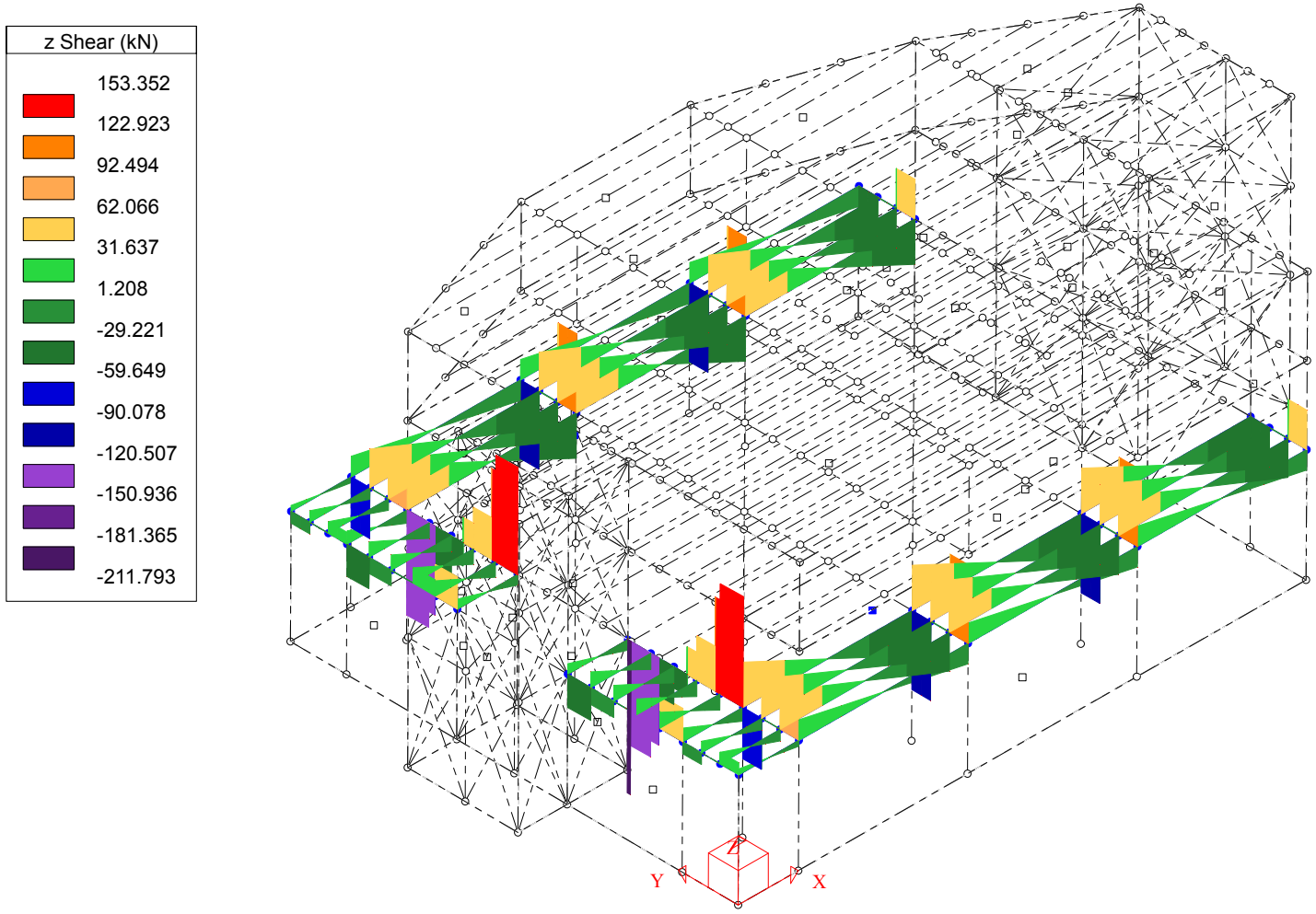



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| Memorial University of Newfoundland | Morrison Hershfield Structural Design | |
|---|---|---|
| , | Filename: E:\Civil Project\STRUCTUREV32_RoofGirders.TEL<br>GRAPHICAL RESULTS - Ld Comb 2 1.25D + 1.5L + 0.5S->z Shear (kN)<br>Engineer: Strata Solutions | |




| | |
|---|---|
| | **S-FRAME**<br>*Enterprise Version 10.0* |

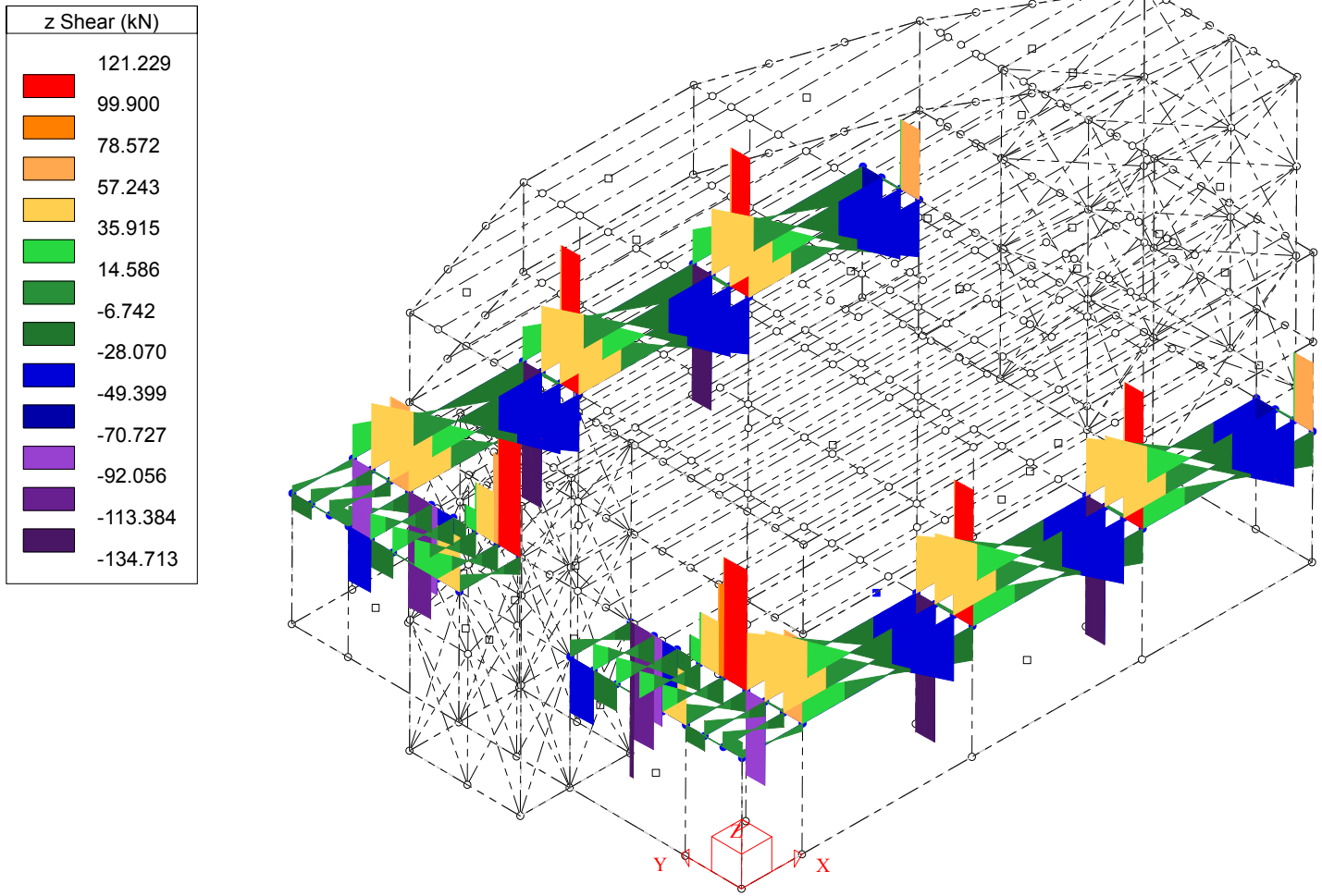
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# Morrison Hershfield Structural Design

Filename: E:\Civil Project\STRUCTUREV32_RoofGirders.TEL
GRAPHICAL RESULTS - Ld Comb 7 1.25D + 1.5S + 0.5L->z Shear (kN)
Engineer: Strata Solutions




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# Appendix F

# Quantities and Cost Estimates for Final Design

| Row Labels | Quantity | Total Cost | Total Cost Incl. O&P |
|---|---|---|---|
| **Concrete** | | **$490,012** | **$628,954** |
| **Elevated Slabs** | | | |
| Concrete Finishing, m2 | 1,321 | $6,222 | $9,247 |
| Concrete, m3 | 163 | $38,543 | $42,483 |
| Edge Forms, m | 120 | $984 | $1,484 |
| Rebar, m2 | 1,321 | $10,568 | $13,131 |
| **Foundations** | | | |
| Concrete Finishing, m2 | 1,051 | $20,957 | $30,752 |
| Concrete, m3 | 204 | $48,238 | $53,169 |
| Formwork, m2 | 635 | $42,203 | $54,923 |
| **Shear Cores** | | | |
| Concrete Finishing, m2 | 1,763 | $35,154 | $51,585 |
| Concrete, m3 | 269 | $63,608 | $70,109 |
| Formwork, Walls, m2 | 1,764 | $172,008 | $241,292 |
| Rebar, Met. Ton | 31 | $2,782 | $3,082 |
| **Slab on Grade** | | | |
| Concrete Finishing, m2 | 837 | $4,244 | $6,344 |
| Concrete, m3 | 126 | $29,699 | $32,735 |
| Edge Forms, m | 132 | $1,411 | $1,977 |
| Rebar, m2 | 1,674 | $13,392 | $16,640 |
| **Earthworks** | | **$11,826** | **$14,936** |
| **Earthworks** | | | |
| Backfill - Structural Fill, m2 | 837 | $4,746 | $5,909 |
| Backfill, m3 | 1,689 | $2,077 | $2,686 |
| Compaction, m3 | 1,689 | $456 | $608 |
| Excavation, m3 | 1,977 | $4,547 | $5,733 |
| **Steel** | | **$621,166** | **$721,110** |
| **Elevated Slabs** | | | |
| Decking, m2 | 1,321 | $54,742 | $63,276 |
| **Steel Superstructure** | | | |
| Open-Web Steel Joists, Met. Ton | 18 | $49,518 | $57,856 |
| Structural Steel, Met. Ton | 113 | $508,726 | $590,991 |
| Open-Web Steel Joists, markup due to small quantity | 1 | $8,180 | $8,987 |
| **Grand Total** | | **$1,123,005** | **$1,365,000** |

| Discipline | Location | Description | Quantity | Unit | Labor Hours | Material | Labor | Equipment | Total | Ext. Total | Ext. Total O&P | Detailed Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concrete | Elevated Slabs | Concrete | 163.3 | m3 | 0 | $ 236.46 | $ - | $ - | $ 236.46 | $ 38,542.98 | $ 42,482.69 | Structural concrete, ready mix, normal weight, 31 MPa, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments |
| Concrete | Elevated Slabs | Edge Forms | 120 | m | 0.21 | $ 0.66 | $ 7.54 | $ - | $ 8.20 | $ 984.00 | $ 1,484.40 | C.I.P. concrete forms, elevated slab, edge forms, to 150 mm high, 4 use, includes shoring, erecting, bracing, stripping and cleaning |
| Concrete | Elevated Slabs | Rebar | 1321 | m2 | 0.06 | $ 5.60 | $ 2.40 | $ - | $ 8.00 | $ 10,568.00 | $ 13,130.74 | Welded wire fabric, sheets, 150 x 150 - W4 x W4 (4 x 4) 2.83 kg/m2, ASTM A185M, incl labor for accessories, excl material for accessories |
| Concrete | Elevated Slabs | Concrete Finishing | 1321 | m2 | 0.13 | $ - | $ 4.71 | $ - | $ 4.71 | $ 6,221.91 | $ 9,247.00 | Concrete finishing, floors, basic finishing for unspecified flatwork, bull float & manual float, excludes placing, striking off & consolidating |
| Concrete | Foundations | Concrete | 204 | m3 | 0 | $ 236.46 | $ - | $ - | $ 236.46 | $ 48,237.84 | $ 53,168.52 | Structural concrete, ready mix, normal weight, 31 MPa, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments |
| Concrete | Foundations | Formwork | 12.8 | m2 | 1.86 | $ 31.89 | $ 66.60 | $ - | $ 98.49 | $ 1,260.67 | $ 1,767.68 | C.I.P. concrete forms, column, square, plywood, 400 mm x 400 mm, 1 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Foundations | Formwork | 91.6 | m2 | 0.93 | $ 13.37 | $ 33.30 | $ - | $ 46.67 | $ 4,274.97 | $ 6,057.51 | C.I.P. concrete forms, footing, spread, plywood, 2 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Foundations | Formwork | 530.8 | m2 | 0.78 | $ 40.84 | $ 28.24 | $ - | $ 69.08 | $ 36,667.66 | $ 47,097.88 | C.I.P. concrete forms, footing, continuous wall, plywood, 2 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Foundations | Concrete Finishing | 1051 | m2 | 0.52 | $ - | $ 17.40 | $ 2.54 | $ 19.94 | $ 20,956.94 | $ 30,752.26 | Concrete finishing, walls, bush hammer, green concrete |
| Concrete | Shear Cores | Concrete | 269 | m3 | 0 | $ 236.46 | $ - | $ - | $ 236.46 | $ 63,607.74 | $ 70,109.47 | Structural concrete, ready mix, normal weight, 31 MPa, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments |
| Concrete | Shear Cores | Formwork, Walls | 588 | m2 | 1.4 | $ 30.77 | $ 51.42 | $ - | $ 82.19 | $ 48,327.72 | $ 66,661.56 | C.I.P. concrete forms, wall, job built, plywood, to 2.44 m high, 1 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Shear Cores | Formwork, Walls | 588 | m2 | 1.84 | $ 34.13 | $ 67.86 | $ - | $ 101.99 | $ 59,970.12 | $ 83,507.76 | C.I.P. concrete forms, wall, job built, plywood, over 2.44 m to 4.88 m high, 1 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Shear Cores | Formwork, Walls | 588 | m2 | 2.2 | $ 27.42 | $ 80.93 | $ - | $ 108.35 | $ 63,709.80 | $ 91,122.36 | C.I.P. concrete forms, wall, job built, plywood, over 4.88 m high, 1 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Shear Cores | Concrete Finishing | 1763 | m2 | 0.52 | $ - | $ 17.40 | $ 2.54 | $ 19.94 | $ 35,154.22 | $ 51,585.38 | Concrete finishing, walls, bush hammer, green concrete |
| Concrete | Shear Cores | Rebar | 30.9 | Met. Ton | 0 | $ 90.02 | $ - | $ - | $ 90.02 | $ 2,781.62 | $ 3,082.28 | Reinforcing steel, shop extra for detailing, under 45 metrictons, A615M, grade 300, material only, included in delivered price |
| Concrete | Slab on Grade | Concrete | 125.6 | m3 | 0 | $ 236.46 | $ - | $ - | $ 236.46 | $ 29,699.38 | $ 32,735.13 | Structural concrete, ready mix, normal weight, 31 MPa, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments |
| Concrete | Slab on Grade | Edge Forms | 132 | m | 0.21 | $ 3.27 | $ 7.42 | $ - | $ 10.69 | $ 1,411.08 | $ 1,977.36 | C.I.P. concrete forms, slab on grade, bulkhead with keyway, wood, 150 mm high, 1 use, includes erecting, bracing, stripping and cleaning |
| Concrete | Slab on Grade | Rebar | 1674 | m2 | 0.06 | $ 5.60 | $ 2.40 | $ - | $ 8.00 | $ 13,392.00 | $ 16,639.56 | Welded wire fabric, sheets, 150 x 150 - W4 x W4 (4 x 4) 2.83 kg/m2, ASTM A185M, incl labor for accessories, excl material for accessories |
| Concrete | Slab on Grade | Concrete Finishing | 837 | m2 | 0.14 | $ - | $ 5.07 | $ - | $ 5.07 | $ 4,243.59 | $ 6,344.46 | Concrete finishing, floors, basic finishing for unspecified flatwork, bull float, manual float & broom finish, includes edging and joints, excludes placing, striking off & consolidating |
| Earthworks | Earthworks | Excavation | 1977 | m3 | 0.02 | $ - | $ 0.89 | $ 1.41 | $ 2.30 | $ 4,547.10 | $ 5,733.30 | Excavating, bulk bank measure, 1.1 m3 capacity = 95.6 m3/hr, backhoe, hydraulic, crawler mounted, excluding truck loading |
| Earthworks | Earthworks | Backfill | 1689 | m3 | 0.01 | $ - | $ 0.57 | $ 0.66 | $ 1.23 | $ 2,077.47 | $ 2,685.51 | Backfill, structural, common earth, 78 kW dozer, 15 m haul, from existing stockpile, excludes compaction |
| Earthworks | Earthworks | Compaction | 1689 | m3 | 0 | $ - | $ 0.13 | $ 0.14 | $ 0.27 | $ 456.03 | $ 608.04 | Compaction, riding, vibrating roller, 2 passes, 300 mm lifts |
| Earthworks | Earthworks | Backfill - Structural Fill | 837 | m2 | 0.05 | $ 3.53 | $ 1.96 | $ 0.18 | $ 5.67 | $ 4,745.79 | $ 5,909.22 | Fill, gravel fill, compacted, under floor slabs, 100 mm deep |
| Steel | Elevated Slabs | Decking | 1321 | m2 | 0.09 | $ 36.94 | $ 4.06 | $ 0.44 | $ 41.44 | $ 54,742.24 | $ 63,275.90 | Metal floor decking, steel, non-cellular, composite, galvanized, 38 mm D, 18 gauge |
| Steel | Steel Superstructure | Open-Web Steel Joists | 17.78 | Met. Ton | 7.35 | $ 2,300.40 | $ 310.62 | $ 174.01 | $ 2,785.03 | $ 49,517.83 | $ 57,856.48 | Open web bar joist, K Series, 36-tonne job lots, spans up to 10 m, shop fabricated, incl shop primer, horizontal bridging |
| Steel | Steel Superstructure | Open-Web Steel Joists | 1 | | 0 | $ 460.08 | $ - | $ - | $ 460.08 | $ 8,180.22 | $ 8,986.72 | Open web bar joist, K Series, for lots 18 to 26 tonnes, add |
| Steel | Steel Superstructure | Structural Steel | 112.8 | Met. Ton | 9.8 | $ 3,942.90 | $ 418.07 | $ 149.01 | $ 4,509.98 | $ 508,725.74 | $ 590,990.78 | Structural steel project, offices, hospitals, etc, 90 metric ton project, 3 to 6 stories, A992 steel, shop fabricated, incl shop primer, bolted connections |
| | | | | | | | | | | $ 1,123,004.66 | $ 1,364,999.95 | |

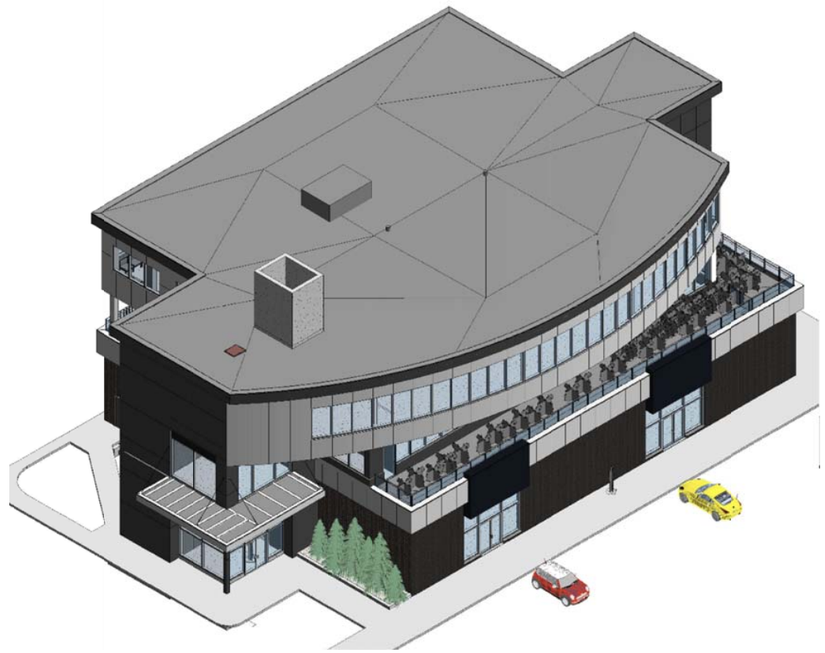



# Appendix G

# Strata Solutions Structural Drawing Package

# Orthodontic Clinic

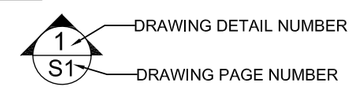
Hebron
Way



Issued for Approval
April 3rd, 2013

| SHEET LIST | | |
|---|---|---|
| Sheet Numer | Sheet Name | Current Revision Description |
| S1 | Foundation Plan and Details | Issued for Approval |
| S2 | Base Plate Layout and Details | Issued for Approval |
| S3 | Slab-on-Grade Plan and Details | Issued for Approval |
| S4 | Second Floor Framing Plan and Details | Issued for Approval |
| S5 | Third Floor Framing Plan and Details | Issued for Approval |
| S6 | Roof Framing Plan and Details | Issued for Approval |
| S7 | Section Views 1 | Issued for Approval |
| S8 | Section Views 2 / Miscellaneous Details | Issued for Approval |
| S9 | Column Schedule | Issued for Approval |
| S10 | General Notes | Issued for Approval |

LEGEND

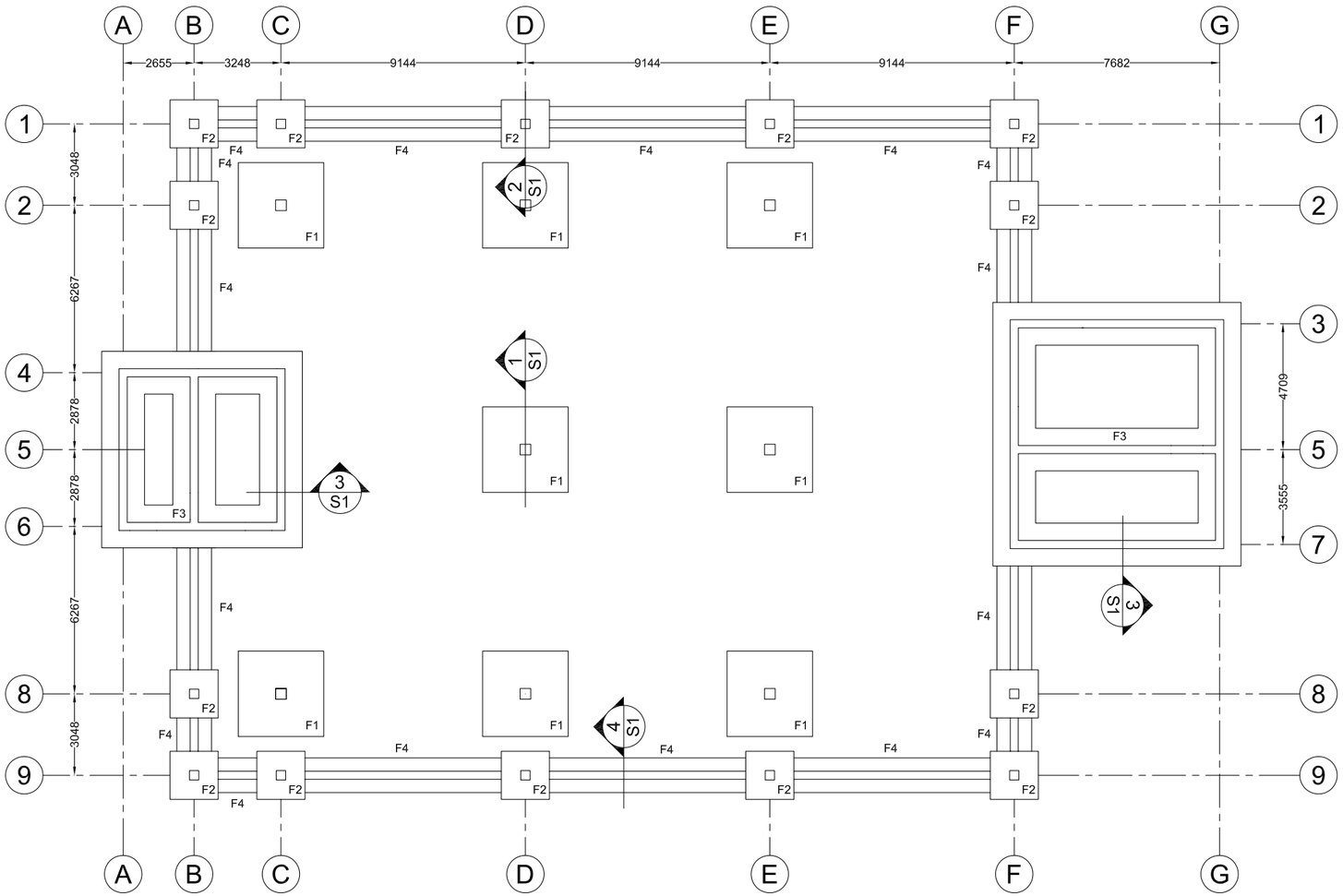



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MORRISON HERSHFIELD

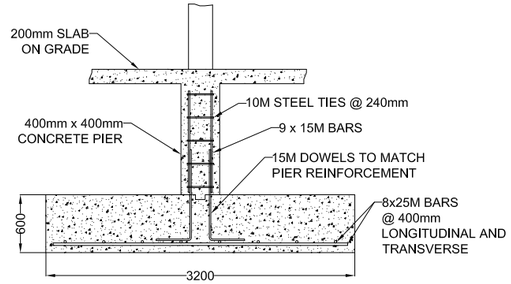
Consultant:

STRATA
SOLUTIONS

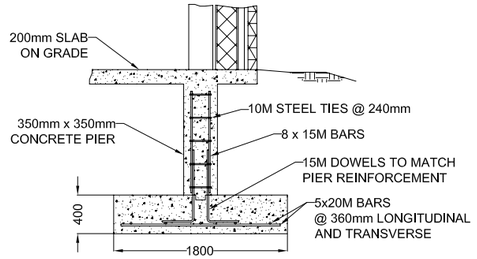



## 1 FOUNDATION PLAN
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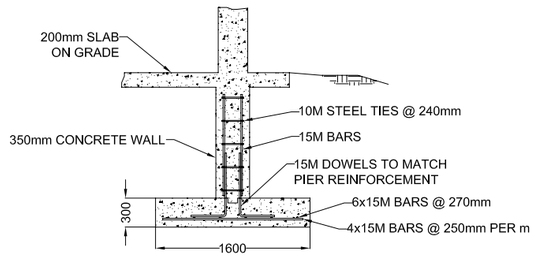
| FOOTING SCHEDULE | | | | |
|---|---|---|---|---|
| MARK | SIZE | DEPTH | REINFORCING | NOTES |
| F1 | 3200mm x 3200mm | 600mm | 25M BARS | SPREAD FOOTING |
| F2 | 1800mm x 1800mm | 400mm | 20M BARS | SPREAD FOOTING |
| F3 | 1600mm | 300mm | 15M BARS | WALL FOOTING |
| F4 | 1300mm | 200mm | 15M BARS | WALL FOOTING |



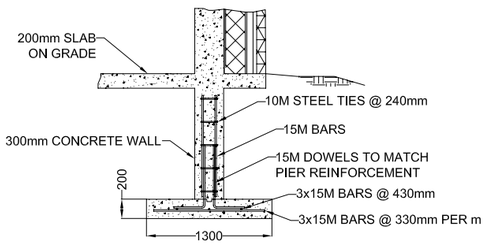

## 1 S1 INTERIOR SPREAD FOOTING
1:30




## 2 S1 EXTERIOR SPREAD FOOTING
1:30




## 3 S1 SHEAR CORE WALL FOOTING
1:30




## 4 S1 EXTERIOR WALL FOOTING
1:30

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NOTES

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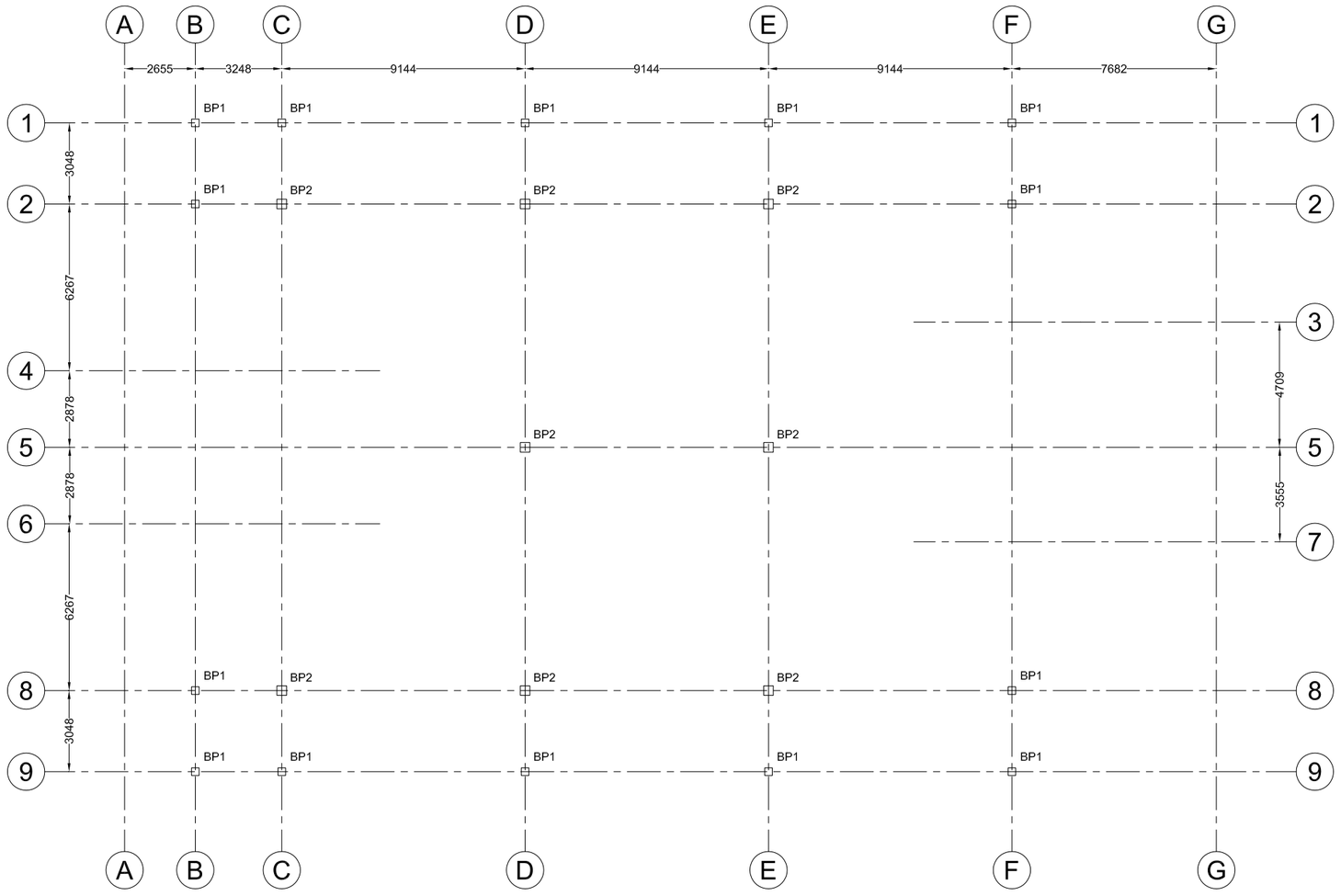
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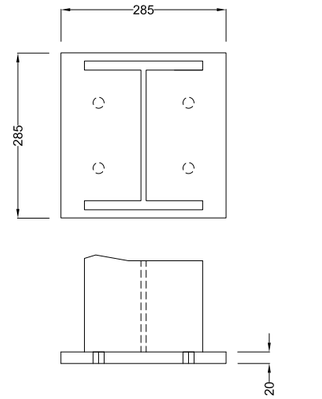
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ORTHODONTIC CLINIC
STRUCTURAL DESIGN

DRAWING DESCRIPTION
FOUNDATION PLAN& DETAILS

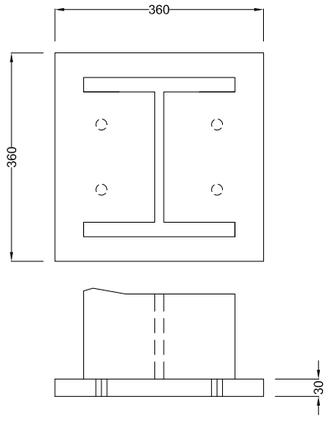
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|---|---|
| VARIES | S01 |




1 BASE PLATE LAYOUT
1:100




2 BASE PLATE1 DETAIL
1:5




3 BASE PLATE 2 DETAIL
1:5

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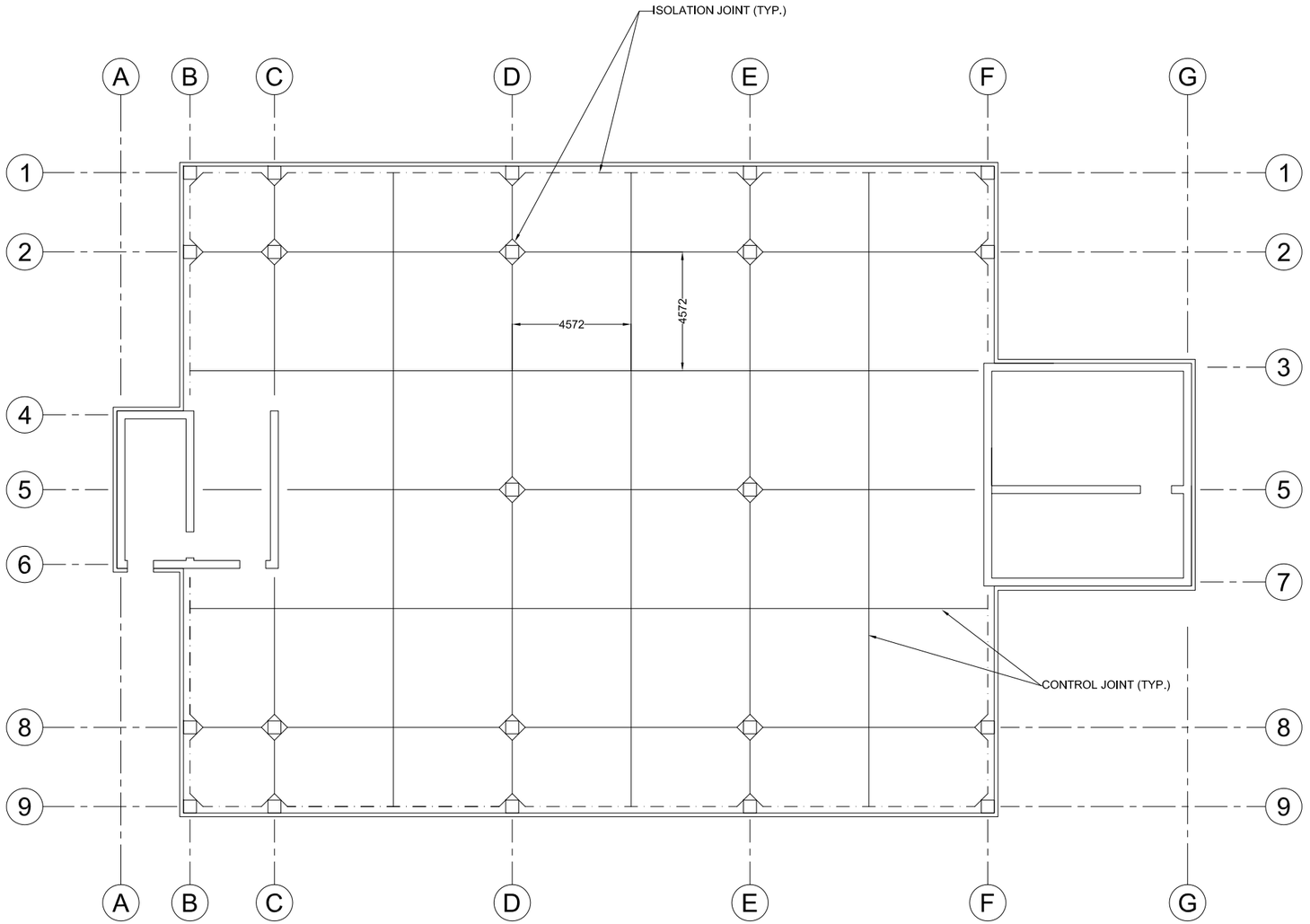
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CLIENT
MORRISON HERSHFIELD

PROJECT
ORTHODONTIC CLINIC STRUCTURAL DESIGN

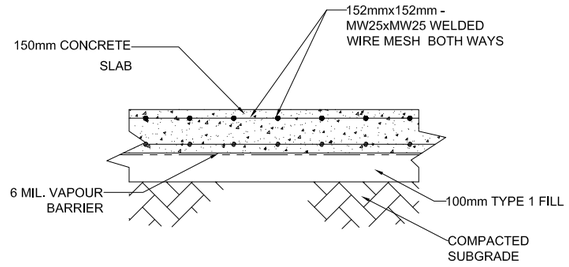
DRAWING DESCRIPTION
BASE PLATE LAYOUT AND DETAILS

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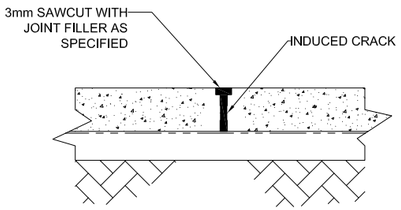



1 SLAB ON GRADE PLAN
1:100

NOTE: ISOLATION JOINT AROUND PERIMETER OF SLAB AND COLUMNS AS SHOWN
CONTROL JOINTS THROUGHOUT INTERIOR SLAB AS SHOWN




2 SLAB ON GRADE DETAIL
1:10




3 TYPICAL SLAB CONTROL JOINT DETAIL
1:10

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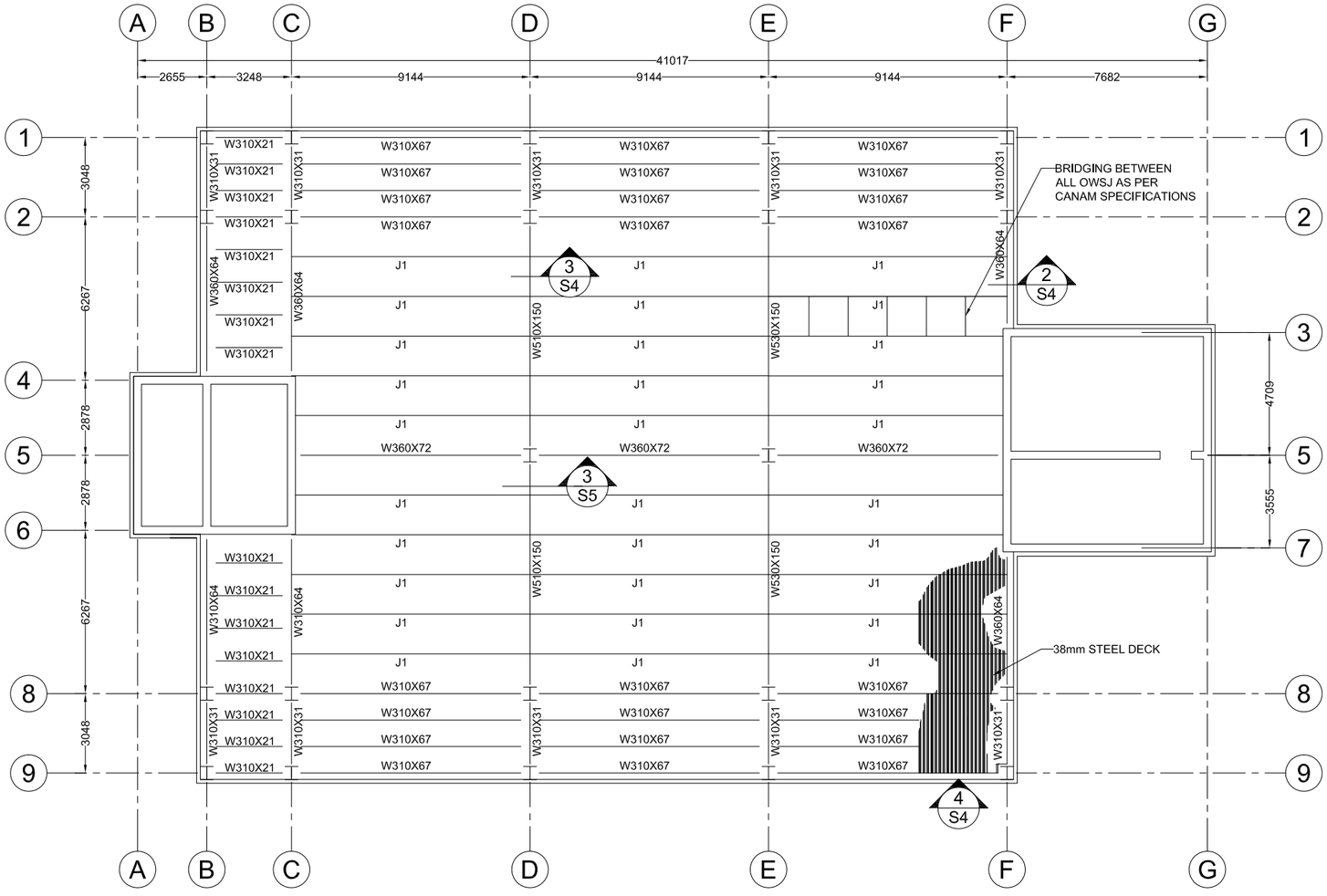
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PROJECT
ORTHODONTIC CLINIC
STRUCTURAL DESIGN

DRAWING DESCRIPTION
SLAB-ON-GRADE PLAN

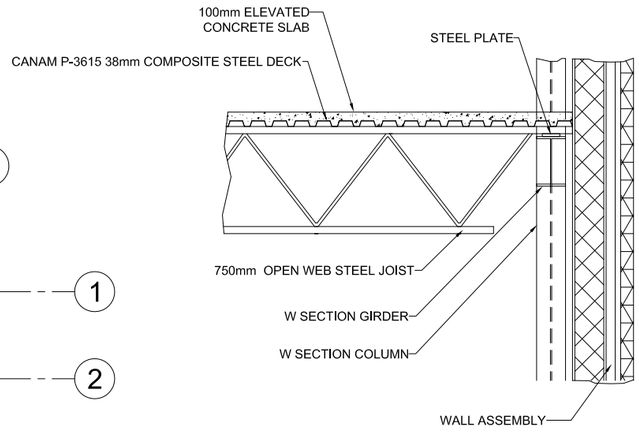
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1 SECOND FLOOR FRAMING PLAN

1:100

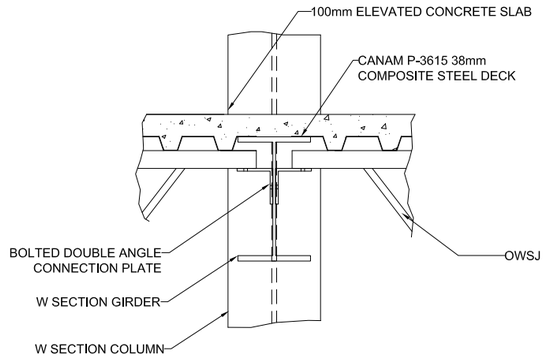
| JOIST SCHEDULE | | | | |
|---|---|---|---|---|
| JOIST NAME | DEPTH (mm) | UNIT WEIGHT (kg/m) | APPROX. LENGTH REQUIRED (m) | LOCATION |
| J1 | 750 | 21.60 | 548.64 | 2ND/3RD FLOOR |
| J2 | 700 | 22.30 | 27.43 | 3RD FLOOR |
| J3 | 750 | 18.30 | 257.02 | ROOF |




SECOND FLOOR JOIST CONNECTION DETAIL - JOIST TO WALL

2 S4

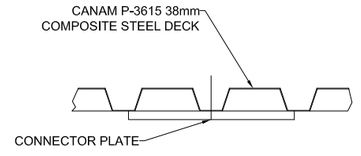
1:20




SECOND FLOOR JOIST CONNECTION DETAIL - JOIST TO GIRDER

3 S4

1:8




TYP. DIAPHRAGM CONNECTOR PLATE

4 S4

1:5

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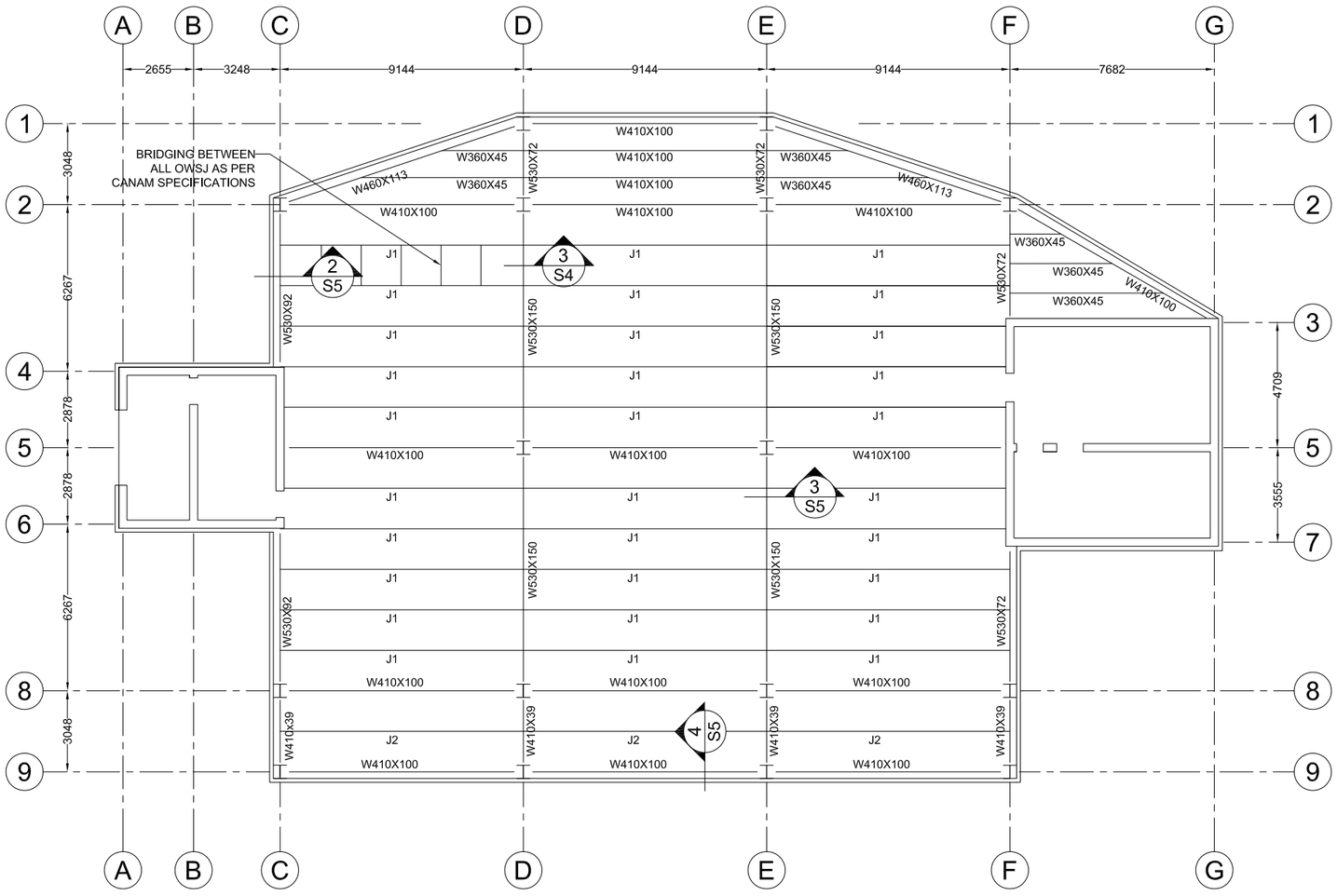
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ORTHODONTIC CLINIC STRUCTURAL DESIGN

DRAWING DESCRIPTION

SECOND FLOOR FRAMING PLAN

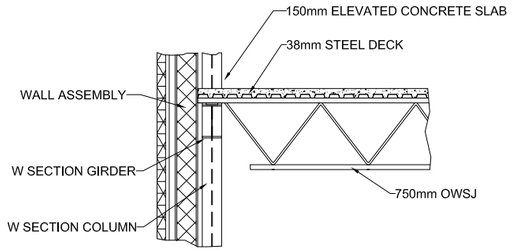
| SCALE | DRAWING NUMBER |
|---|---|
| VARIES | S04 |




1 THIRD FLOOR FRAMING PLAN

1:100

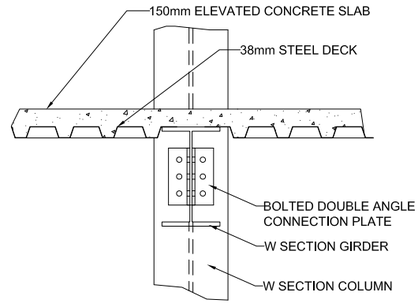
| JOIST SCHEDULE | | | | |
|---|---|---|---|---|
| JOIST NAME | DEPTH (mm) | UNIT WEIGHT (kg/m) | APPROX. LENGTH REQUIRED (m) | LOCATION |
| J1 | 750 | 21.60 | 548.64 | 2ND/3RD FLOOR |
| J2 | 700 | 22.30 | 27.43 | 3RD FLOOR |
| J3 | 750 | 18.30 | 257.02 | ROOF |




THIRD FLOOR JOIST CONNECTION DETAIL - JOIST TO WALL

2 S5

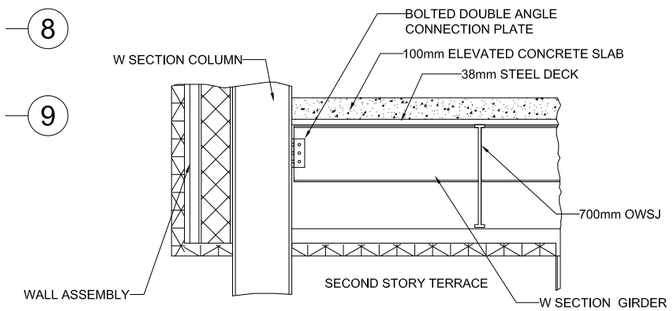
1:30




TYPICAL GIRDER TO COLUMN CONNECTION

3 S5

1:10




THIRD FLOOR GIRDER TO COLUMN DETAIL

4 S5

1:20

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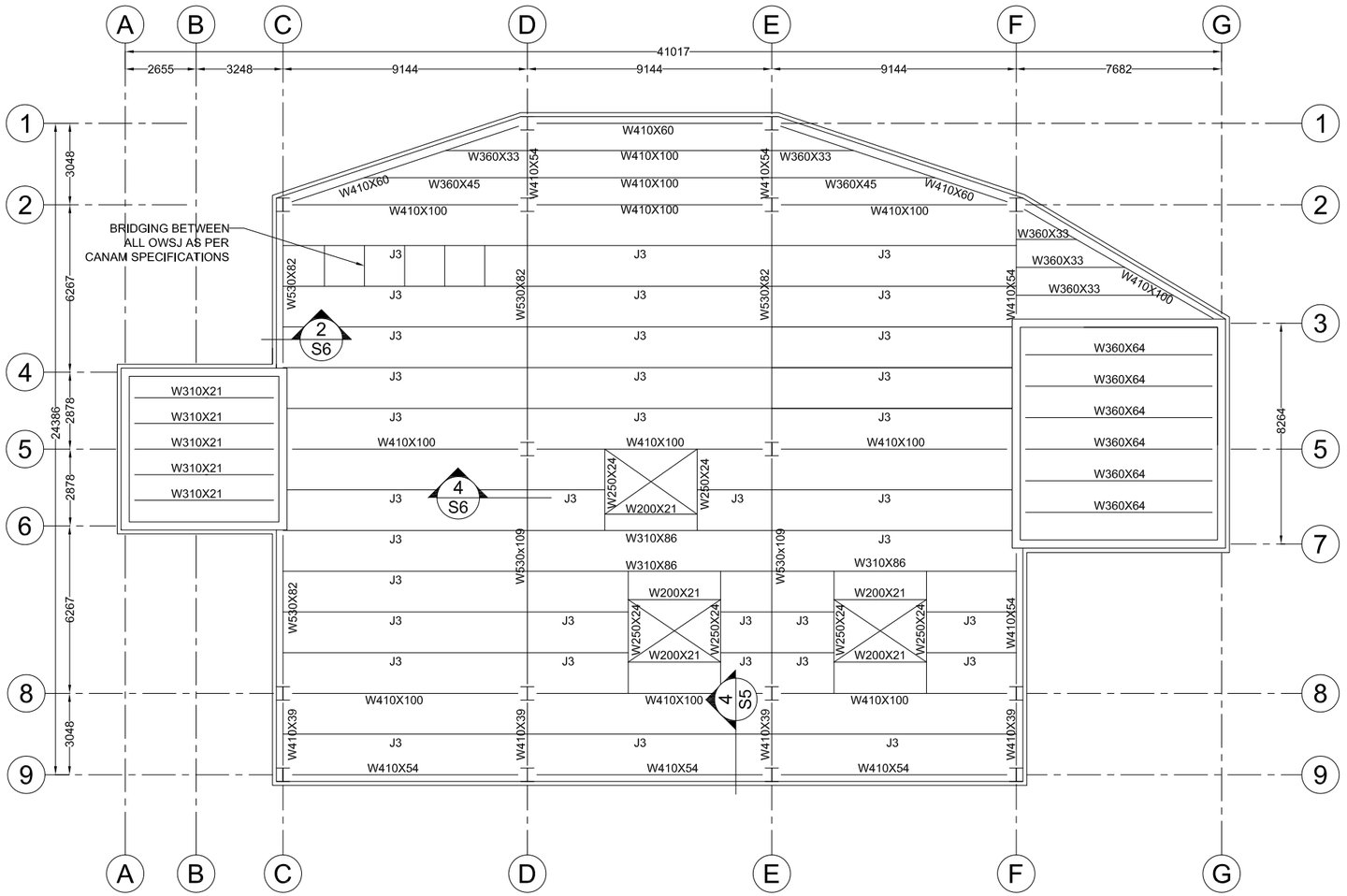
PROJECT

ORTHODONTIC CLINIC STRUCTURAL DESIGN

DRAWING DESCRIPTION

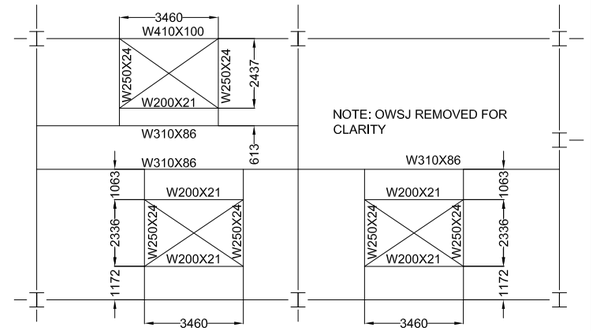
THIRD FLOOR FRAMING PLAN

| SCALE | DRAWING NUMBER |
|---|---|
| VARIES | S05 |

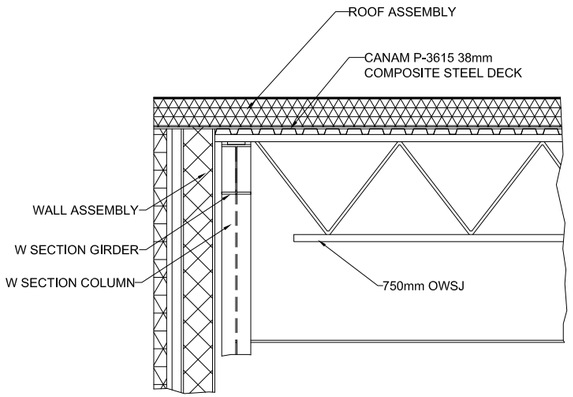



1 ROOF FRAMING PLAN
1:100

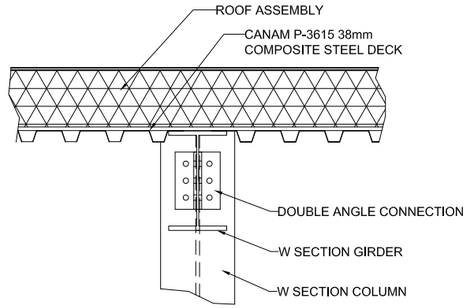
| JOIST SCHEDULE | | | | |
|---|---|---|---|---|
| JOIST NAME | DEPTH (mm) | UNIT WEIGHT (kg/m) | APPROX. LENGTH REQUIRED (m) | LOCATION |
| J1 | 750 | 21.60 | 548.64 | 2ND/3RD FLOOR |
| J2 | 700 | 22.30 | 27.43 | 3RD FLOOR |
| J3 | 750 | 18.30 | 257.02 | ROOF |




2 MECHANICAL EQUIPMENT DETAIL
1:100




ROOF JOIST CONNECTION DETAIL - JOIST TO WALL
2 S6 1:30




GIRDER COLUMN ROOF CONNECTION DETAIL
4 S6 1:10

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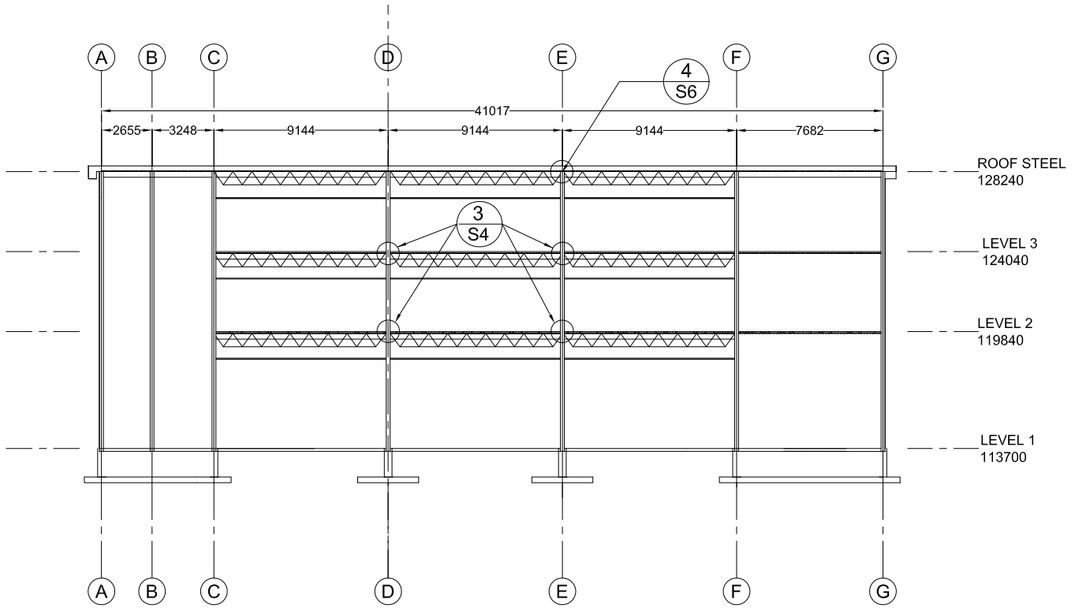
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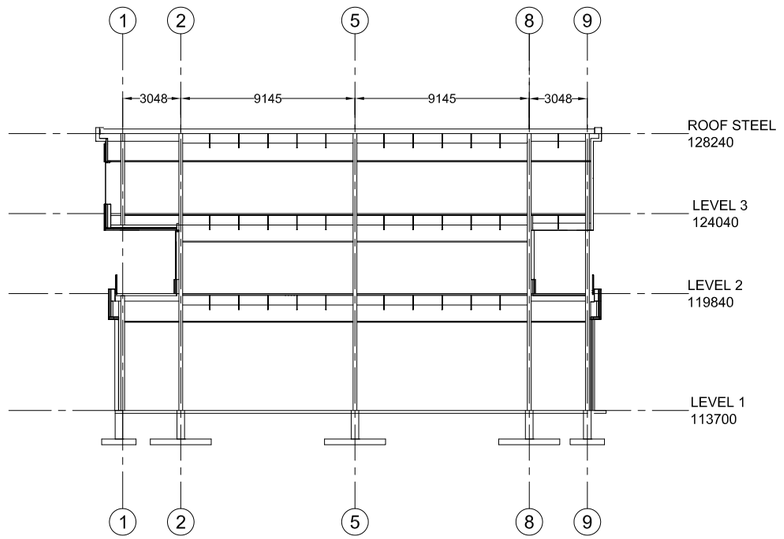
PROJECT
ORTHODONTIC CLINIC STRUCTURAL DESIGN

DRAWING DESCRIPTION
ROOF FRAMING PLAN

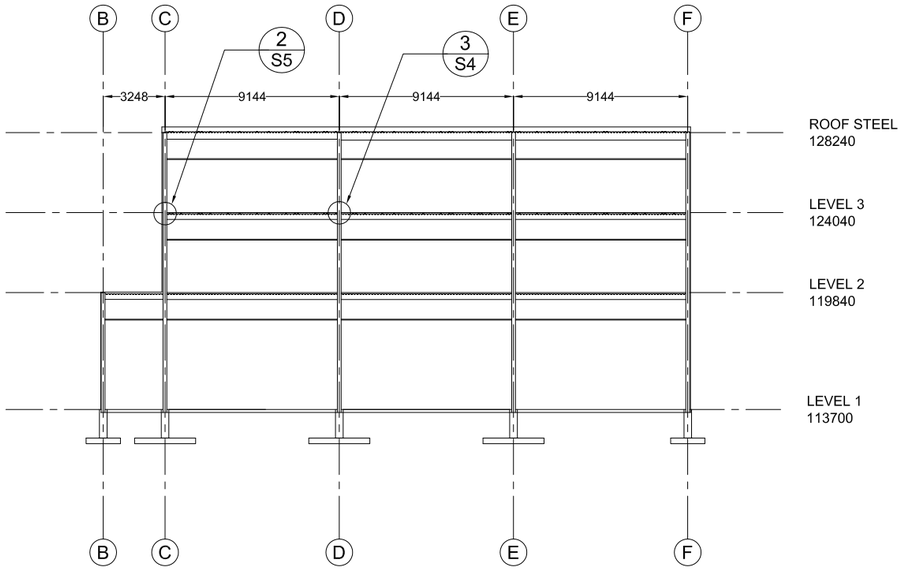
| SCALE | DRAWING NUMBER |
|---|---|
| VARIES | S06 |



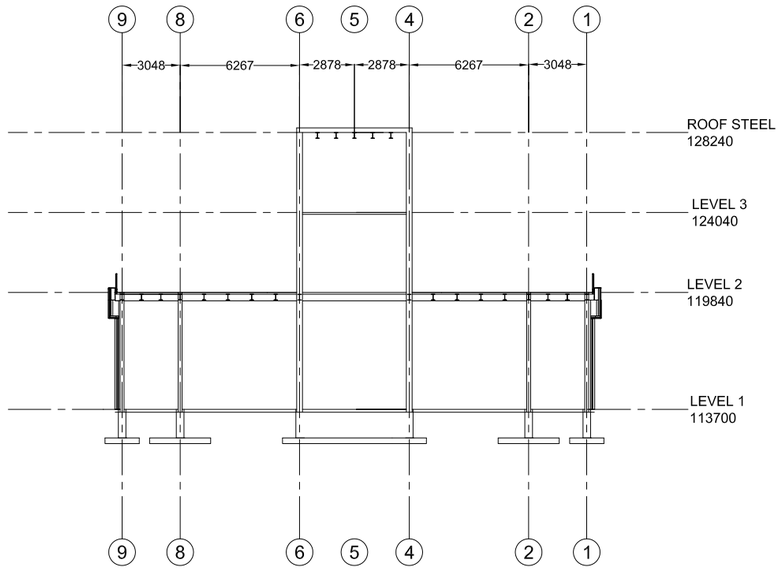

1 GRIDLINE "5" – VIEWING NORTH
1:150




2 GRIDLINE "E" – VIEWING EAST
1:150




3 GRIDLINE "2" – VIEWING NORTH
1:150




4 GRIDLINE "B" – VIEWING WEST
1:150

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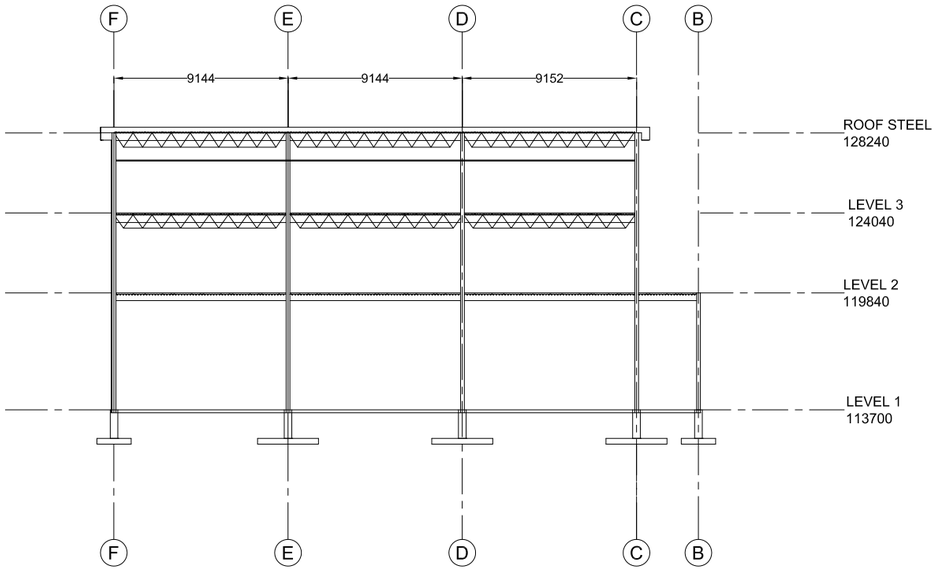
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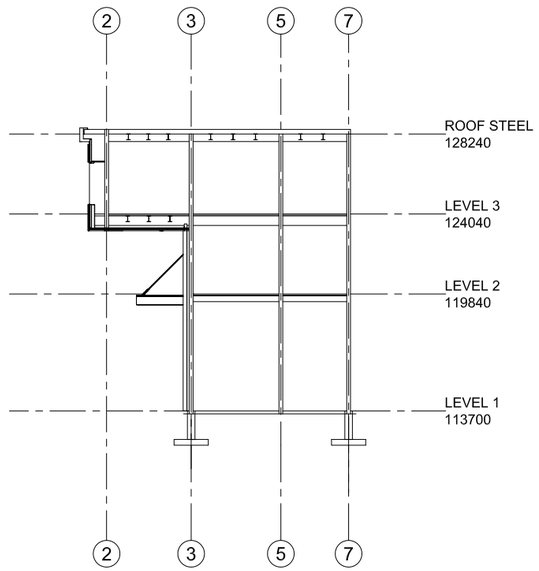
PROJECT
ORTHODONTIC CLINIC
STRUCTURAL DESIGN

DRAWING DESCRIPTION
SECTION VIEWS 1

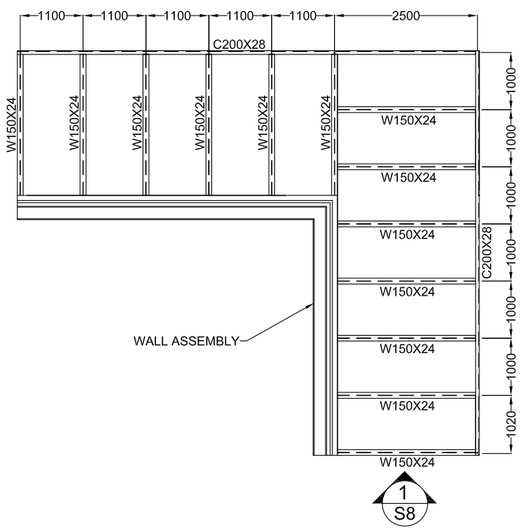
| SCALE | DRAWING NUMBER |
|---|---|
| VARIES | S07 |



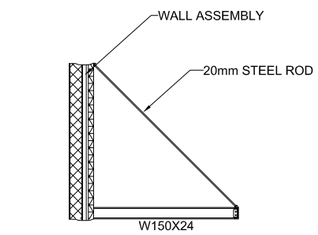

1 GRIDLINE "8" – VIEWING SOUTH
1:150



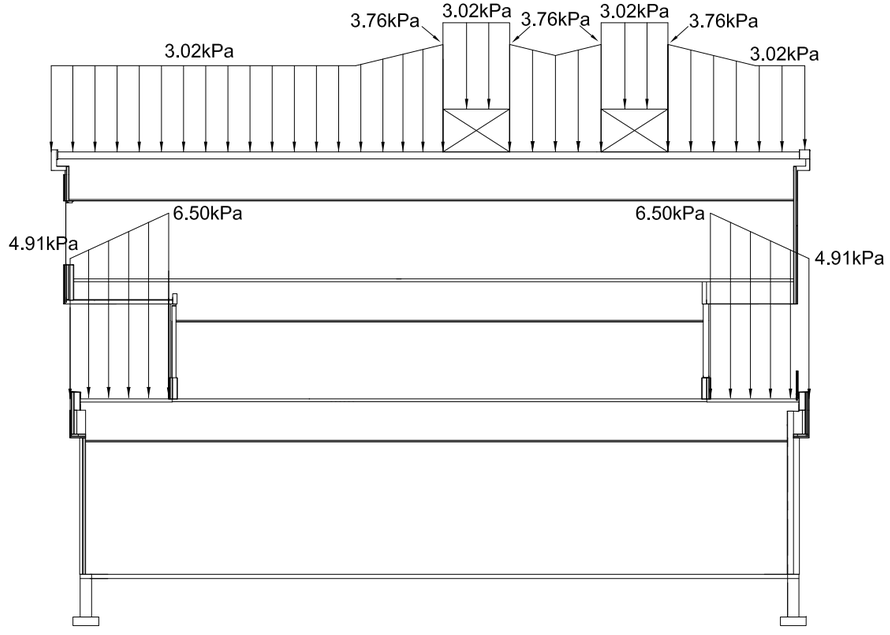

2 GRIDLINE "F" – VIEWING EAST
1:150




3 CANOPY DESIGN
1:50




1
S8
CANOPY ROD DETAIL
1:50




4 SNOW LOADS
1:50

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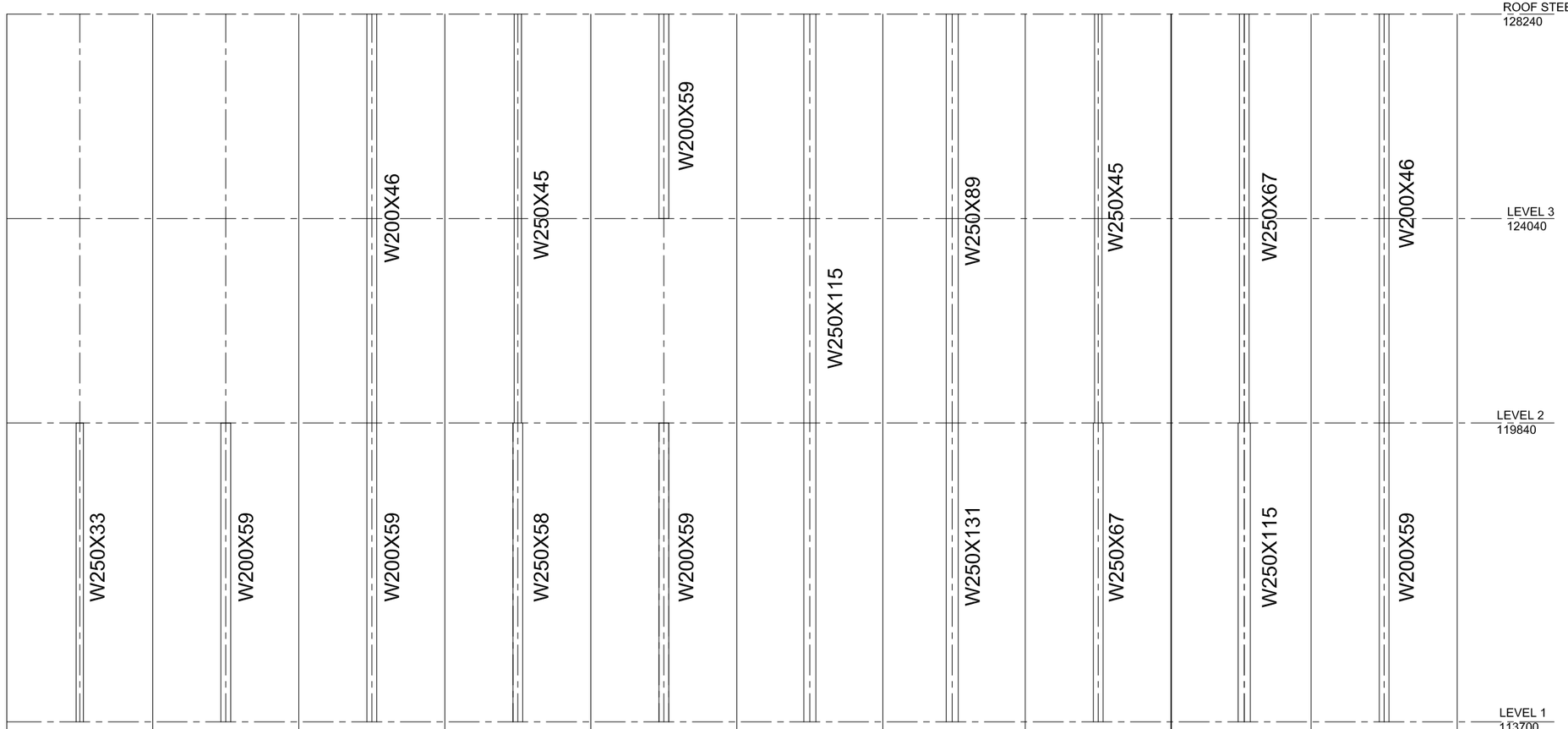
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STRUCTURAL DESIGN

DRAWING DESCRIPTION
SECTION VIEWS 2 / MISCELLANEOUS DETAILS

| SCALE | DRAWING NUMBER |
|---|---|
| VARIES | S08 |




| COLUMN LOCATION | B-1,B-2,B-8,B-9 | C-1,F1 | C-9 | C-2,C-8 | D-1,E-1 | D-2,E-2 | D-5,E-5 | D-9,E-9,F-2 | D-8, E-8 | F-8,F-9 |
|---|---|---|---|---|---|---|---|---|---|---|

## 1 COLUMN SCHEDULE


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ORTHODONTIC CLINIC STRUCTURAL DESIGN

DRAWING DESCRIPTION
COLUMN SCHEDULE

| SCALE | DRAWING NUMBER |
|---|---|
| N/A | S09 |

CAST-IN-PLACE CONCRETE

1. ALL CONCRETE WORK SHALL CONFORM TO C.S.A. STANDARDS A23.1, A23.1 & A23.3
2. ALL BARS SHOULD HAVE A MINIMUM YIELD STRENGTH OF 400 MPa.
3. PROVIDE CONCRETE COVER FOR REINFORCEMENT AS FOLLOWS:
   - SLAB ON GRADE (30mm)
   - ELEVATED SLAB (30mm)
   - CONCRETE POURED AGAINST EARTH (75mm).
4. GROUT UNDERSIDE OF STEEL COLUMN AND BEAM BEARING PLATES WITH DRY PACK NON-SHRINKING GROUT TO MANUFACTURER'S INSTRUCTIONS.
5. USE APPROPRIATE CONTROL JOINT FILLER AND ISOLATION JOINT FILLER

SLAB-ON-GRADE

1. COMPACTION: UNDER CONCRETE SLAB: PROVIDE 100mm BASE COURSE OF TYPE 1 MATERIAL, COMPACTED TO 98% DENSITY S.P.D.
2. BACKFILLING MATERIALS:
   TYPE 1 FILL. CLEAN NATURAL SAND AND GRAVEL MATERIAL, FREE FROM SILT, CLAY, LOAM, FRIABLE OR SOLUBLE MATERIALS AND VEGETABLE MATTER AND GRADED WITHIN FOLLOWING LIMITS:

| SIEVE SIZE (TYLER) | % PASSING |
|---|---|
| 19.000mm | 100 |
| 9.510mm | 55-80 |
| 4.760mm | 35-80 |
| 0.300mm | 7-20 |
| 0.075mm | 3-6 |

3. CONCRETE STRENGTH FOR SLAB ON GRADE TO BE A MINIMUM 30MPa @ 28 DAYS.
4. PROVIDE SAW-CUT CONTROL JOINTS AS SHOWN ON DRAWING S03.
5. PROVIDE SAW-CUT ISOLATION JOINTS AS SHOWN ON DRAWING S03.

STRUCTURAL STEEL

1. ALL STRUCTURAL STEEL SHALL CONFORM TO CSA STANDARD G40.21.
2. FABRICATION AND ERECTION SHALL CONFORM TO C.S.A. STANDARDS CAN/CSA S16.1.
3. ALL WELDING SHALL BE DONE BY QUALIFIED WELDER OF COMPANIES IN COMPLIANCE WITH CSA STANDARDS W47.1 AND IN ACCORDANCE WITH CSA STANDARD W59, LATEST EDITION.
4. PROVIDE WELDED AND BOLTED CONNECTION TO RESIST REACTION PRODUCED BY THE FRAMING LOAD AND CONNECTIONS.
5. VERIFY ALL DIMENSIONS ON SITE BEFORE BEGINNING STEEL FABRICATION.

OPEN WEB STEEL JOIST (OWSJ)

1. OWSJ SHALL BE DESIGNED FOR LOADING AS SHOWN ON DRAWING.
2. SHOP DRAWING OF THE OWSJ TO BE STAMPED BY A PROFESSIONAL ENGINEER.
3. ANCHOR BOLTS TO SUPPORTS IN ACCORDANCE WITH CSA STANDARDS CAN/CSA - S16/1.
4. WELD OR BOLT ANCHORAGE FROM JOIST TO STRUCTURAL STEEL MEMBER.
5. JOISTS TO SPAN TO THE CENTERLINE OF THE BEAM WITH A TOLERANCE OF 0-25mm.
6. DESIGN STEEL JOIST SHOE SUCH THAT JOIST REACTION IS TRANSFERRED AT CENTERLINE OF BEAM WEB. MAX ECCENTRICITY IS TO BE 12mm TO BEAM WEB.
7. TIE JOISTS WHERE JOISTS ARE USED. JOIST MANUFACTURER MUST TAKE INTO CONSIDERATION THE EFFECT OF THE TIES ON THE JOIST DESIGN.
8. EXTEND BOTTOM CHORDS OF THE JOIST TO SUPPORT THE CEILING WHERE REQUIRED.

STEEL DECK SPECIFICATIONS

1. CONFORM WITH C.S.A. STANDARDS S136 - "COLD FORMED STEEL STRUCTURAL MEMBERS", AND CSSBI ARTICLES CONTAINED IN "STANDARDS FOR STEEL ROOF DECK" PUBLISHED BY CANADIAN SHEET STEEL BUILDING INSTITUTE, LATEST EDITION.
2. PROVIDE DECK IN SPAN LENGTHS TO SPAN CONTINUOUSLY OVER THREE SUPPORTS WHEREVER POSSIBLE.
3. WELD FLUTES TO STEEL SUPPORTS WITH ¾" (19mm) ARC WELDS IN ACCORDANCE WITH C.S.A. STANDARDS - W59.1, LATEST EDITION.
4. PROVIDE WELDS AT END LAPS AND AT INTERMEDIATE SUPPORTS, AT MAXIMUM SPACING OF 16" (400mm) O.C., SECURE PANELS TO EACH OTHER BY CLINCHING SIDE LAPS AT 24" (600mm) O.C. OR BY 1' (25mm) WELD AT 24" (600mm) O.C..
5. SUBMIT SHOP DRAWINGS FOR REVIEW PRIOR TO FABRICATION, PER SPECIFICATION.
6. WELDING SHALL COMPLY WITH C.S.A. STANDARD W59, AND WELDING INSPECTION TO W178.1-1990, AND W178.2-1990.
7. LAY ROOF DECK TO WITHIN A TOLERANCE OF ¼" OM 40'-0" (6mm IN 12 METRES) FOR UNIT ALIGNMNET.
8. ALL STEEL DECK WORK TO INCLUDE ALL SHEET STEEL ANGLE COVER PLATES, CELL CLOSURE, FASTENERS, STIFFENERS AND ANY ACCESSORIES AS REQUIRED.
9. LAP ENDS OF PANELS NO LESS THAN 1-3/4" (44mm).

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DRAWING DESCRIPTION

GENERAL NOTES

| SCALE | DRAWING NUMBER |
|---|---|
| N/A | S10 |

STRATA SOLUTIONS

# Appendix H

# Presentation Slides

**MEMORIAL UNIVERSITY**
**ENGI 8700 – CIVIL ENGINEERING PROJECT**
**WINTER 2013**

# ORTHODONTIC CLINIC STRUCTURAL DESIGN




**STRATA SOLUTIONS**
COLIN GIBLING
KATHY HIGGINS
MARK REYNOLDS
JACOB TUCKER

STRATA SOLUTIONS

**MORRISON HERSHFIELD**
RYAN NOEL
LINDSAY ANTLE
VANESSA PYNN

MORRISON HERSHFIELD

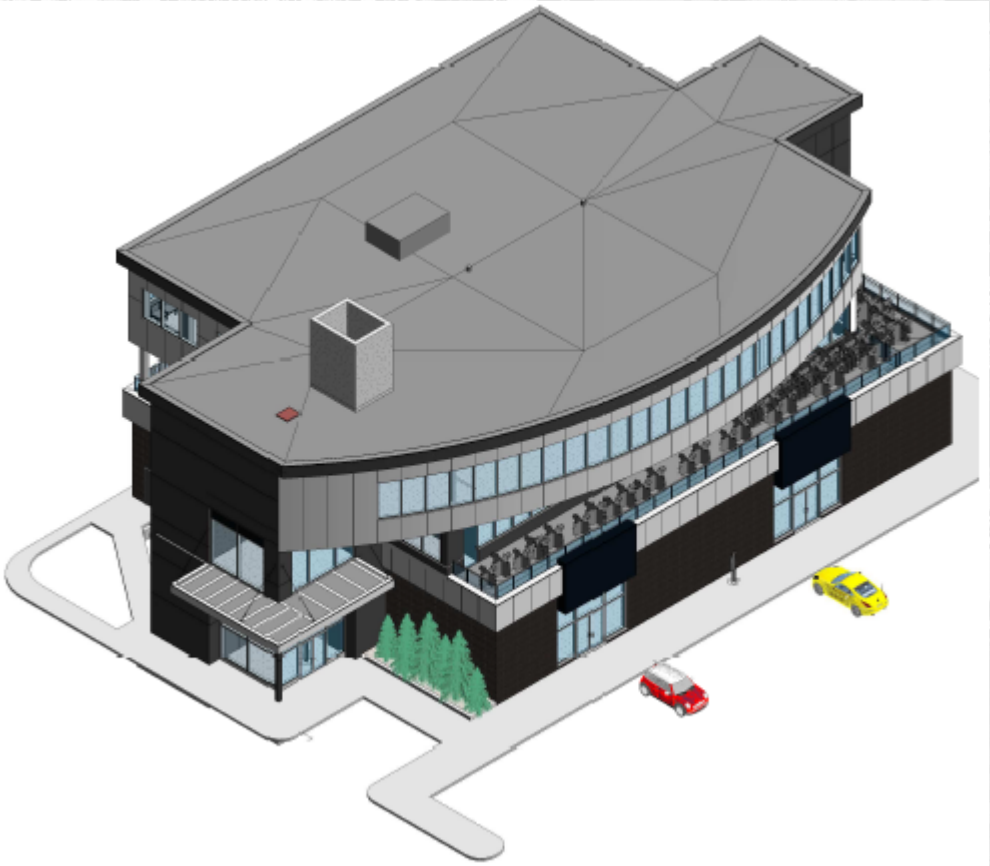
# OUR ROLE

## STRUCUTRAL DESIGN CONSULTANTS

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**Requirements:**

- Design of vertical load resisting system:
  - Roof
  - Elevated slab system
  - Slab-on-grade
  - Structural steel
  - Foundations
- Provide structural drawings
- Include cost estimate
- NOT required to design lateral load resisting system

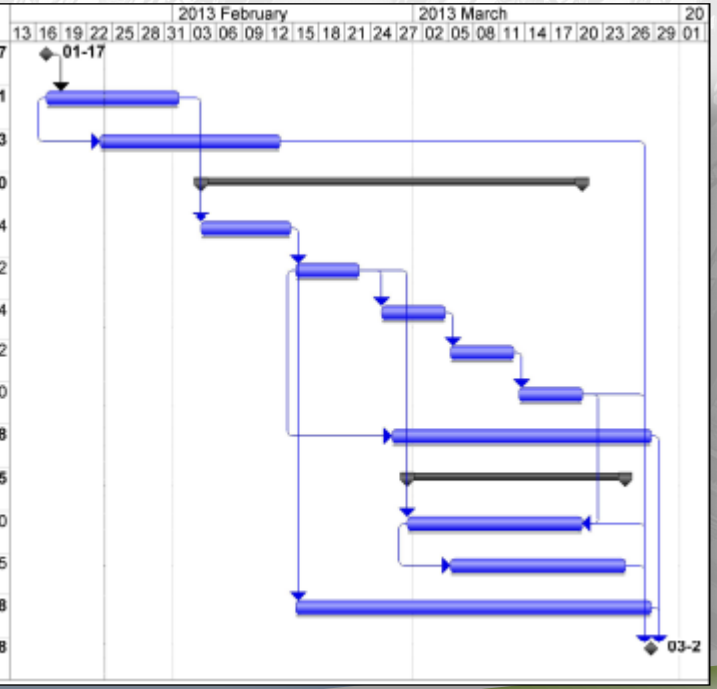


# INITIAL PLANNING

STRATA SOLUTIONS

- Project Plan > Organization
- Project Schedule > Effective Time Management
- Individual Tasks
- Set Deliverables

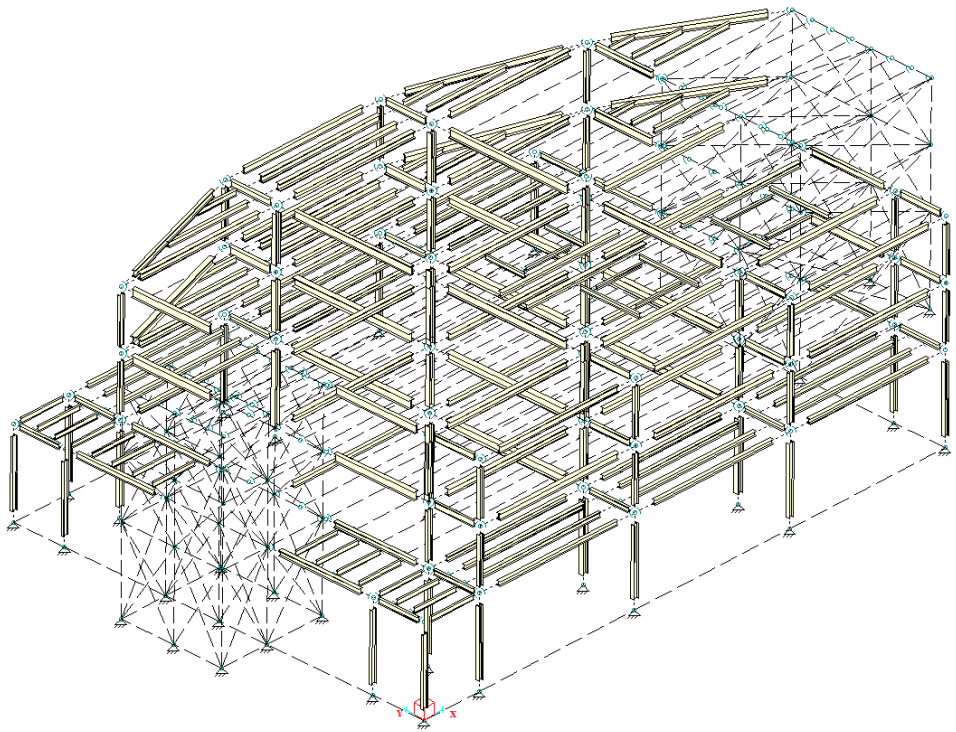
| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Project Start** | **0 days** | **Jan 17** | **Jan 17** |
| 2 | **Create project plan** | **8 days** | **Jan 17** | **Feb 01** |
| 3 | **Research technical requirements** | **10 days** | **Jan 23** | **Feb 13** |
| 4 | **Structural design** | **22 days** | **Feb 04** | **Mar 20** |
| 5 | Determination of loading patterns | 6 days | Feb 04 | Feb 14 |
| 6 | Roof design | 4 days | Feb 15 | Feb 22 |
| 7 | Wall and column design | 4 days | Feb 25 | Mar 04 |
| 8 | Floor design | 4 days | Mar 05 | Mar 12 |
| 9 | Foundation design | 4 days | Mar 13 | Mar 20 |
| 10 | **Drafting** | **15 days** | **Feb 26** | **Mar 28** |
| 11 | **Project control** | **12 days** | **Feb 28** | **Mar 25** |
| 12 | Quantity takeoffs | 10 days | Feb 28 | Mar 20 |
| 13 | Cost estimate | 10 days | Mar 05 | Mar 25 |
| 14 | **Project report** | **20 days** | **Feb 15** | **Mar 28** |
| 15 | **Project Completion** | **0 days** | **Mar 28** | **Mar 28** |



# DESIGN METHODOLOGY

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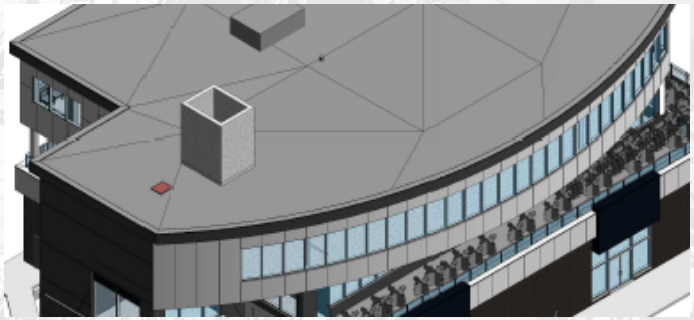
- Determined design loads
- Designed floor systems:
  - Slab on grade
  - Elevated slabs
  - Steel deck and open-web steel joists
- Modeled structure in S-Frame
- Structural steel design
- Foundation design

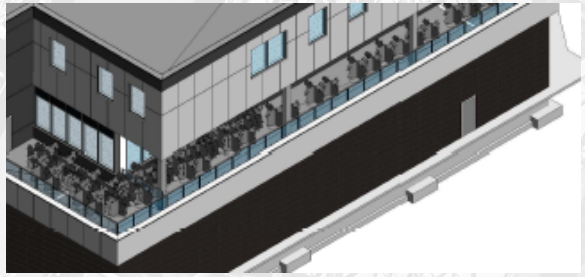


# DESIGN ASSUMPTIONS

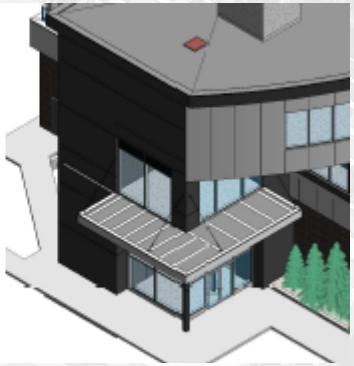
STRATA SOLUTIONS

- Concrete shear cores
- Curved third storey
- Snow drifting onto terrace
- Geotechnical information





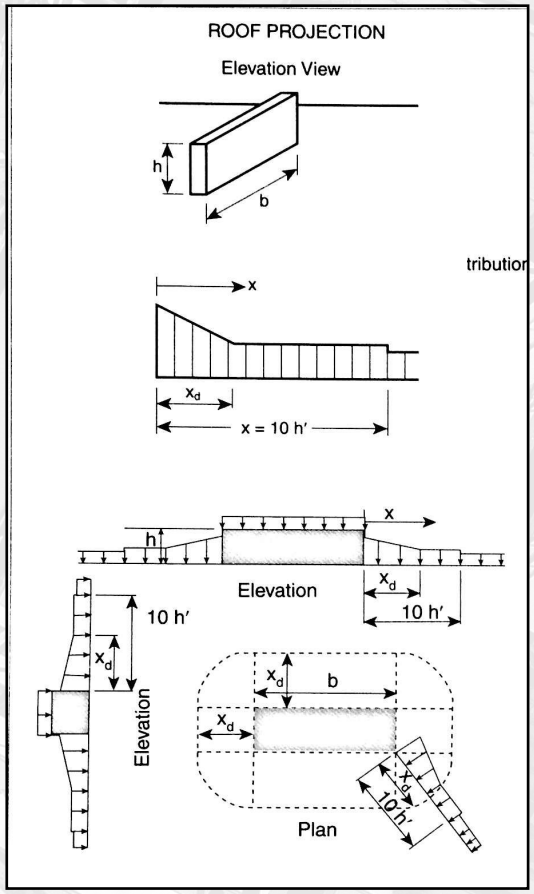




# STRUCTURAL LOADS

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- **Loads were determined as per NBCC 2010 criteria:**
  - **Dead Loads**
    - Mechanical equipment
    - Self-weight of structure
  - **Live Loads**
    - Roof live load
    - Live load for commercial space
  - **Snow Loads and Snow Drift Load**
    - Mechanical equipment
    - Second level terraces
  - **Wind Loads**
- **Factored Load Combinations from NBCC**



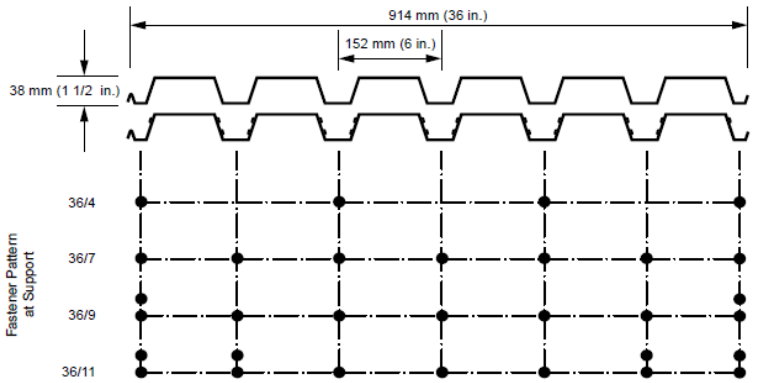
# DECK AND JOISTS

STRATA SOLUTIONS

- CANAM Steel Decking and Open-Web Steel Joists
- Manually Determine loadings (Roof and Floors)
- Select Appropriate Decks and Joists from CANAM guides for each floor

| Span (m) | Joist Depth (mm) | Factored load (kN/m) / Service load (kN/m) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **4.5** 3.0 | **6.0** 4.0 | **7.5** 5.0 | **9.0** 6.0 | **10.5** 7.0 | **12.0** 8.0 | **13.5** 9.0 | **15.0** 10.0 | **16.5** 11.0 | **1** 1 | | | |
| 10 | 500 | 11.6 66 | 13.5 65 | 16.8 64 | 18.2 65 | 21.8 65 | 24.7 64 | 31.5 64 | 33.1 64 | 33.6 64 | 3 | | | |
| | 550 | 10.5 70 | 13.3 68 | 13.9 68 | 15.6 65 | 18.4 65 | 20.2 63 | 24.6 65 | 28.3 65 | 28.3 64 | 3 | | | |
| | 600 | 11.1 83 | 13.2 77 | 13.6 76 | 14.4 70 | 17.2 71 | 18.8 69 | 21.8 67 | 23.9 65 | 24.8 67 | 2 | | | |
| | 650 | 11.8 132 | 13.4 112 | 13.7 89 | 14.2 83 | 16.0 78 | 17.8 76 | 20.7 74 | 22.7 72 | 23.2 72 | 2 | | | |
| | 700 | 11.9 153 | 13.5 14 | 13.8 104 | 14.3 87 | 15.4 85 | 17.2 85 | 19.9 81 | 22.3 80 | 22.3 76 | 2 | | | |
| | 750 | 12.1 177 | 13.6 133 | 14.0 120 | 14.4 100 | 15.7 95 | 16.8 98 | 18.3 90 | 19.9 90 | 21.6 87 | 2 | | | |
| | 800 | 12.3 200 | 13.7 172 | 14.1 137 | 14.5 114 | 16.0 98 | 17.1 95 | 19.3 100 | 21.9 96 | 21.9 93 | 22.9 95 | 24.1 93 | 26.0 94 | 27.4 93 |

**P-3615 & P-3615 COMPOSITE**



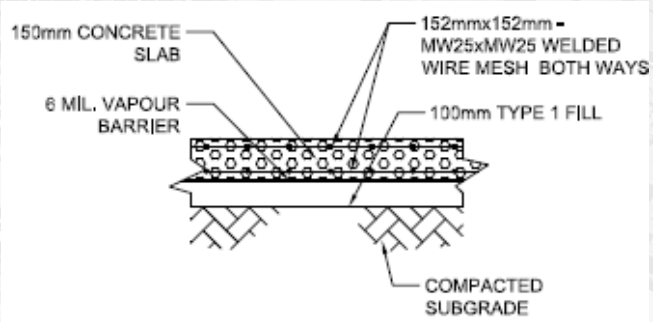

**PHYSICAL PROPERTIES**

| Type | Nominal Thickness mm (in.) | Overall Depth mm (in.) | Weight kg/m² (lb./ft.²) | Gross Moment of Inertia mm⁴/m (in.⁴/ft.) |
|---|---|---|---|---|
| 22 | 0.76 (0.030) | 37.4 (1.47) | 8.50 (1.74) | 228 227 (0.1671) |
| 20 | 0.91 (0.036) | 37.5 (1.48) | 10.07 (2.06) | 272 365 (0.1994) |
| 18 | 1.21 (0.048) | 37.8 (1.49) | 13.26 (2.72) | 364 468 (0.2669) |
| 16 | 1.52 (0.060) | 38.1 (1.50) | 16.34 (3.35) | 452 803 (0.3316) |

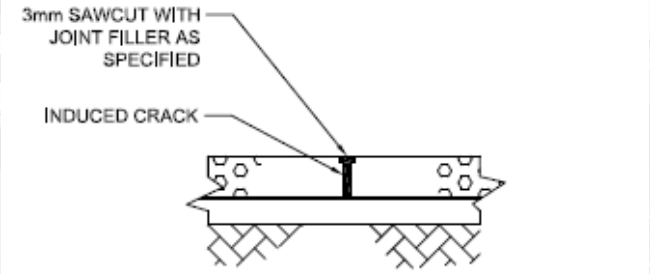
# SLAB ON GRADE

STRATA SOLUTIONS

- Designed based on CSA 23.3 – 04
- Used welded wire mesh reinforcement
- Saw cutting based on ASTM standards



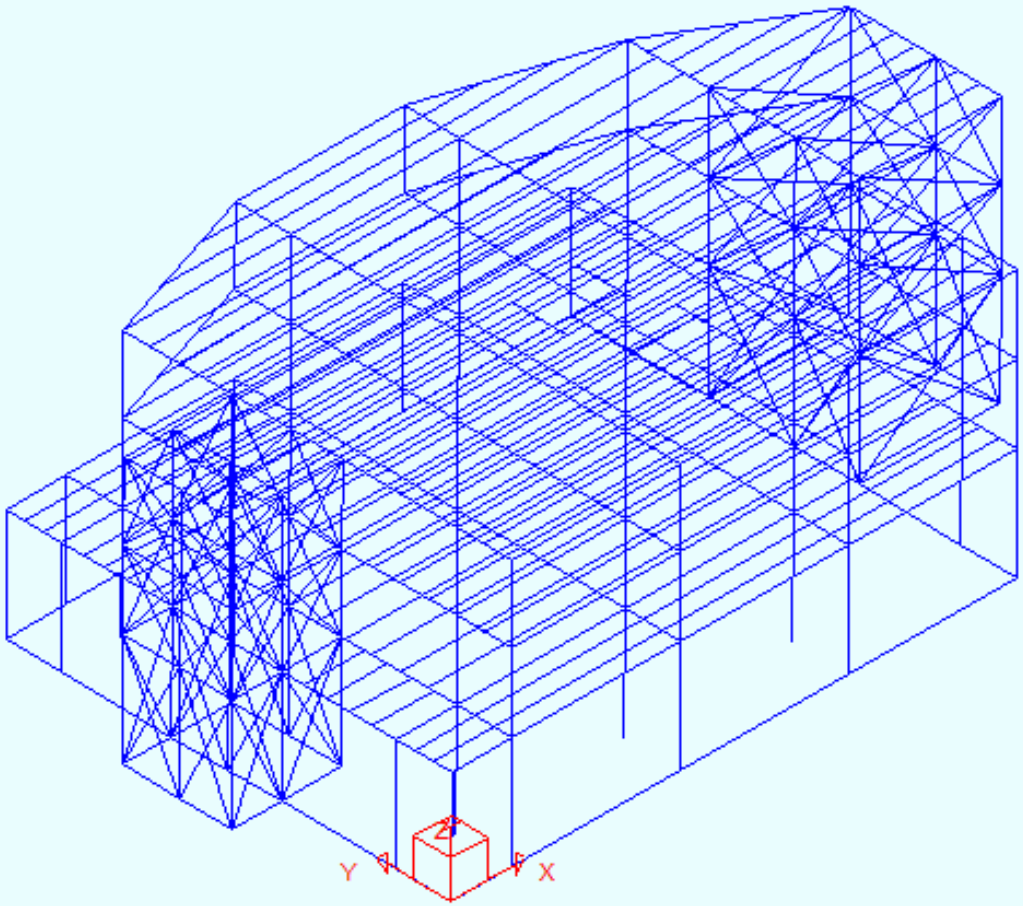

SLAB-ON-GRADE DETAIL




TYPICAL SLAB CONTROL JOINT DETAIL

# MODELING

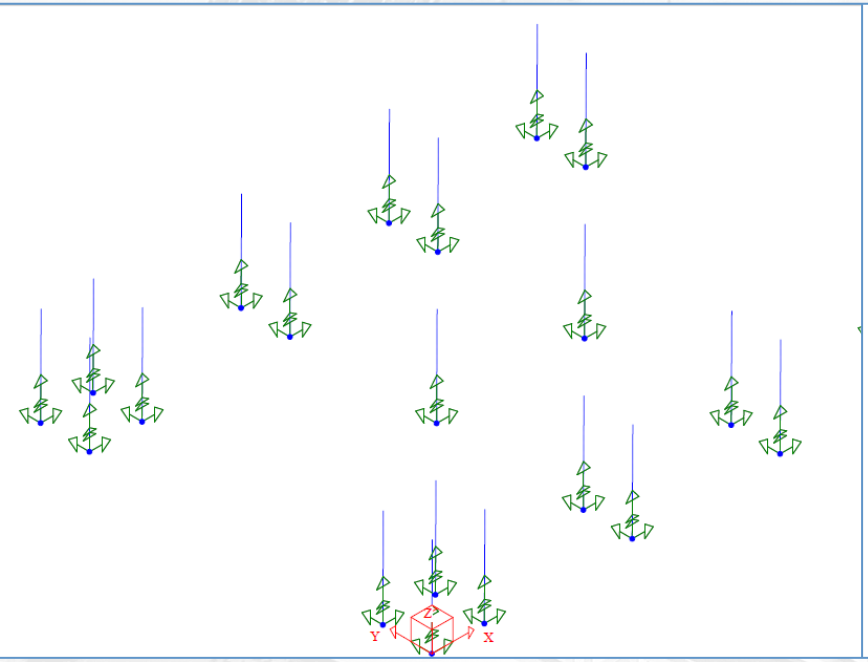
STRATA SOLUTIONS

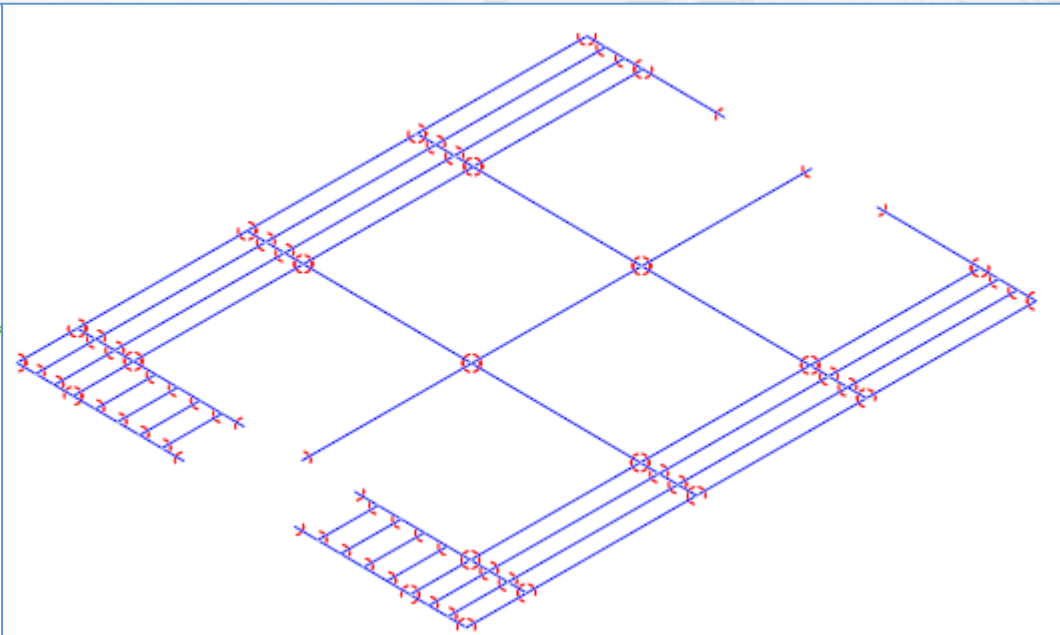



- **S-Frame**
  - Model generated based on gridlines of architectural drawings
  - Shear cores simulated as stiff beams and columns with cross-bracing
  - Joists modeled for load transfer and self weight, not for design

# MODELING

- **Modeling Procedure and Assumptions**
  - Pinned supports and member end moments released

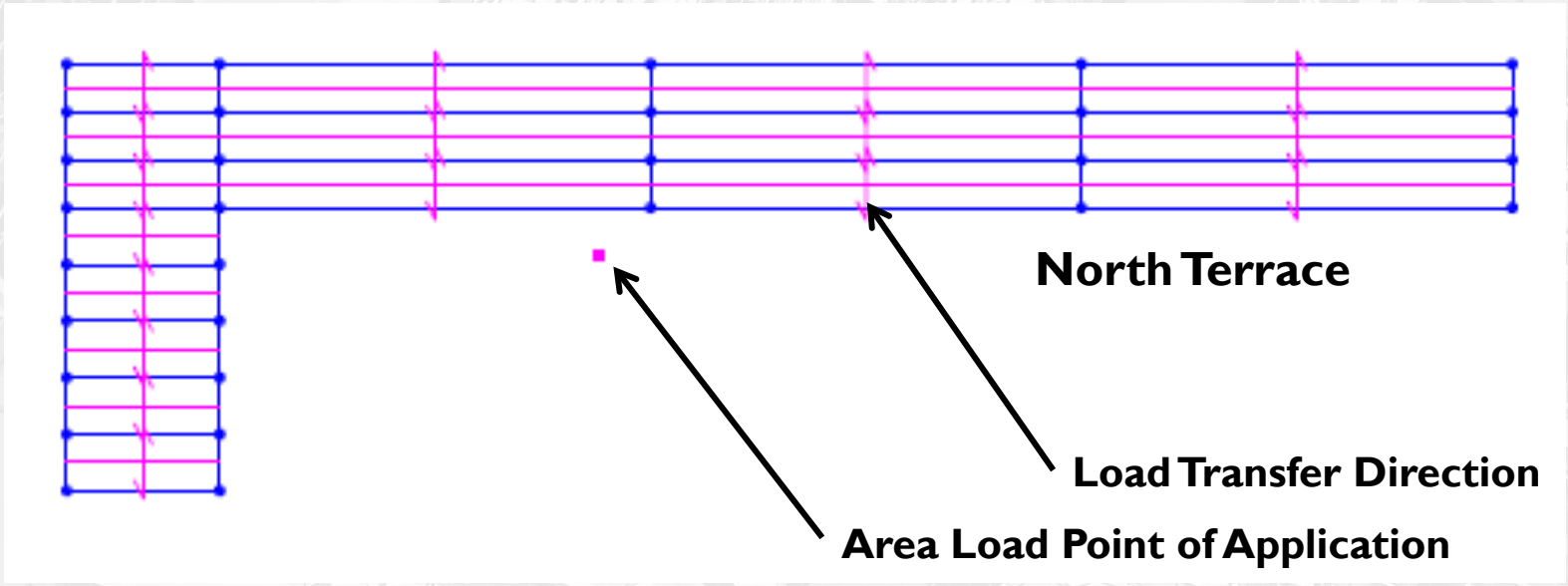


# MODELING

STRATA SOLUTIONS

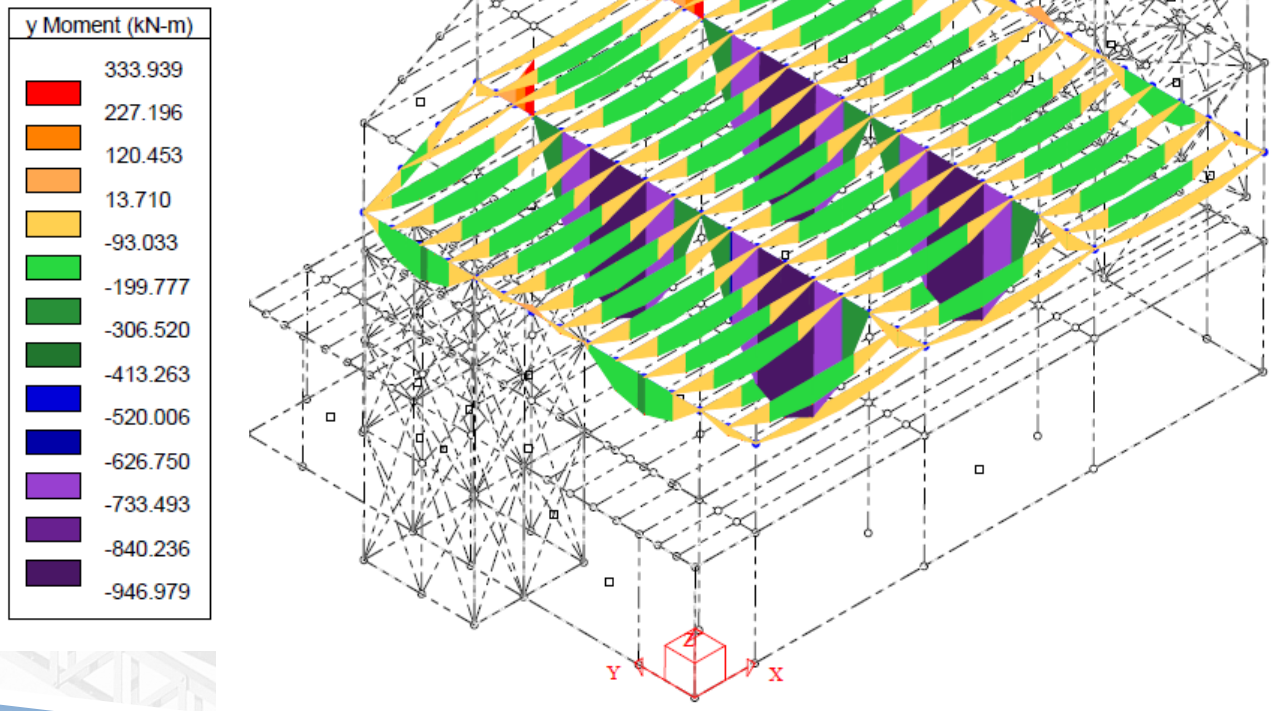
- **Modeling Procedure and Assumptions**
  - Area loads applied using panels and load transfer tool



# MODELING

STRATA SOLUTIONS

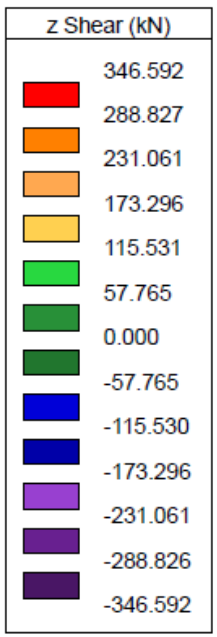
- **Modeling Results**
  - Member Moments

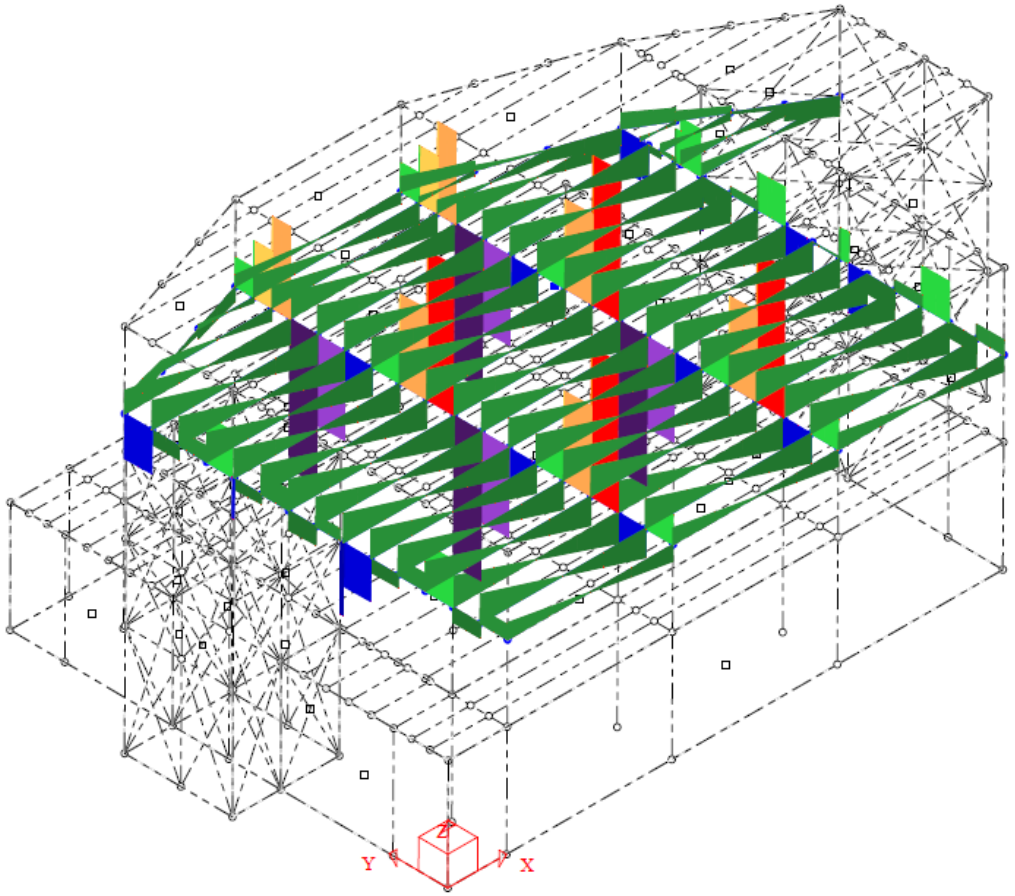


# MODELING

STRATA SOLUTIONS

- **Modeling Results**
  - Member Shear

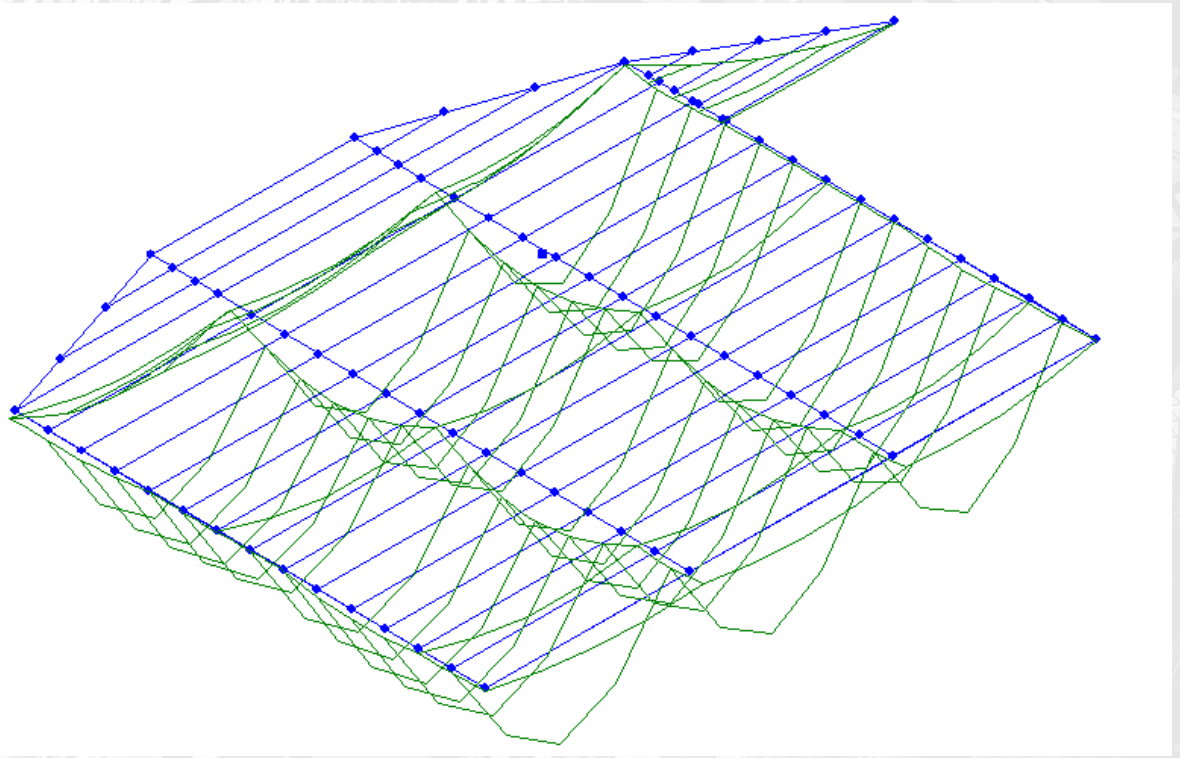


# MODELING

STRATA SOLUTIONS

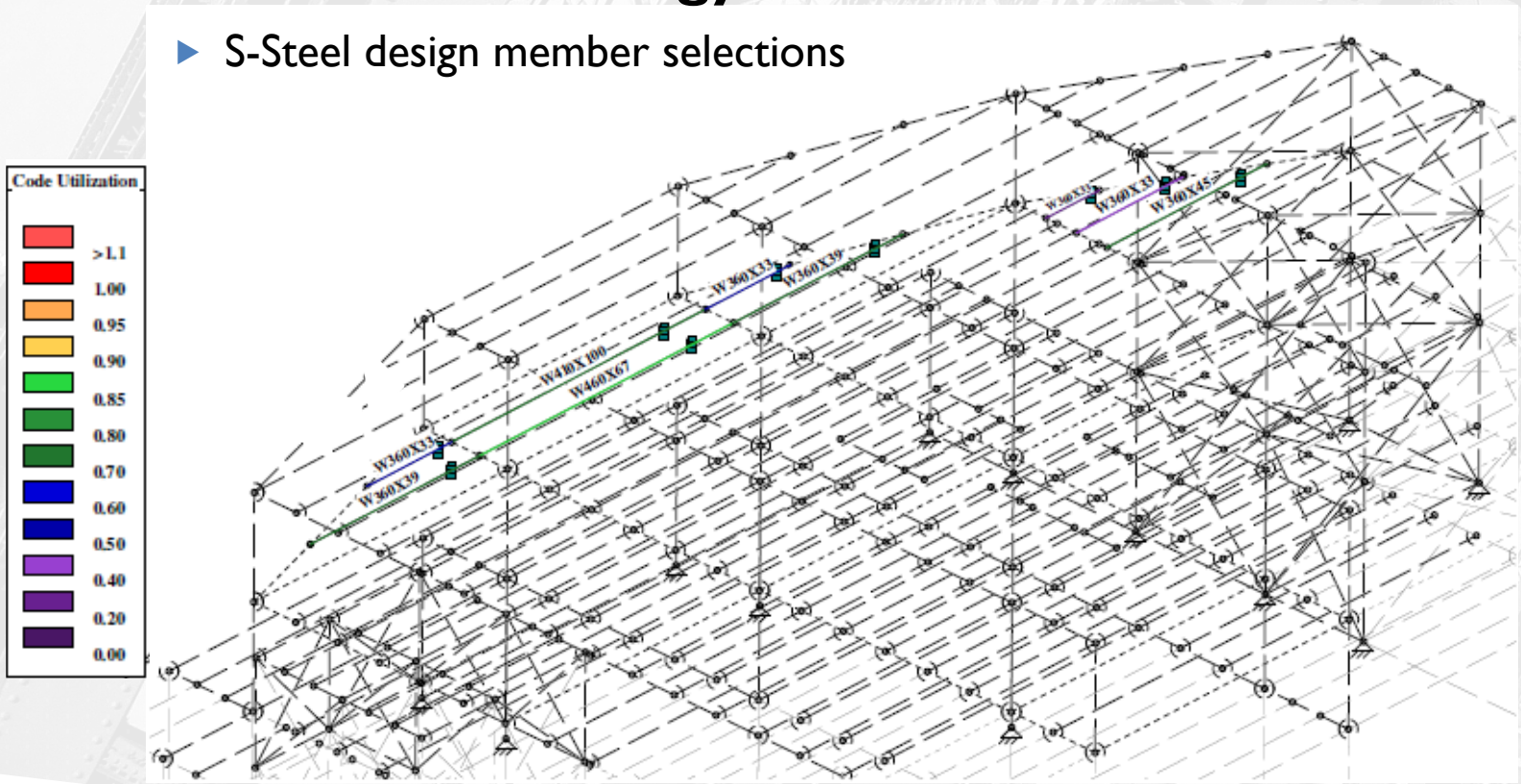
- **Modeling Results**
  - Member Deflection



# BEAM & COLUMN DESIGN

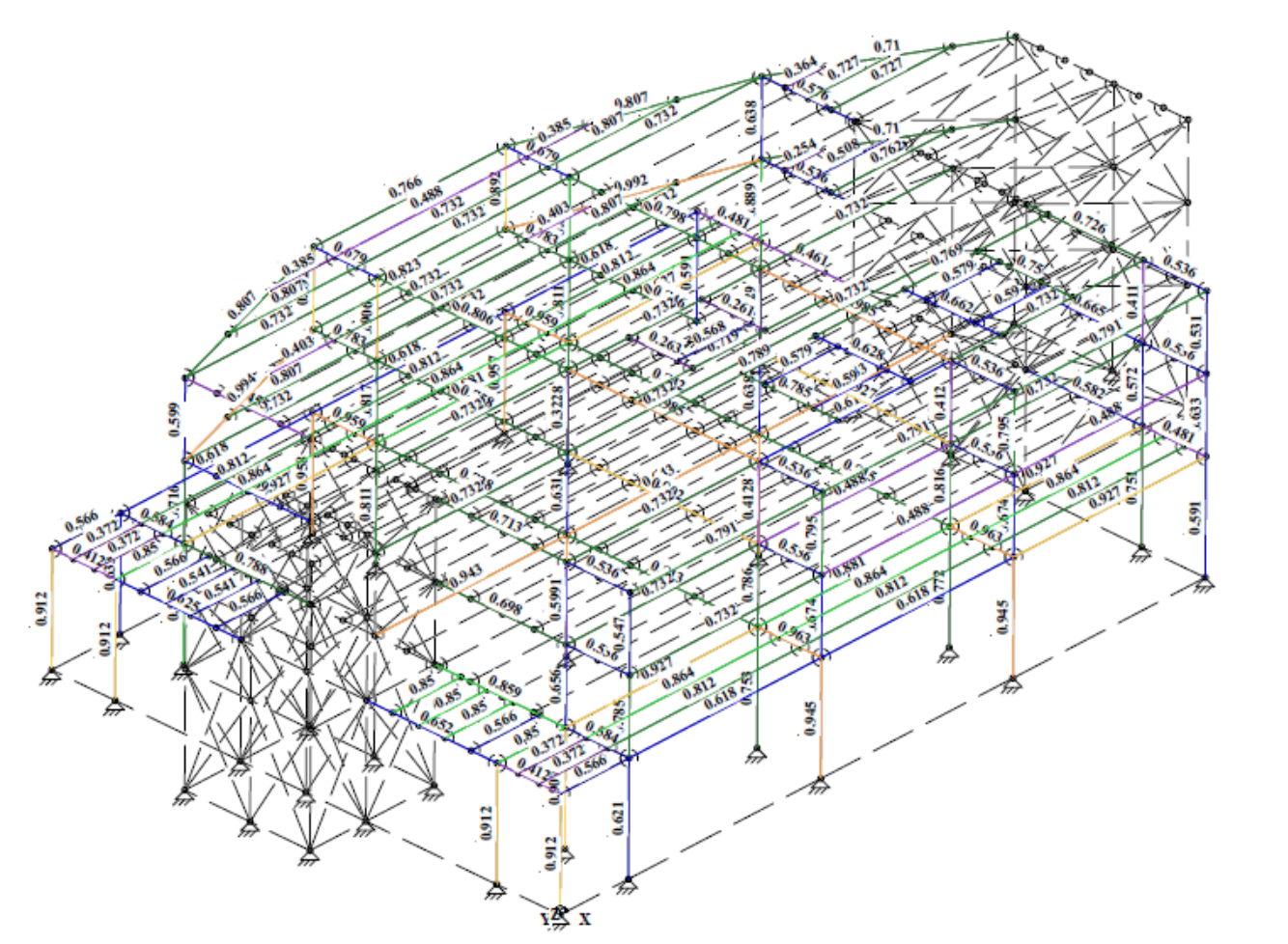
STRATA SOLUTIONS

- **S-Steel Methodology**
  - S-Steel design member selections



# BEAM & COLUMN DESIGN

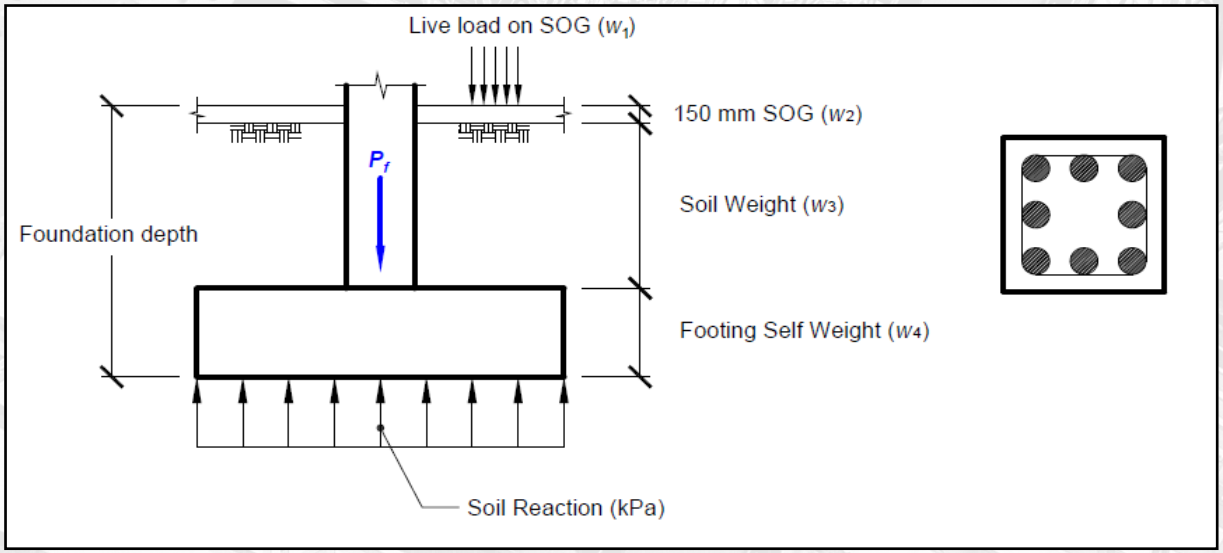
- **Results: Full Structural Member Utilizations**



# FOUNDATION DESIGN

STRATA SOLUTIONS

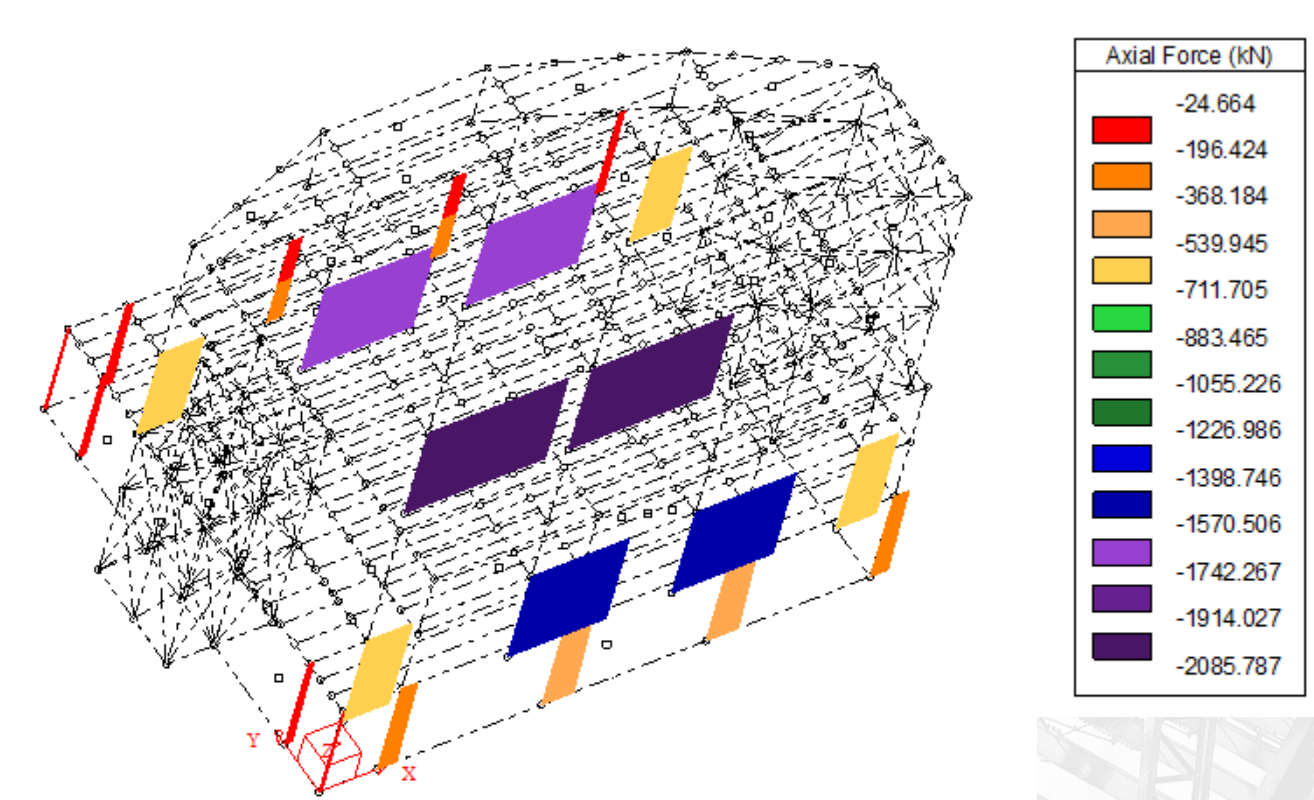
- **Design followed procedures from Dr. Amgad Hussein's Concrete Lecture Notes**
  - Interior and exterior spread footings
  - Exterior wall footings
  - Shear core wall footings



# FOUNDATION DESIGN

STRATA SOLUTIONS

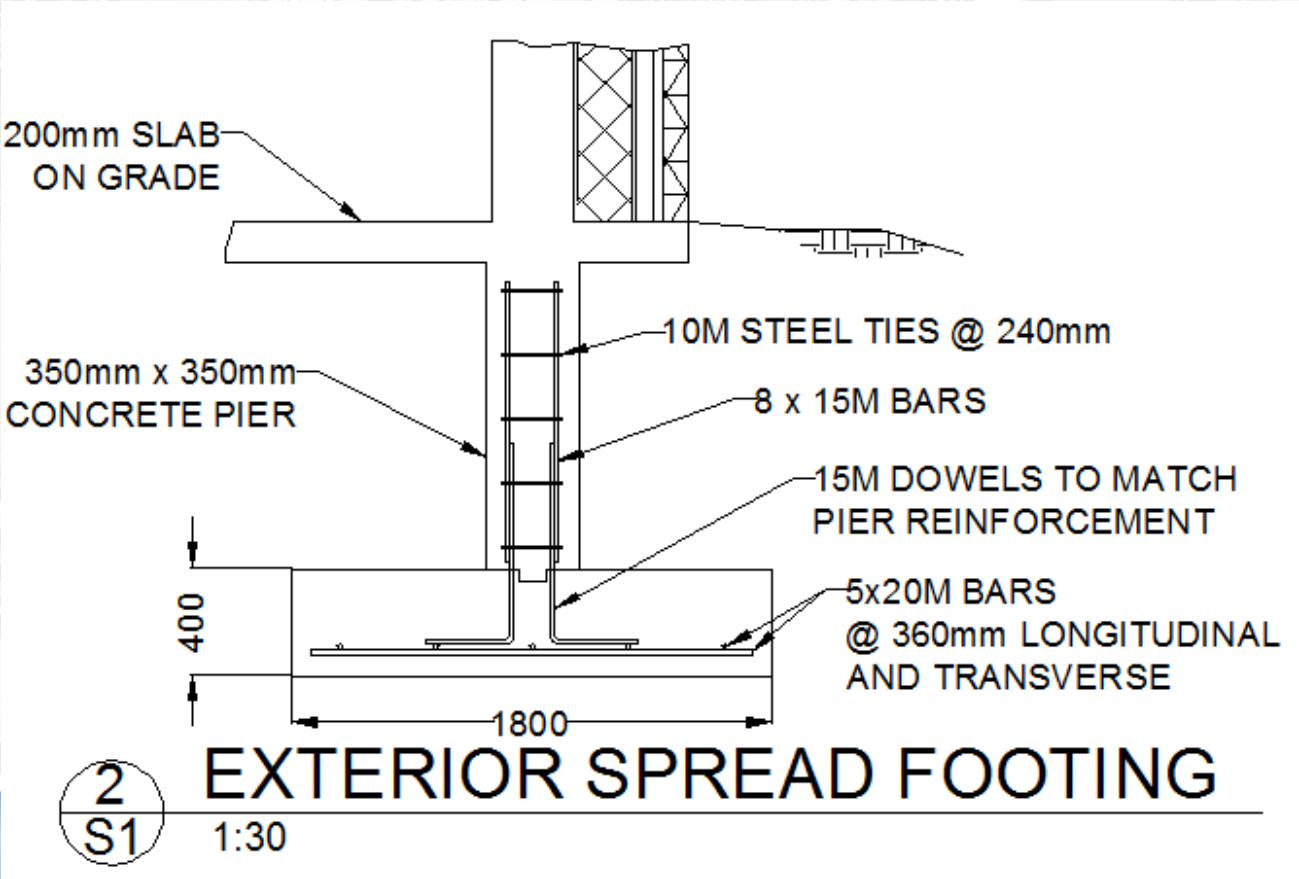
- Loads Transferred through Columns to Foundations



# FOUNDATION DESIGN

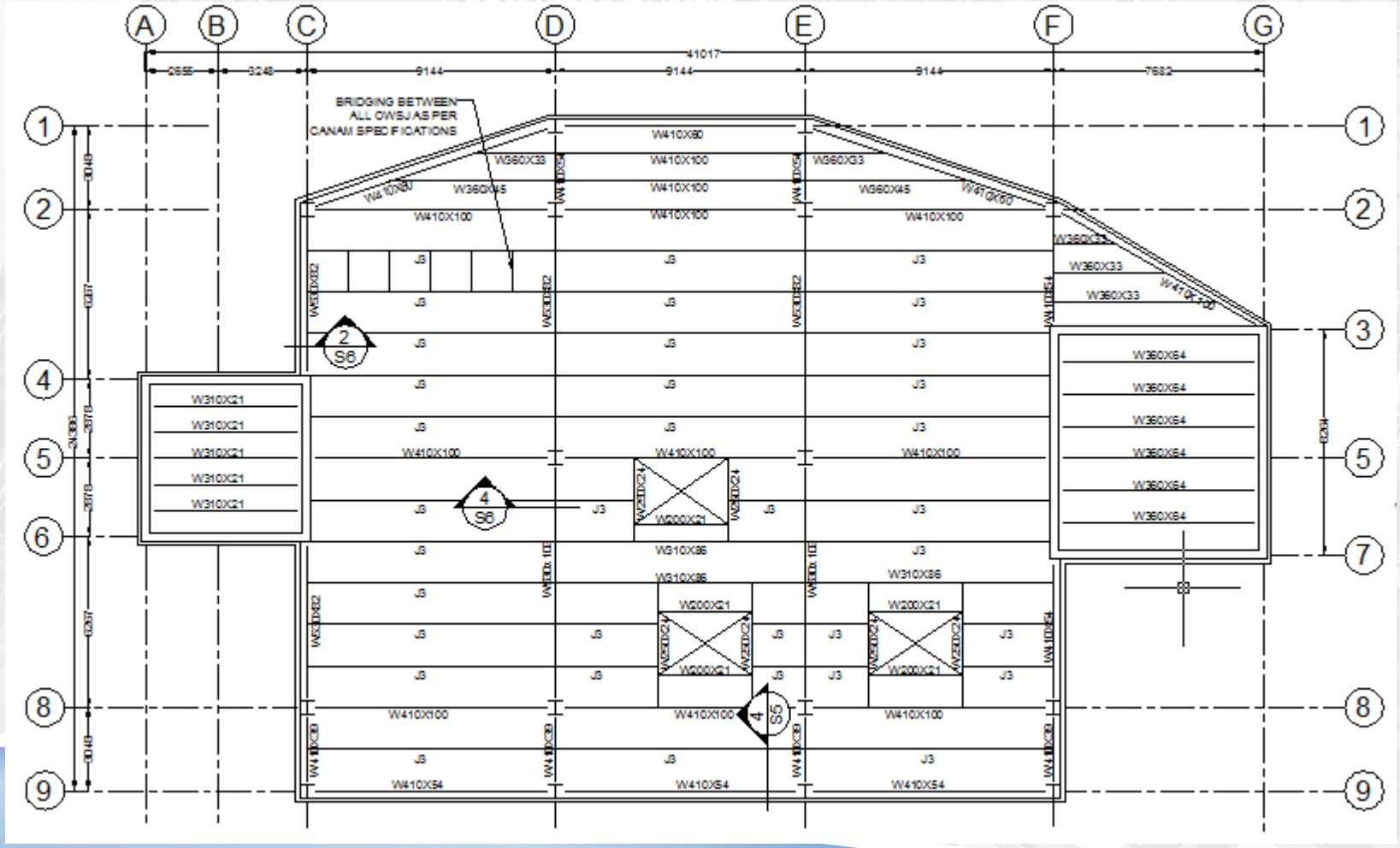
STRATA SOLUTIONS

- Worst loading case governed for design for similar foundations



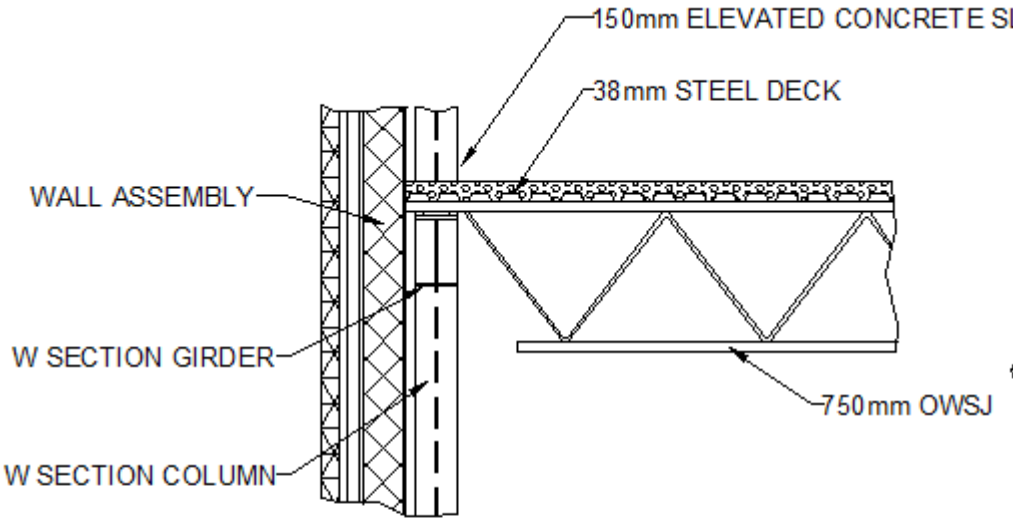
# DRAFTING

STRATA SOLUTIONS



# DRAFTING

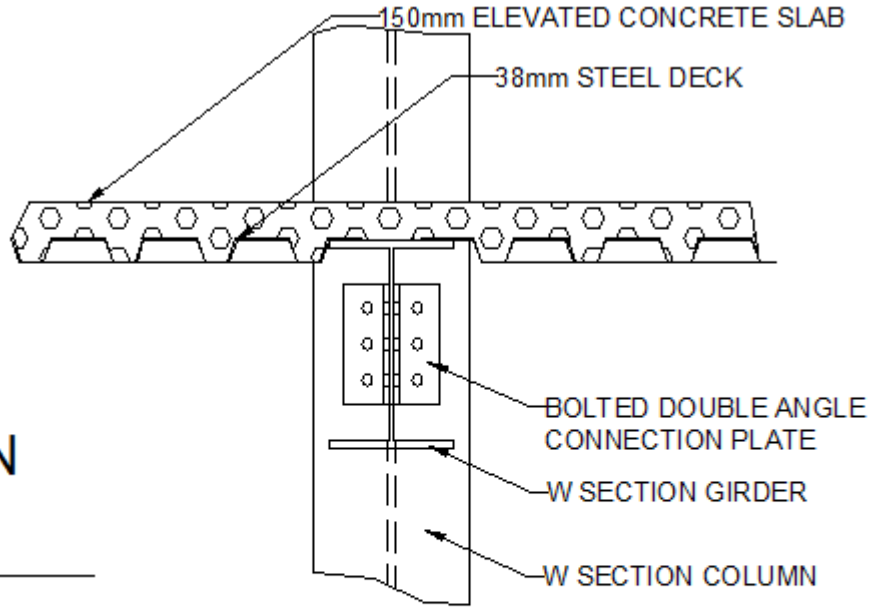
STRATA SOLUTIONS




THIRD FLOOR JOIST CONNECTION
DETAIL - JOIST TO WALL

2
S5

1:30




TYPICAL GIRDER TO COLUMN
CONNECTION

3
S5

1:10

# COST ESTIMATION

STRATA SOLUTIONS

| Concrete | Quantity | Unit | Total Cost | Total Cost Incl. O&P |
|---|---|---|---|---|
| Concrete | 762 | m3 | $180,088 | $198,496 |
| Edge Forms and Blockouts | 252 | m | $2,395 | $3,462 |
| Formwork, Walls | 1,764 | m2 | $172,008 | $241,292 |
| Formwork, Other | 635 | m2 | $42,203 | $54,923 |
| Concrete Finishing | 4,972 | m2 | $66,577 | $97,929 |
| Rebar, Welded Wire Mesh | 2,995 | m2 | $23,960 | $29,770 |
| Rebar | 31 | Met. Ton | $2,782 | $3,082 |
| | | | **$490,012** | **$628,954** |

| Earthworks | Quantity | Unit | Total Cost | Total Cost Incl. O&P |
|---|---|---|---|---|
| Excavation | 1,977 | m3 | $4,547 | $5,733 |
| Backfill | 1,689 | m3 | $2,077 | $2,686 |
| Compaction | 1,689 | m3 | $456 | $608 |
| Backfill - Structural Fill | 837 | m2 | $4,746 | $5,909 |
| | | | **$11,826** | **$14,936** |

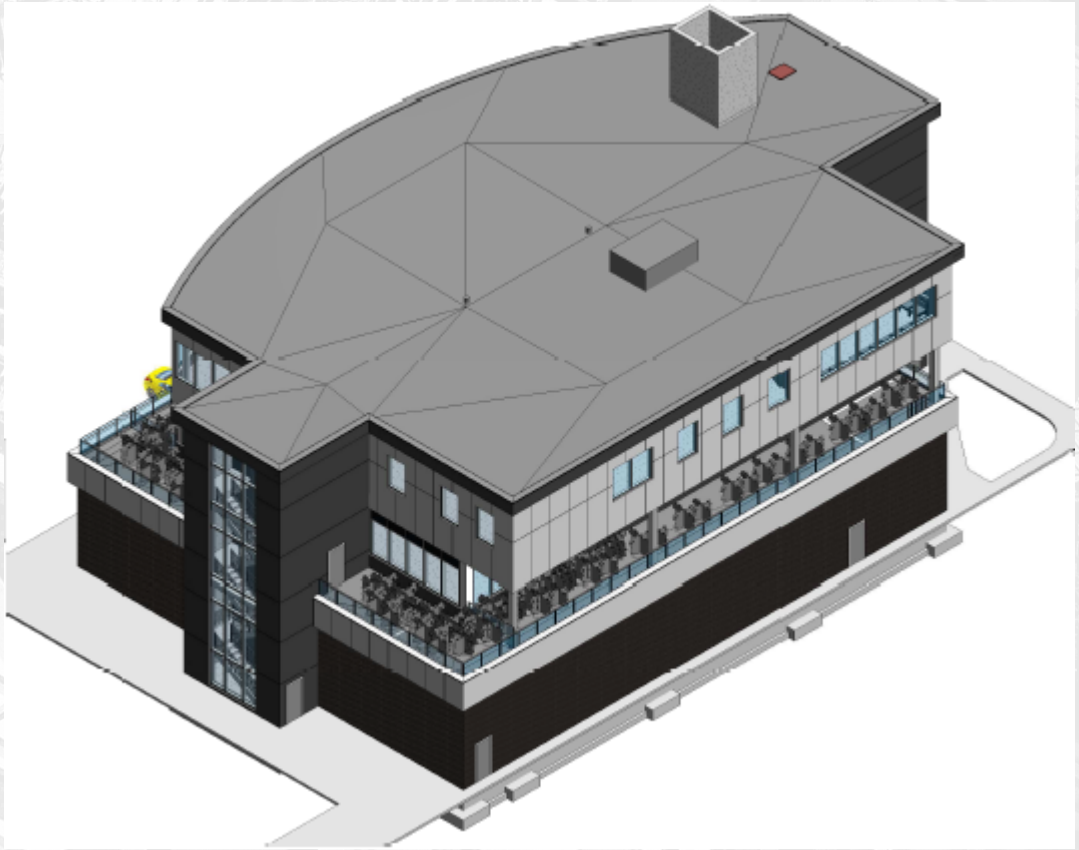
| Steel | Quantity | Unit | Total Cost | Total Cost Incl. O&P |
|---|---|---|---|---|
| Structural Steel | 113 | Met. Ton | $508,726 | $590,991 |
| Decking | 1,321 | m2 | $54,742 | $63,276 |
| Open-Web Steel Joists | 18 | Met. Ton | $57,698 | $66,843 |
| | | | **$621,166** | **$721,110** |

| **Total Cost** | **$1,123,005** | **$1,365,000** |
|---|---|---|

# CONCLUDING REMARKS

STRATA SOLUTIONS

- The team collectively spent _____ hours completing the required deliverables
- Unfamiliarity with some of the tasks resulted in some back loading of work
- The team learned that planning and organization is the key to successful project



# THANK YOU FOR YOUR TIME

**We will now answer any questions**

STRATA SOLUTIONS

MORRISON HERSHFIELD