University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

East Mall Redesign Between Agronomy Road and West 16th Avenue

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CIVL 446: CIVIL ENGINEERING DESIGN PROJECT II

East Mall Redesign Between Agronomy Road and West 16th Avenue

FINAL DESIGN REPORT

University of British Columbia - UBC SEEDS
(Social Ecological Economic Development Studies) Sustainability Program.

16 April 2021

EXECUTIVE SUMMARY

As requested by UBC SEEDS (Social Ecological Economic Development Studies), Urban Tech Consultants Ltd. is pleased to present the final detailed design for UBC's East Mall road layout between Agronomy and West 16th Ave. The design aims to promote sustainable transportation and safe use for all traffic modes, implement green infrastructure and efficient stormwater drainage systems, accommodate high drop-off and pick-up activities, and incorporate the future Stadium Neighborhood development to a most cost-effective solution.

The detailed design utilizes stop control intersections on Agronomy Road, Eagles Drive, Stadium Neighborhood intersections, and a roundabout on W 16th Avenue. Thunderbird Boulevard intersection will remain as an actuated signalized intersection but with efficient reconfigured sequencing and timing. The new roadway design consists of 2 travel lanes separated by a median boulevard with dedicated bike lanes and sidewalks separated by green space with a weather-protected shelter for a pedestrian crossing at Agronomy Road. Detailed plan and cross-sectional view of the roadway, construction specifications, traffic analysis data, schedule and cost estimations are included in the appendix.

The updated total life cycle project cost is **$4,297,674.43**, with **$1,874,074.43** allocated for the initial consulting and construction costs, **$2,503,500.00** for the operation and maintenance cost for 50 years, and **$79,990.00** project decommissioning salvage value. The project's expected start date and completion date are on **May 1, 2021, and September 30, 2021**, respectively. A Gantt chart consisting of time and duration for both project construction and completion tasks is also provided.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. PROJECT OVERVIEW

1.1 Project Site

The project site is located on East Mall between Agronomy Road and West 16th Avenue at the UBC Vancouver Point Grey campus (Figure 1). East Mall is surrounded by UBC institutional buildings, sports fields and building facilities, low-rise residential buildings, offices, utility buildings, and undeveloped green spaces. East Mall runs north-south and is primarily separated by a median boulevard with a single travel lane for each direction, bike lanes, sidewalks, curbside parking stalls, and green spaces between West 16th Avenue and Thunderbird Boulevard. At the Agronomy Road intersection, the road narrows down into single travel lanes and with shared vehicle and bike lanes with no median boulevard. There are 2 bus stops located at the intersection of Eagles Drive that provide service for the local #68 community bus and a signalized intersection at Thunderbird Boulevard (Figure 2).

Figure 1: Project Design Area Within UBC Campus. (Source: google.com/maps)

Figure 2: Thunderbird Boulevard Intersection, Looking South.
(Source: https://dailyhive.com/vancouver/ubc-skytrain-route-options)

The existing road network is currently experiencing high traffic and pedestrian volumes during peak hours and an over-demand of curb uses for pick-up and drop-off field activities. With further development from the proposed Stadium Neighbourhood, the existing road network will exceed its capacity and result in overwhelming traffic delays. Vehicle speeding is also an issue at East Mall which poses a serious road safety issue to pedestrians, cyclists, and other road users. Finally, the existing stormwater sewer may also be inadequate to manage increased rainfall volume as a result of climate change and a more sustainable rainwater management is required for environmental protection.

1.2 Project Objectives

UBC SEEDS have outlined several key project objectives required for the East Mall redesign. Our team designed and optimized each implementation to include each objective and meet UBC Sustainable Transportation requirements. The following table summarizes each objective according to the design criteria.

Safety	Improve public safety by decreasing the potential conflicts between pedestrians, cyclists, and motor vehicles, and provide weather protection facilities for pedestrians along Agronomy Road.
Social	Ensure social equity through the entire design process. Provide a pedestrian weather protection system across East Mall at Agronomy Road. Tie-in future Stadium Neighborhood changes.
Efficiency	Implement an efficient transportation system, including pick-up/ drop-off needs.
Environmental	Increase green space and incorporate green infrastructure to retain rainwater.
Economical	Provide resilient design for future changes and minimize costs for all roadway users.

Table 1: Project Objectives Sorted by Criteria.

1.3 Summary of Team Member Contribution

2. PROJECT CRITERIA

2.1 Design Issues

Road Safety

Road safety for pedestrians and cyclists was identified as the most important issue to be addressed in the new roadway design. Excessive speeding between Thunderbird Blvd and Stadium Rd has resulted in unsafe conditions for crossing pedestrians and cyclists. To increase road safety, all risks associated with all travel modes should be minimized or eliminated. The level of safety is increased in this design by increasing the separation distance between users of different modes, the use of buffer zones between vehicles and cyclists, and installing a new warning system to alert oncoming traffic at the pedestrian crossing.

Level of Service

To accommodate existing and future traffic demands, the Level of Service (LOS) of the existing roadway needs to be improved. LOS can be improved by implementing efficient infrastructure and reducing congestions. During peak hours, the intersection at Agronomy Rd & East Mall experiences high pedestrian and vehicle volumes. Pedestrians may be required to wait for a long time before crossing the roadway, exposing them to the weather elements. Hence, an overhead weather protection system for pedestrian crossing was developed for pedestrian comfort. The alternative option for an underground pedestrian tunnel was discarded due to the space constraint around the intersection.

Traffic Efficiency

Congestion at popular intersections in the university is primarily due to large numbers of crossing pedestrians, inappropriate signal/stopping design, and dense car flow. Better utilization of roadway space and signal systems needs to be designed to improve traffic efficiency through increased capacity, velocity, or diversion.

Environmental Impact

Throughout the entire design and construction process, the project will be deliberately delivered, abiding by the net-zero principle. The choice of material for construction accounts for not only the cost but also the CO2 emission. The carbon footprint of the possible design options is incorporated into the Weighted Decision Matrix. It is accordingly assigned a considerable heavyweight, imposing a significant impact on the final choice of design.

Neighbourhood Disturbance

As construction takes place, noises and delays of traffic are inevitable. Proper stakeholder engagement processes should be conducted with the local communities and transportation municipalities. Notices should be provided in advance. The rerouting of transit should also be considered in the design process.

2.2 Design Criteria

The criteria listed below are both succinct summaries and additions made to the above issues. Some of the criteria are not listed as primary design issues due to the order of priority.

- Choice of material and the ease of construction
- Structural performance and stability
- Cost of construction
- Ease of maintenance
- Effectiveness of shelter under severe weather
- Reduction of congestion
- Increase of both perceived and unperceived safety
- Result of feedback from roadway users

2.3 Technical Considerations

Structural Performance of the Installed Shelter at Agronomy Rd. & East Mall

The canopy function at the intersection is to provide pedestrians with cover from rain and snow. The most critical section of the structure is at the vertical wooden member. Considering dead load, live load, and primarily wind load and snow load, the vertical members need to resist the derived demand and achieve a factor of safety of at least 1.1, considering its importance category. A detailed calculation will be provided in this report.

Traffic Efficiency of the Updated Signalized Intersection at Thunderbird Blvd.

The signal light system at Thunderbird Blvd & East Mall is optimized through software modeling. The new signal light system should decrease vehicles' delay time on Agronomy Rd, Thunder Blvd, and Eagles Drive. Though the model's result is positive, the effectiveness of this new signal light system is yet to be tested in real life. Adjustment should be made if the reduction in delay does not meet the anticipation.

Effectiveness of the Central Island

A central island is installed at the Eagles Dr. & East Mall intersection to minimize stoppage or slow-down due to left-turning vehicles. Observations should be made after the installation of the island to measure the average car flow speed so that the central island's effectiveness can be tested.

Construction Permit

Considering the nature of land ownership, construction permits should be acquired before the ordering of material. The list of permits required can be found in the cost estimation appendix.

2.4 Standards & Software Packages Used

Urban Tech Consultants Ltd. has conducted the detailed design throughout the design process by following several standards and software packages listed below.

- *Transportation Association of Canada (TCA)*

  Associate with technical issues related to road and urban transportation for detailed geometric design since TAC brings together governments, private companies, academic institutions, and other organizations in Canada.

- *American Association of State Highway and Transportation Officials (AASHTO)*

  Follow up specifications and guidelines related to public transportation design and construction in AASHTO for the street geometric design.

- *City of Vancouver Engineering Design Manual*

  Follow the manual guide for detailed municipal infrastructure design and pavement design while ensuring safety and accessibility.

- *BC Building Code*

  Table C-2 in BC Building Code provides the climate design data for selected locations (Vancouver City Hall) in British Columbia, which is for the canopy load demand calculations.

- *National Building Code of Canada 2015 (NBC2015)*

  NBC2015 illustrates the equations of the roof snow load and wind load as the canopy analytical demands.

- *CSA O86:19 Engineering Design in Wood (National Standard of Canada)*

  Generate the canopy structural compression capacity following the CSA standards.

- *Traffic Analysis Software Synchro*

  Use Synchro to determine and analyze East Mall's capacity requirement with future traffic volumes and determine the appropriate intersection control type and lane configurations at the Thunderbird and Agronomy Road intersections.

- *AutoCAD*

  Use AutoCAD to generate engineering drawings of the road design for complex components and the layouts of overview plan, intersections, and cross-sections.

- *Microsoft Office*

  Use Excel for the Weighted Decision Matrix and Word for report generation.

3. DESIGN LAYOUT

According to the Canadian Highway Manual and BC Active Transportation Design Guide, the width of sidewalk, bike lane, travel lane are determined to be 1.8m, 1.5m, and 3.5m, respectively. On both sides of the road, storm sewers are buried 2m down, under green spaces. The size of the storm sewer pipe is 200mm in diameter. The road pavements are layered systems with 140mm thick asphalt at the top, 150mm thick granular base in the middle, and 300mm thick granular sub-base in the lower layer. For the sidewalk, 100mm thick concrete is selected instead of 140mm thick asphalt. In addition, the cross-slope of the paved roads are 2%. The detailed design drawings are shown in the Appendix G.

3.1 Overview Layout

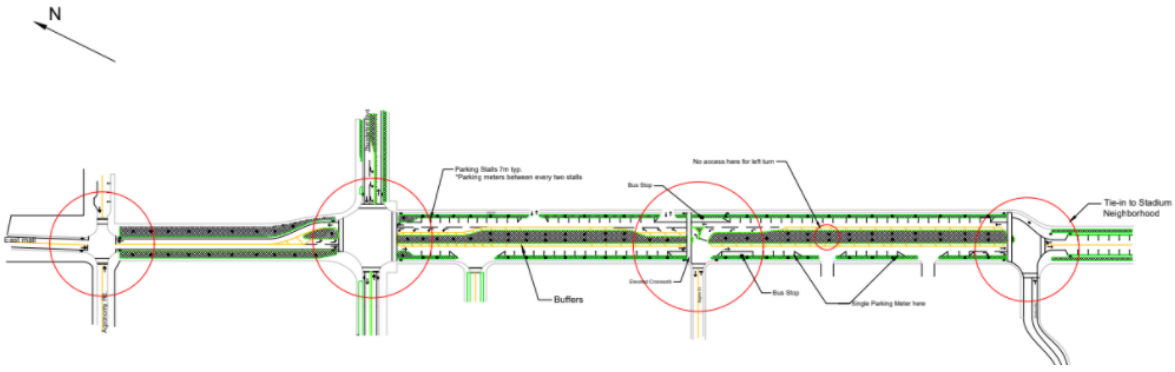


Figure 3: Overall Project Design Plan View.

Figure 3 displays the overall plan view of the design project. The intersections studied in Synchro Analysis and detailed in the drawings are circled in red. An enlarged version of the plan views for each intersection are included in the appendix.

3.2 Agronomy Road Intersection

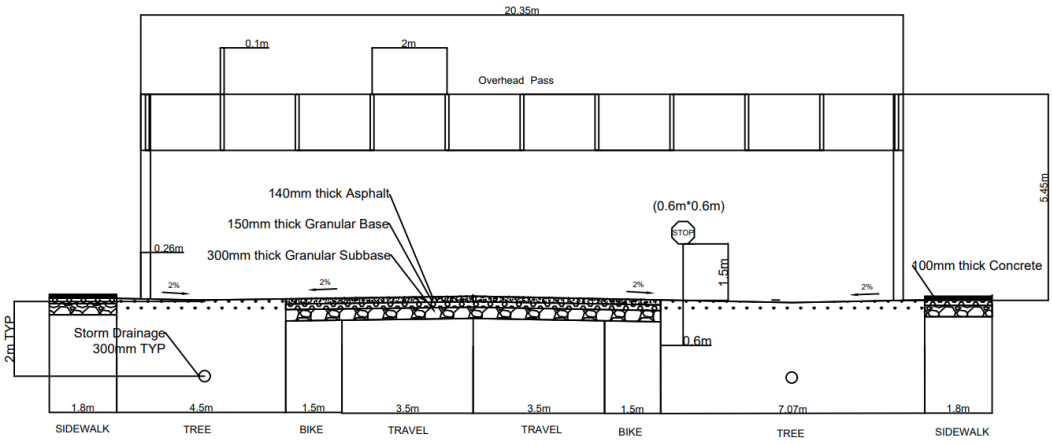


Figure 4: Cross-sectional View for Agronomy Road Intersection (Looking North, Southern Part of The Intersection).

- Agronomy Road intersection is controlled by stop signs.
- The pedestrian overhead weather protection is installed.
- The bike lanes are added

3.3 Agronomy Road - Thunderbird Boulevard Roadway

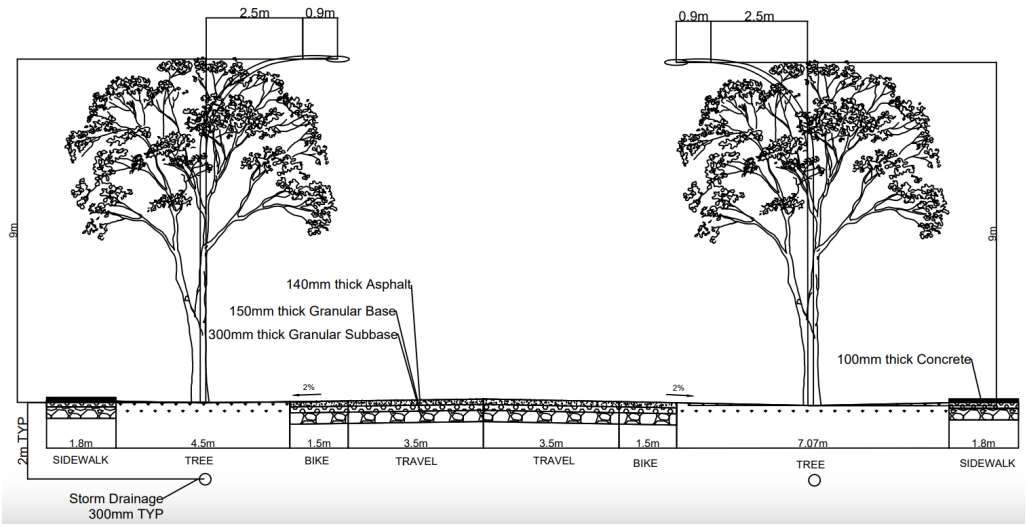


Figure 5: General Profile Between Agronomy Rd to Thunderbird Blvd (Looking North).

- Sidewalk is separated from bike lanes by green spaces

3.4 Thunderbird Boulevard Intersection

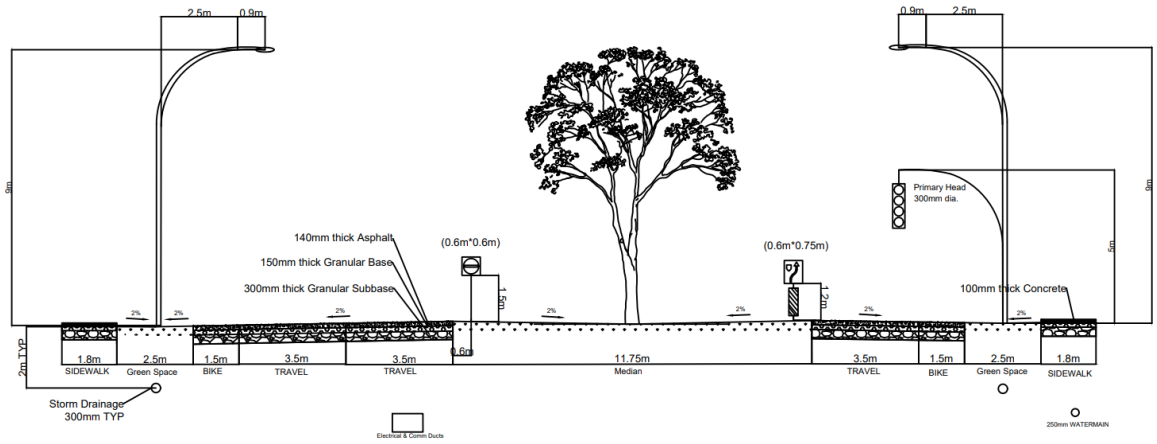


Figure 6: Cross-section View at Thunderbird Blvd (Looking North, Northern part of the intersection).

- Electrical & communication ducts and 250mm waternain are buried underground.
- The intersection is regulated by traffic signals.
- Left-turn lane is added to southbound traffic.

3.5 Thunderbird Boulevard - Eagles Drive Roadway

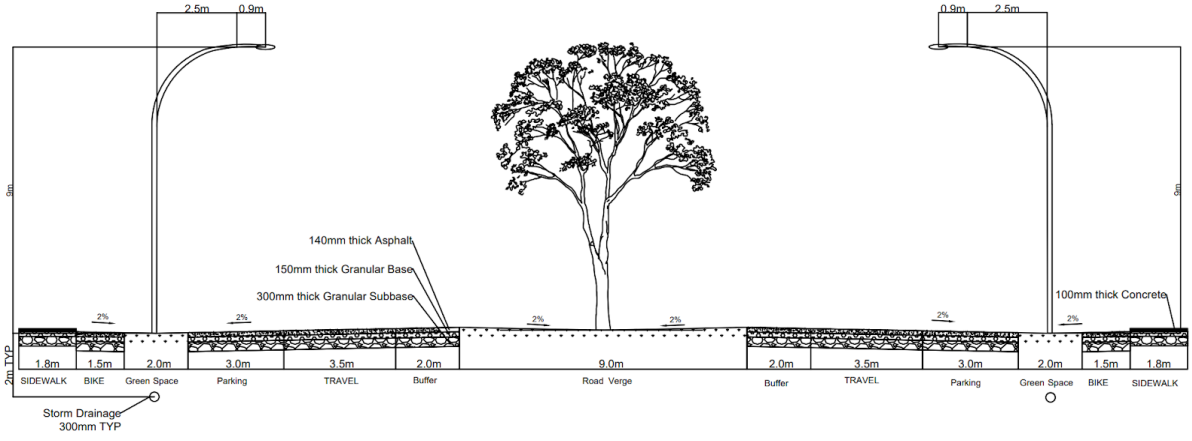


Figure 7: General Profile Between Thunderbird Blvd and Eagles Drive (Looking North).

- Bike lanes are separated from travel lanes by green spaces.

3.6 Eagles Drive Intersection

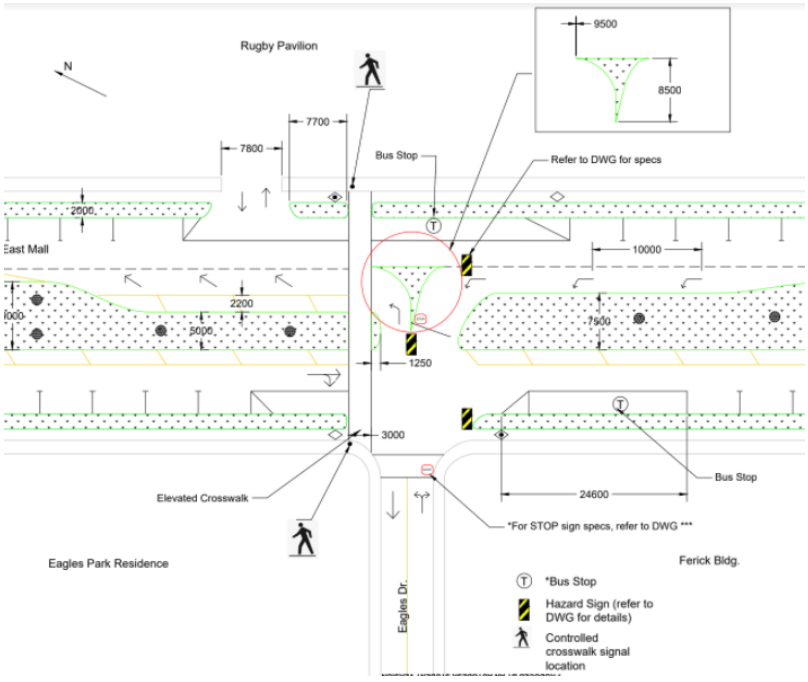


Figure 8: Plan View of Eagles Drive Intersection.

- The intersection is regulated by stop signs with additional road median divider to assist left-turn traffic

3.7 Eagles Drive - Stadium Road Roadway

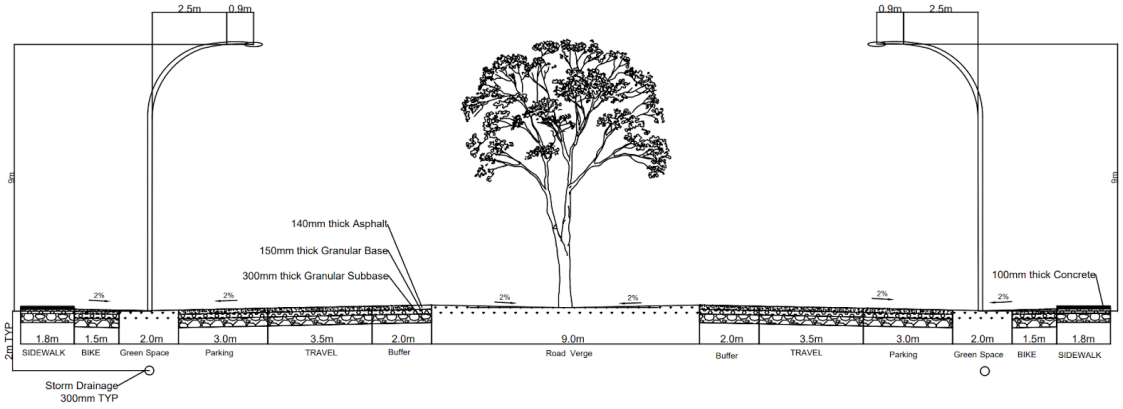


Figure 9: General Profile Between Eagles Drive and Stadium Road (Looking North).

- Metered parking is installed along the west side.
- 15-min pickup/dropoff parking is added on the east side.

3.8 Stadium Road Intersection

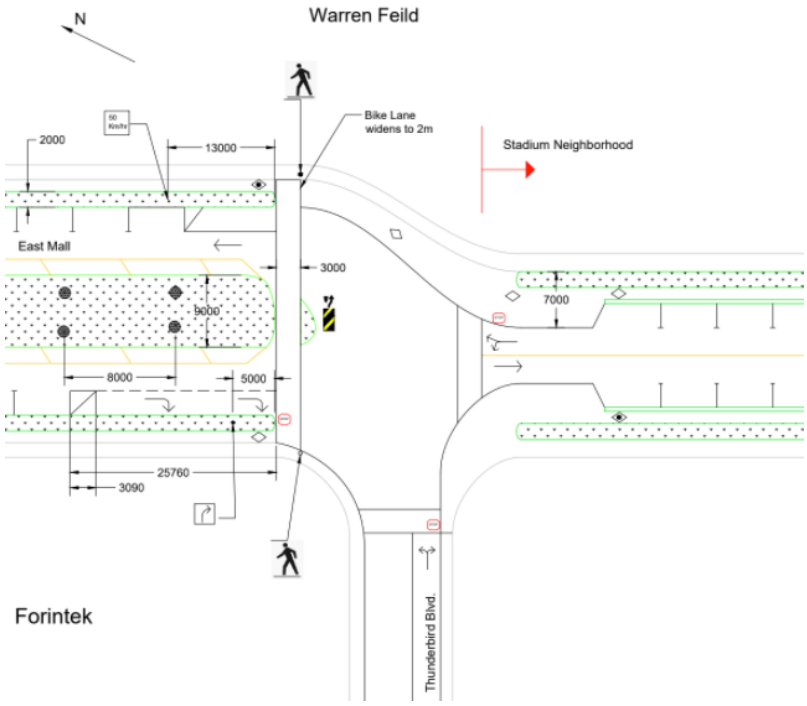


Figure 10: Plan View of Stadium Road Intersection.

- This intersection is stop-controlled with a pedestrian crossing. This intersection ties into the Stadium Neighbourhood development plan.

3.9 Stadium Road - West 16th Avenue Roadway

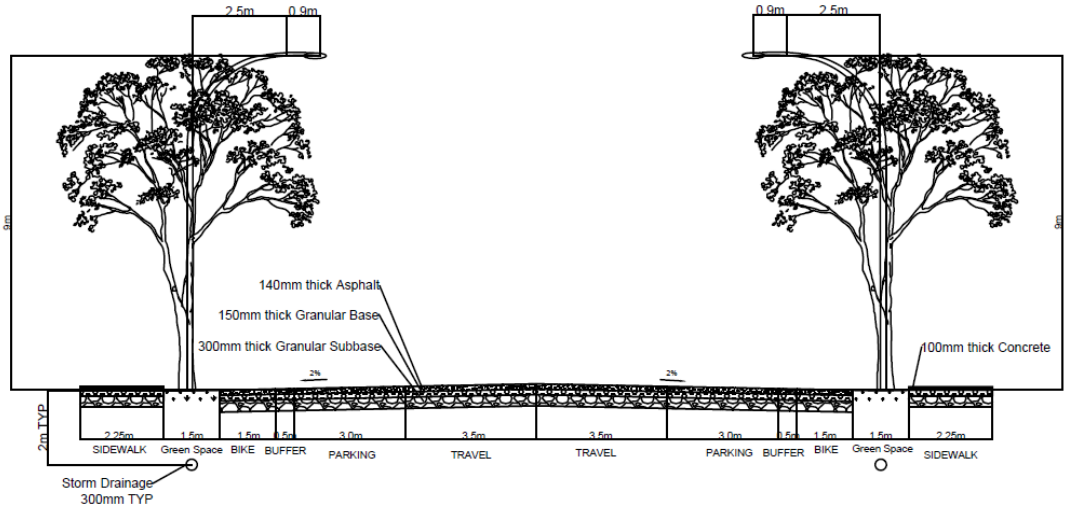


Figure 11: General Profile between Stadium Rd and West 16th Ave (Looking North).

- Install metered parking along both west and east sides

- Bike lanes are separated from parking lanes by buffer

3.10 West 16th Avenue Intersection

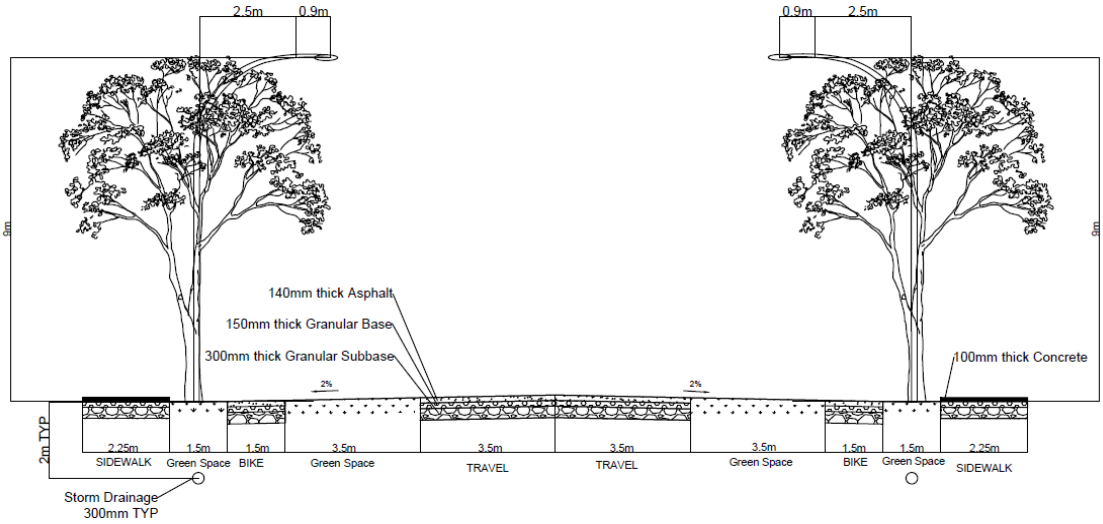


Figure 12: West 16th Ave Intersection (Looking North, Northern Part of The Intersection).

- One travel lane is used in each direction.
- Bike lanes are separated from travel lanes by green spaces.

3.11 Detailed Components

3.11.1 Signage Designs

The signage and traffic signal designs in this section follows the standard drawings of the City of Vancouver.

Regulatory Signs

Sign	Sign Code	Description	Dimension (W x H)	Location
	RA 1	Stop	600mm x 600mm	1. East Mall & Agronomy Rd Intersection 2. East Mall & Eagle's Dr. Intersection 2. East Mall & Stadium Rd Intersection
	RA 1-T2	4 Way Tab	450mm x 230mm	1. East Mall & Agronomy Rd Intersection 2. East Mall & Stadium Rd

				Intersection
	RB 91	Bike Lane (side mount)	600mm x 900mm	East Mall section between Agronomy Rd &Thunderbird Blvd.
	RB 1-2	Maximum Speed Sign 30 Km/h	600mm x 750mm	East Mall section between Agronomy Rd & Eagle's Dr.
	RA 4R/4L	Pedestrian Crosswalk	600mm x 750mm	1. East Mall section between Agronomy Rd &Thunderbird Blvd 2. East Mall & Eagle's Dr. Intersection 3. East Mall & Stadium Rd Intersection 4. East Mall & W 16th Ave Intersection
	RB 25	Keep Right	600mm x 750mm	East Mall & Thunderbird Blvd. Intersection
	RB 23	Entry Prohibited	600mm x 600mm	East Mall & Thunderbird Blvd. Intersection
	RB 58	Bus zone	300mm x 450mm	East Mall between Eagle's Dr. and Stadium Rd.
	RA 7	Roundabout Yield	750mm Sides	East Mall & W 16th Ave Intersection

	RB 53	Parking Sign	300mm x 450mm	1. East Mall between Thunderbird Blvd. and Eagle's Dr. 2. East Mall between Eagle's Dr. and Stadium Rd.

Table 3: Regulatory Signs.

Warning Signs

Sign	Sign Code	Description	Dimension (W x H)	Location
	WC 20	Shared Use Lane Single File Sign	750mm x 750mm	East Mall & Agronomy Rd Intersection
	WC 19S	Share The Road Tab	600mm x 300mm	East Mall & Agronomy Rd Intersection
	WA 36L	Object Marker to mark object on left side of road	300mm x 900mm	East Mall & Thunderbird Blvd. Intersection
	WA 37	Roundabout Ahead	900mm x 900mm	East Mall between Stadium Road & 16th Ave
	WA 7S	Advisory Speed Tab 30 km/h	450mm x 450mm	East Mall between Stadium Road & 16th Ave
	WA 38	Roundabout Directional	1660mm x 600mm	East Mall & W 16th Ave Intersection

Table 4: Warning Signs.

Temporary Construction Signs

Sign	Sign Code	Description	Dimension (W x H)
	TC 1	Construction Ahead	750mm x 750mm
	TC 5R/5L	Temporary Lane Closed Ahead	750mm x 750mm
	TC 68	Bicycle Lane Closed	750mm x 750mm
	TC 71	Bike Detour	450mm x 450mm

Table 5: Temporary Conditions Signs.

3.11.1 Traffic Signal Designs

Traffic Light Dimensions

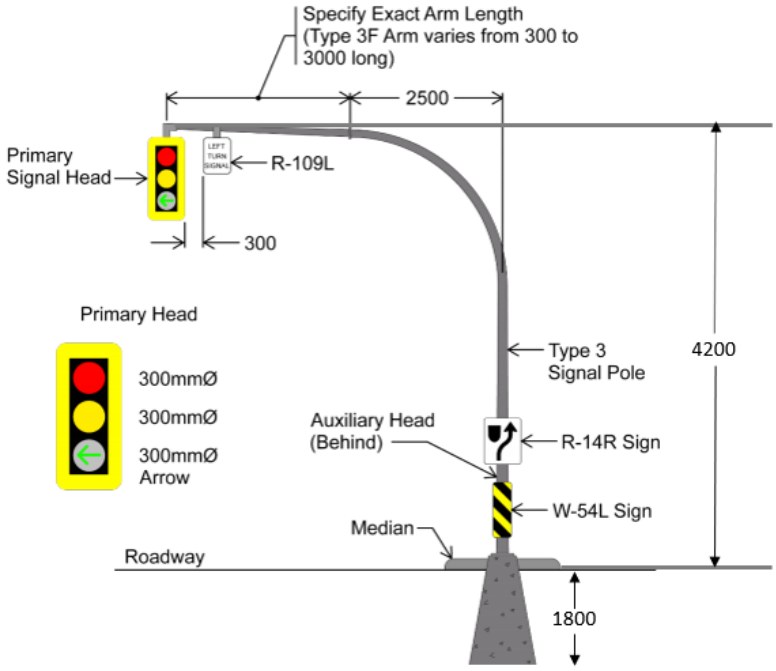


Figure 13: Traffic Light Dimensions.

Signal Pole Dimensions

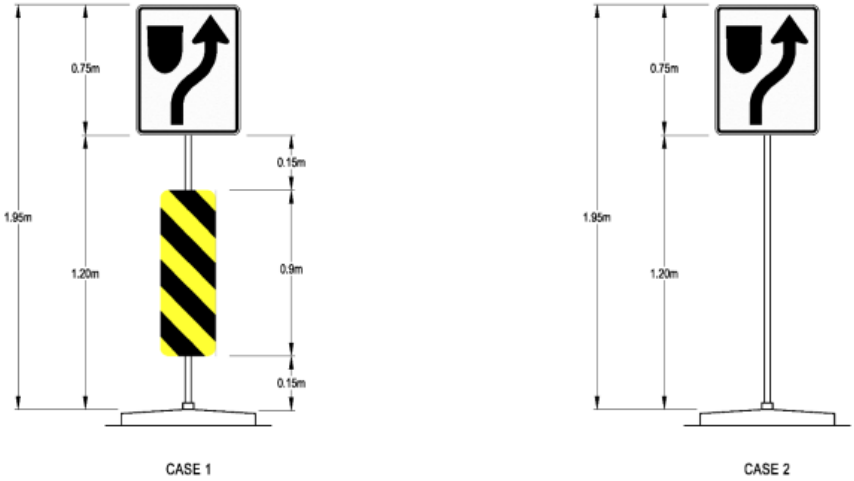


Figure 14: Signal Poles.

Marking Dimensions

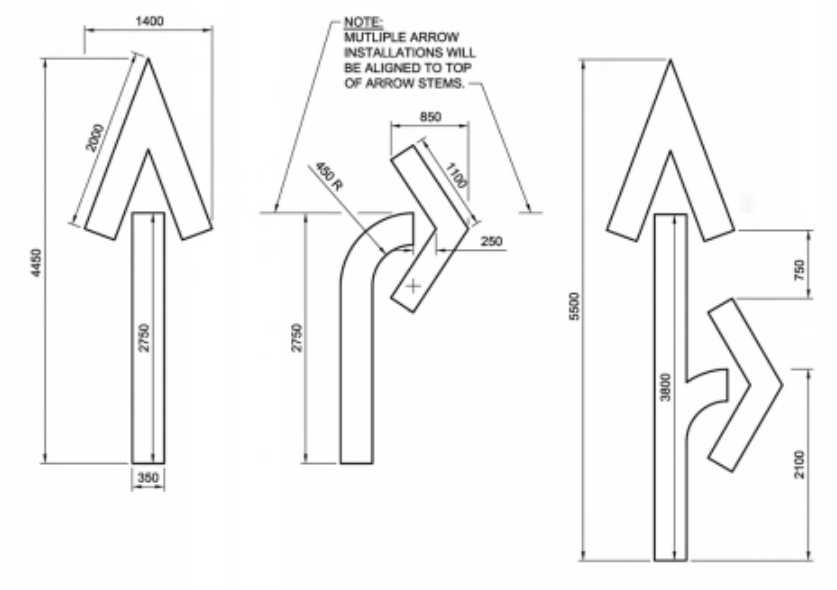


Figure 15: Lane Marking Dimension.

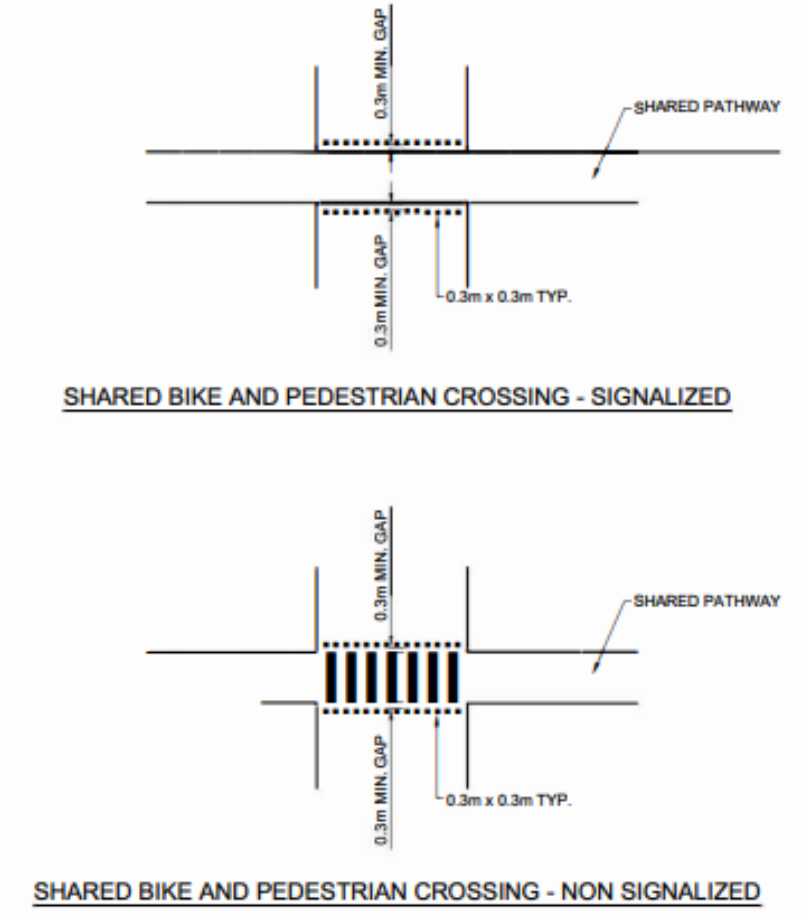


Figure 16: Crosswalk Marking Dimension.

3.11.3 Pavement Design

The roadway pavement design is shown in the figure below. Our design uses permeable concrete for asphalt pavement, which enables rainwater to infiltrate through the surface. Despite its relatively high maintenance cost, it is analyzed to be a more sustainable and environmentally friendly solution for the stormwater management plan. The depth of the pavement, granular base and granular subbase follows the pavement design standard in the City of Vancouver Engineering Design Manual (P264, Table 8-21).

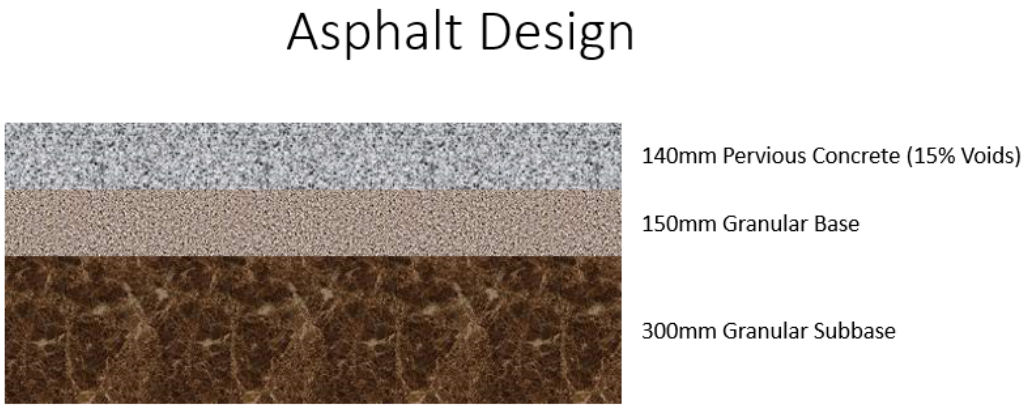


Figure 17: Pavement Design.

4. DESIGN ANALYSIS

4.1 Safety Analysis

4.1.1 Traffic Speeding

A strategic review of infrastructure design criteria and infrastructure changes at high-risk locations helps reduce the speeds. Implement traffic calming infrastructures such as the raised pedestrian crossings and installing additional stop signs along the East Mall at Eagles Drive and Stadium Road. Moreover, a radar speed sign slows cars down by making drivers aware of driving at speeds above the posted limits. The overall average traffic speeding is reduced from 30 km/hr to 20 km/hr based on Synchro analysis results. See details in Section 4.4.3.

4.1.2 Pedestrian & Cyclist Safety

During peak hours, the amount of pedestrians crossing the Agronomy Rd & East Mall is excessively high. As the intersection is situated right after some of the heavily used vehicle entries to the university, congestion is often observed. In bad weather, the pedestrian may usually neglect the incoming vehicle and cross the intersection without paying attention. This, along with the congested car flow and possibly already impatient drivers, poses a risk to pedestrians' safety. The installation of canopies at the intersection of Agronomy Road & East Mall primarily accounts for the user's comfort and potentially decreases the chance of pedestrians rushing through the crosswalk in bad weather, which, on the other hand, increases the overall level of safety at the intersection.

Bike lanes near Thunderbird Blvd & East Mall have been suffering from extreme proximity to vehicles due to the narrow roadways. The high risk of crashing between drivers and cyclists has always been a concern. The separation of space between the bike lane and the driveway must be increased to release the issue.

4.1.3 Canopy Structural Capacity

Structural capacity analysis is conducted to investigate the canopy performance to ensure pedestrians' safety from structural failure. The vertical wooden member primarily provides the structural resistance of the canopy. The load imposed on the canopy consists of dead load from glass and steel connection components, wind load, and snow load. The latter two are assigned based on BC building code, assuming a 1 in 50 events. Using a load combination of 1.25D + 1.5S + 0.4W, the most critical demand case yields a compression demand of 5.365 KN.

For the computation of the canopy resistance, course notes from CIVL439 and CSA-O86 design code are used. The wooden vertical member is designed to be a cylinder and is not among the common shape of posts. Therefore, the member is treated as square posts with a side length equal to the diameter. For the material, Douglas Fir Larch, Grade SS wood is chosen. Assuming a standard load duration, a system factor for Case 2, and dry-service condition, the member compression resistance parallel to the grain is calculated to be 522.69 KN. This capacity surpasses the demand by a significant amount and is within expectation, considering the extraordinary compression capacity parallel to the wood material grain. Detail hand-written calculations can be found in Appendix A.

4.2 Stormwater Analysis

4.2.1 Drainage System

Increased runoff from impervious surfaces causes dangerous floods, severe erosion damage to our stream channels, diminished recharge of groundwater, and degraded habitat for our fisheries. These same impervious surfaces can transport the many pollutants deposited in urban areas, such as nutrients, sediment, bacteria, pesticides, and chloride. In the worst cases, the amount of pollutants in urban runoff are high enough to prevent us from being able to swim or fish in our local waters (William Selbig). Taking this into consideration, our design uses permeable pavement for stormwater management, which challenges the

traditional sewer pipe storm water management method. The permeable asphalt let the storm water infiltrate through the ground, which promotes groundwater recharge while preventing the heating and conveyance of storm water into the storm drainage system. Soil infiltration also cleans up the contaminants brought by storm water from the road surfaces before discharging into the ocean, which is a more environmentally friendly solution. Another benefit of permeable pavement is the reduced need to apply road salt for deicing in the winter time. Researchers at the University of New Hampshire have observed that permeable asphalt only needs 0 to 25% of the salt routinely applied to normal asphalt (Houle and others, 2009).

4.2.2 Green Spaces

Along with permeable pavement, our design also incorporates a considerable amount of green space. The green spaces not only reduces heat conveyance in the city, but also contributes to the stormwater management plan, as there is no buffer between the green space and the pavements; therefore, if stormwater is not able to be all captured by the permeable pavement, it can flow freely into the green space for irrigation and groundwater recharge.

4.2.3 StormWater Management Design Analysis

Take the segment of East Mall between Agronomy Road and Sopron Ln for sample calculation, under the assumptions of:

- the volumetric reduction criteria is 72% of the 2-year, 24-hour rainfall, and from Surrey Design Criteria, Intensity Table, the amount of rainfall is 66.9mm
- the maximum distance water can travel in a swale is 1 city block before it is picked up by the minor drainage system
- the post-development infiltration rate of the soil is 1.5 mm/hour
- the post-development evaporation rate of the soil is 1.0 mm/day

- a typical house footprint, deck, and driveway occupies 65% of the lot (65% of the lot area is impervious)
- the paved roads have a width of 8 metres
- measured lot area at that segment = 5100 sq.m
- total pavement area = 500 sq.m
- total greenspace area = 281.3 sq.m
- Soil depth = 0.3m, Soil field capacity = 25%, Soil wilting point = 5%

Please refer to Appendix C for detailed calculation. The input and captured volume of our design using permeable pavement is shown in the Table 6 below. We can see that the total volume our system is able to catch iis larger than the input volume. Therefore, all the stormwater can infiltrate into the ground with this design without having to discharge the storm water through a sewer pipe system.

V input (cu.m)	V capture-capacity (cu.m)
160	249

Table 6: Stormwater Input & Captured.

4.3 Synchro Analysis

4.3.1 Modeling Assumptions

Synchro traffic simulation models provide valuable information on the performance and potential improvements of transportation systems. The models for both existing and new designs were established to simulate the East Mall traffic performance and surrounding impacts over the transportation network. Several assumptions were made during the modeling process:

- Assign the existing lane width to be 3.5m based on the measurements from Google Map.

- Input a 30 conflicting pedestrian/hour during Peak Period for Eagles Drive Intersection from the field study measurements.
- Total lost time for each approach at an intersection is 4s.
- Assume a 1% traffic growth rate throughout the project service life.
- Neglect traffic flows at Logan Lane, FP Innovation, UBC Tennis Centre junctions since they are minor intersections in the design area.

4.3.2 Modeling Process

Traffic networks can be easily created for modeling by adding street links. The following figures illustrate the segments of the designing transportation networks, both existing and new optimized, that have been modeled, including the main arterial and adjacent frontage roads. The white dot indicates a signalized intersection where the blue dots represent the unsignalized intersection, stop-controlled in this case. Network information such as lane data, traffic volumes, signal timings, peaking hour factors and channel types can be simply assigned with the toolbar icons.

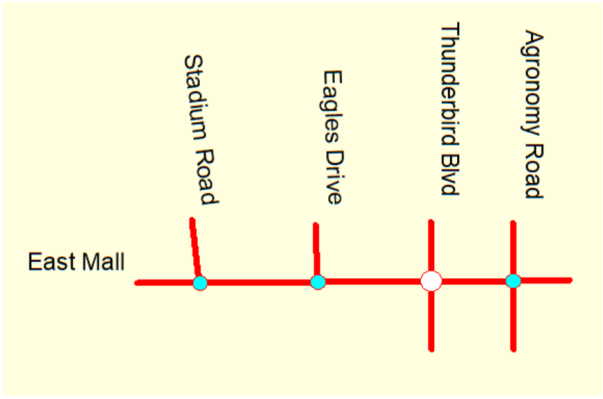


Figure 18: Synchro Model Network.

4.3.3 Traffic Performance

The simulation results provide the technical confirmation and validation of the final design as a feasible design that aligns with the project objectives. Table 7 below concludes the intersection traffic performance by approach for the detailed design.

Intersections	Delays			Average Speed (kph)
	Total Delay (hr)	Delay/Veh (s)	Stop Delay (hr)	
Agronomy Rd (Stop-controlled)	1.8	58.7	1.8	6
Thunderbird Blvd (Pretimed)	0.9	19.1	0.7	17
Eagles Drive (stop-controlled)	0.4	9.5	0.1	30
Stadium Rd (Stop-controlled)	0.6	14.8	0.4	22

Table 7: Detailed Design Traffic Performance by Approach.

The following table summarizes the design performance for existing and new optimized designs. A detailed Synchro report can be found in Appendix C.

Intersections		Agronomy Rd	Thunderbird Blvd	Eagles Drive	Stadium Rd	Total Network
Capacity-Volume %	Existing	38.2	69.7	44.9	64.8	-
	New Optimized	**38.2**	**59.6**	**44.9**	**54.3**	**-**
Total Delay (hr)	Existing	4.2	4.6	0.6	0.8	10.8
	New Optimized	**1.8**	**0.9**	**0.4**	**0.6**	**3.9**
Average Speed (kph)	Existing	11	19	40	37	27
	New Optimized	**6**	**17**	**30**	**22**	**19**
LOS Level	Existing	B	B	U	U	-
	New Optimized	**B**	**B**	**B**	**C**	**-**

Table 8: Comparison Between Existing and New Optimized Designs.

After all of the East Mall's modifications are in place, the delay time at all intersections has now been decreased. The Agronomy Road intersection suffered from high delay time due to heavy traffic flow and benefited the most from the modification, from 4.2 hours to 1.8 hours.

The reduction of the total delay at other intersections is relatively minor. All intersections exhibit a moderate decrease in vehicle speed. The capacity to volume percentage is decreased, resulting in improvements in LOS level at Eagles Drive and Stadium Road.

Thunderbird Blvd intersection is the only signalized intersection. Figure 19 is the screenshot from the synchro simulation that presents the traffic conditions at the Thunderbird Blvd intersection. Protected left turns were added at both northbound and southbound intersections. The intersection is semi-actuated and uncoordinated with a total cycle length of 85 seconds and an average 19.1 seconds delay per vehicle. Figure 20 below shows the signal diagrams for different phases.

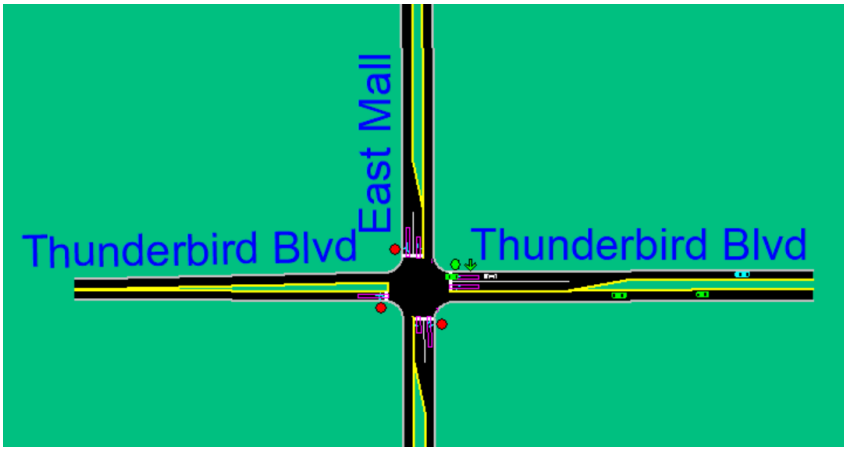


Figure 19: Thunderbird Blvd Intersection From Synchro Simulation.

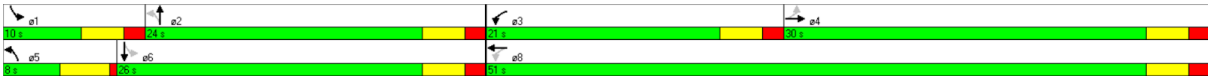


Figure 20: Signal Diagrams at Thunderbird Blvd Intersection.

4.4 Environmental Assessment

Design environmental assessment was done and reflected from two aspects: stormwater management plan and Synchro data analysis, shown as the following.

4.4.1 Stormwater Management Plan

The traditional storm sewer system catches storm water through catch basins along the street and discharges the water directly back to the natural water deposit. However, when the rain runs down the streets in urban areas, it washes down the deposited contaminants and when discharged, it can pollute the local water body and damage fish habitats. Our permeable asphalt pavement design can largely decrease the area of impervious surfaces. All rainwater can be absorbed and filtered through the soil, which acts as a natural filter and cleans up the contaminants. It also promotes infiltration and groundwater recharge while preventing the heating and conveyance of storm water into the storm drainage system. The usage of permeable asphalt pavement offers a more sustainable and environmentally friendly solution to stormwater management plan.

4.4.2 Emissions from Traffic Synchro Analysis

Table 9 below demonstrates the gas emissions at different intersections from the Synchro analysis. A significant amount of gas reductions is noticed at all intersections for the new optimization. CO emissions are reduced by the most, followed by NOx and HC emissions. Across all intersections, the reductions in CO, NOx, and HC emissions at Thunderbird Blvd are the most and have been reduced by 1362g, 111g, and 32g, respectively. The emissions at other intersections also show a decreasing trend, which proves the effectiveness of the optimization.

Intersections		Emissions		
		HC (g)	CO (g)	NOx (g)
Agronomy Rd (Stop-controlled)	Existing	22	850	71
	New Optimized	5	138	14
Thunderbird Blvd	Existing	40	1716	140

(Pretimed)	New Optimized	8	354	29
Eagles Drive (stop-controlled)	Existing	25	1146	89
	New Optimized	6	291	21
Stadium Rd (Stop-controlled)	Existing	27	1233	92
	New Optimized	7	290	23

Table 9: Gas Emissions at Each Intersection.

5. STAKEHOLDER ENGAGEMENT PLAN

For different stakeholder groups, various communication methods will be used to engage with them. The following table summarizes communication methods depending on stakeholder groups as well as key issues to be discussed with stakeholders.

Stakeholder group	Type of Communication	Key issues
Governmental Authorities (The University Endorsement Land and the GVRD)	• Official correspondence • Public meetings	• Permits • Project progress and reports
First Nation Consultant (The Musqueam first nation community)	• Official correspondence • Public meetings	• Explanation of the construction process • Impacts of the project on the land
Local Community	• Online Survey • Community meetings • Public notice boards • Dissemination via local media such as newspaper, news or radio	• Publish information on the project such as extent and schedule of the project • Obtain their opinion on the project • Community safety • Expected disruption during construction
Interested non-governmental organisations (NGOs)	• Public meeting • Informing via local media such as newspaper, TV or radio	• Discuss the pollution prevention and environmental impact • Community health and safety
Employees	• Small meetings • Email • Bulletin board	• Project progress update
Construction workers and contractors	• Communication via supervising engineers • During tender process • Reports	• Update project progress of works

Table 10: Summary of Stakeholder Engagement Plan.

6. PROJECT CONSTRUCTION

6.1 Construction Requirements

6.1.1 Safety & Environmental

To ensure the safety of the construction crew, equipment, public, and protect the environment, all construction work zones and staging areas will be barricaded with modular fencing, safety hoarding, traffic cones and signages etc. General project information, site safety board, first aid information, and evacuation plan will be posted along the project boundaries. All crew members are required to have Personal Protection Equipment (safety vest, hard hat, steel-toe boots, and hand gloves) when working on site.

Dust curtains will be set up for any concrete curb or asphalt removal to contain construction dust and debris while all construction crews working in the vicinity will be required to wear proper respiratory masks and safety glasses to reduce exposure to silica dust. To adhere to City of Vancouver Erosion & Sedimentation Control (ESC) for construction work zones, all stormwater catch basins around the work zone will be fitted with drain guards and silt bags to prevent any waste from entering the stormwater system from storm runoffs. Temporary excavated areas will have a dewatering and treatment system in place to treat water onsite before discharging back to the environment.

Figure 21: Catch Basin Bags as Shown in Downtown Vancouver.
(Source: Photographed by Carlson Lau)

6.1.2 Traffic Closures & Routing

In order to ensure public safety and construction work, periodic traffic closures of different sections of East Mall will be in-placed. The traffic closure plan will start from the south side of East Mall (West 16th Avenue) and progressively shift up north all the way to Agronomy Road intersection. The first section of the traffic closure will be in place at West 16th Avenue and Stadium Road intersections followed by Stadium Road to Eagles Drive intersections, Eagles Drive to Thunderbird Blvd Intersections, and Thunderbird Blvd to Agronomy Road Intersections. Each closure section will be a full traffic closure for northbound and southbound traffic except for Stadium Road to Eagles Drive Intersection which must be done in 2 separate sequences due to limited accessibilities for the adjacent buildings and sports fields. The following diagram highlights the traffic closure sequence.

Figure 22: Traffic Closure Sequence and Approximate Timeline.

6.2 Construction Sequence & Schedule

As requested by UBC SEEDS, construction will commence on May 1st, 2021. The construction sequence will be divided into 4 sections, aligning with the traffic closure sequence. The first section will involve construction work along West 16th Avenue to Stadium Road, followed by Stadium Road to Eagles Drive, Eagles Drive to Thunderbird Blvd, and lastly Thunderbird Blvd to Agronomy Road. The project is estimated to have a

duration of 152 days. The project schedule gantt chart can be found in the appendix. The following table summarizes the milestone dates.

Section	Start Date	Finish Date
W 16th Ave - Stadium Rd	May 1st, 2021	June 1st, 2021
Stadium Rd - Eagles Dr	June 1st, 2021	July 4th, 2021
Eagles Dr - Thunderbird Blvd	July 4th, 2021	August 10th, 2021
Thunderbird Blvd - Agronomy Rd	August 10th, 2021	September 10th, 2021
Testing & Completion	September 10th, 2021	September 30th 2021

Table 11: Project Milestone Dates.

6.3 Anticipated Risk & Mitigation Strategy

The following risks associated with the construction are forecasted and outlined. Mitigation strategies were also recommended to reduce and manage the construction risks.

- **Permitting & Approval Delays:** Prepare and submit permit and approval application way in advance before construction start date to allow for more schedule slack time.
- **Construction Material & Crew Shortages:** Subcontracts shall be tendered out and sub-contractor should be selected prior to the start of the construction works to ensure construction material and manpower are in-placed and ready for mobilization.
- **Noise & Traffic Disturbances:** All construction work scheduled to be done outside of the City of Vancouver construction hours shall be planned in advance and noise by-law variance application shall be submitted to the city. Notifications shall be sent out to the client, surrounding properties and UBC for any noise and traffic impacts.
- **Schedule Delays:** To eliminate the risk of any schedule delays, all critical paths outlined in the construction schedule shall be prioritized to avoid any subsequent delays to other activities.

7. PROJECT OPERATION & MAINTENANCE

7.1 Pre-Operation Requirements

Prior to project handover and completion, several key systems must be inspected and verified before opening East Mall to traffic users. The following checklist outlines the pre-operation requirements:

- Verify that permeable road asphalt permeability rate, drainage slope, and line paintings
- Verify that all road and sidewalk surfaces are smooth
- Test and confirm the operation of Thunderbird Blvd intersection traffic lights, sequence, presence detectors etc.
- Verify all street signs and street furnishings are in the designated places

7.2 Maintenance Plan

7.2.1 Permeable Asphalt Road Pavement

Given the relatively low traffic volumes, low heavy vehicle traffic (<0.5%), mild winter conditions, and moderate intensity rainfall, the permeable asphalt road pavement is designed to have a service life of 10 years from normal wear and tear. The entire road layout including the subbase and topping shall be reconstructed and repaved at the end of the service life.

- **Crack Repair:** Longitudinal cracks, block cracks, thermal cracks, alligator (fatigue) cracks etc. that are wider than 2 inches (51 mm), or longer than 4 ft (1.2 m) shall be repaired and surface patched to maintain integrity of the subbase and granular base.
- **Depression Repair:** Port holes, localized and channelized depressions, rutting etc. that are wider than 12 inches (300 mm) and deeper than 3 inches (80 mm) shall be repaired and surface patched to maintain integrity of the subbase and granular base.

- **Road Salting & Snow Removal:** Pre-salting roads shall be performed before forecasted snow storms or when temperature approaches 3 degree celsius. Accumulation of snow greater than 20 mm shall be plowed and removed.

7.2.2 Precast Concrete Sidewalk Slabs

All precast concrete slabs used for sidewalk pavement and its sub-base are designed to last 25 years under normal wear and tear conditions with minimal maintenance. Accumulation of deicing salt on the sidewalk should be avoided to prevent rapid surface deterioration.

7.2.3 Landscaping Components

Cappadocicum Maple (Botanical Name: Acer cappadocicumis, Figure _) is selected to be used as the trees along the roadsides between Thunderbird Blvd to Stadium Road Intersection while the existing trees on the median boulevard will remain. Cappadocicum Maple is a large and slow growing deciduous tree which will require minimum irrigation and trimming. Irrigation shall be provided naturally from rainfall and storm water inflow year-round, reducing the need for purpose built irrigation systems. Branch trimming shall be performed every 2 to 3 years to maintain tree grow width and falling branch risk during strong winds. Grasses and other ground coverings shall be trimmed once a year during the summer season for uniform height, promote deeper root growth and withstand environmental stresses. Excessive accumulation of leaves and branches shall be disposed and composted appropriately to ensure road user safety and prevent catch basin blockage.

Figure 23: Cappadocicum Maple trees along East Mall.

7.2.4 Stormwater Drainage & Mechanical Components

Storm drainage facilities along East Mall shall be maintained in accordance with City of Vancouver by-laws. Catch basins shall remain free of debris, leaves, and foreign contaminants to avoid drainage blockage. It is recommended to inspect and clear if necessary, of all catch basins prior to forecasted extreme weather events or after any high intensity rainfalls. Manhole covers shall be secured safely and manhole openings shall remain debris free to avoid any blockage. Periodic cleaning of manholes, drainage, and storm sewage system is not required under normal weather events.

Underground sanitary sewage, water supply, and gas lines shall remain untouched during the cleaning of any storm sewage system. Please consult the City of Vancouver, Metro Vancouver, Fortis BC, and licensed civil engineers if the maintenance or repair work requires the relocation or removal of any of the mechanical lines.

7.2.5 Electrical Components

Street lights and traffic lights are installed with energy efficient, long life, and high luminosity LED bulbs. All electrical systems including street lights, sunlight detectors, traffic lights, presence detectors, underground power cables shall not require periodic maintenance. Repair or replacement is only necessary for faulty systems.

7.2.6 Miscellaneous Components

- ***Street Furnishings: Bike racks, garbage bins, tactile strips etc:***

  Paint & touch-ups every 5 years, replace if necessary
- ***Street Signs: Traffic and pedestrian signs, bus stop signs, street name signs etc:***

  Paint & touch-ups every 5 years, replace if necessary

8. COST ESTIMATION

As requested by UBC SEEDS, Class 'C' Estimate was used to conduct the cost estimates based on the project detail design. The final cost of the project may deviate up to 25% of the current estimates.For detailed breakdown of each cost component, please refer to appendix.

8.1 Capital Costs

The capital cost for the project consists of the design consulting cost, permitting cost, and construction cost. The following table summarizes the cost estimation for the capital costs.

	Estimated Cost (CAD)
Consulting Fee	220,771.20
Permitting	6,934.50
Construction	1,867,139.93
Total Capital Cost	**2,094,845.63**

Table 12: Summary of Capital Cost Estimates.

8.2 Operational & Maintenance Cost

The operational & maintenance cost of the project was estimated based on the periodic maintenance required for the design area over the design life of the project of 50 years. The following table summarizes the O&M cost per division.

	Estimated Cost (CAD)	
Division	**Average Annual Cost**	**50-Year Cost**
Permeable Asphalt Road Pavement	35,220	1,761,000.00
Precast Concrete Slab Sidewalk	50.00	2,500.00
General Landscaping Maintenance	13,200.00	660,000.00
Mechanical	300.00	15,000.00

Electrical	500.00	25,000.00
Miscellaneous	800.00	40,000.00
Total O&M Cost	**50,070.00**	**2,503,500.00**

Table 13: Summary of O&M Cost.

8.3 Salvage & Reimbursement Value

At the end of the design project life (50 years), several components of the project may be demolished for recycling, or be decommissioned and reused for other services. The following table summarizes the project end of life returns.

	Estimated Value (CAD)
Salvage Recycling Revenue (Estimate)	1,400.00
Estimated Asset Reimbursement	78,500.00
Total	**79,900.00**

Table 14: Summary of Salvage & Reimbursement Value.

8.4 Life Cycle Cost

The Life Cycle Cost of the project includes the capital costs, operational & maintenance costs, and final decommissioning cost over the design life of the project (50 years).

	Estimated Cost (CAD)
Capital Costs	2,094,845.63
Operational & Maintenance	2,503,500.00
Salvage	(-) 79,900.00
Total Life Cycle Cost	**4,297,674.43**

Table 15: Life Cycle Cost calculation.

9. REFERENCES

- Road Pavement Defects

  https://www.pavemanpro.com/article/identifying_asphalt_pavement_defects/
- Class C Cost Estimate

  https://www.tpsgc-pwgsc.gc.ca/biens-property/sngp-npms/bi-rp/formulaires-forms/estimat-eng.html
- William Selbig, 2018, Evaluating the potential benefits of permeable pavement on the quantity and quality of stormwater runoff, www.usgs.gov/science
- Houle, K., Roseen, R., Ballestero, T., Briggs, J., and Houle, J., 2009, Examinations of Pervious Concrete and Porous Asphalt Pavements Performance for Stormwater Management in Northern Climates: World Environmental and Water Resources Congress 2009: p. 1–18.
- City of Vancouver Construction Specifications
- City of Vancouver Engineering Design Manual
- City of Vancouver Standard Detailed Drawings
- Stakeholder Engagement Plan for “Local Roads Connectivity Project”
- BC Ministry of Transportation and Infrastructure Section 400 Signal Design Electrical and Traffic Engineering Manual

10. APPENDIX

Appendix A - Canopy Capacity Calculation

Specified Snow Load S:

$$S = I_s [S_s (C_b C_w C_s C_a) + S_r]$$

I_s = important factor of snow load

= 1.0 (assume a normal importance category, ULS)

S_s = 1-in-50-year ground snow load

= 1.8 kPa (Vancouver City Hall)

w = smaller plan dimension of the roof = 4.82 m

l = larger plan dimension of the roof = 20.35 m

C_w = wind exposure factor = 0.75 (normal importance factor, rural areas)

$l_c = 2w - w^2/l$

$= 2(4.82\text{m}) - (4.82)^2/20.35\text{m}$

$= 8.5\text{ m} < 70/C_w^2 = 124.44$

$\Rightarrow C_b$ = basic roof snow load factor = 0.8

C_s = slope factor ($\alpha = 16.18°$)

$= (60° - \alpha)/45° = 0.974$ (unobstructed slippery roofs, $15° < \alpha \leq 60°$)

C_a = accumulation factor

- = 0 on the upwind side of the roof peak.
- = $0.2 + \alpha/20 = 1.05$ or on the downwind side of the roof peak with $15° \leq \alpha \leq 20°$

S_r = 1-in-50-year associated rain load

= 0.2 kPa (Vancouver City Hall) $< S_s (C_b C_w C_s C_a)$

$S = 1.0[(1.8\text{kPa})(0.8)(0.75)(0.974)(1.05 \text{ or } 0) + 0.2\text{kPa}]$

$=$
- $\leq$ 0.2 kPa on the upwind side
- 1.314 kPa on the downwind side

Wind Load W:

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

I_w = importance factor for wind load

= 1.0 (normal importance category, ULS)

q = reference velocity pressure

= 0.45 kPa (Vancouver City Hall)

h = mid-height of the roof = 5.225m

C_e = exposure factor

= $0.7(h/12)^{0.3}$ for rough terrain.

= $0.7(5.225m/12)^{0.3} = 0.545 < 0.7$, use $C_e = 0.7$

C_t = topographic factor = 1.0

Tributary area = $\frac{1}{2}(20.35m)(4.82m) = 49.04\ m^2$

$C_p C_g$ = 0.5 based on Figure 4.1.7.6-E

$p = 1.0(0.45kPa)(0.7)(1.0)(0.5) = 0.1575$ kPa.

Dead Load:

Assume the glass thickness = 5mm

Total glass volume $V = (2)(0.66m)(20.35m)(0.005m) = 0.541\ m^3$

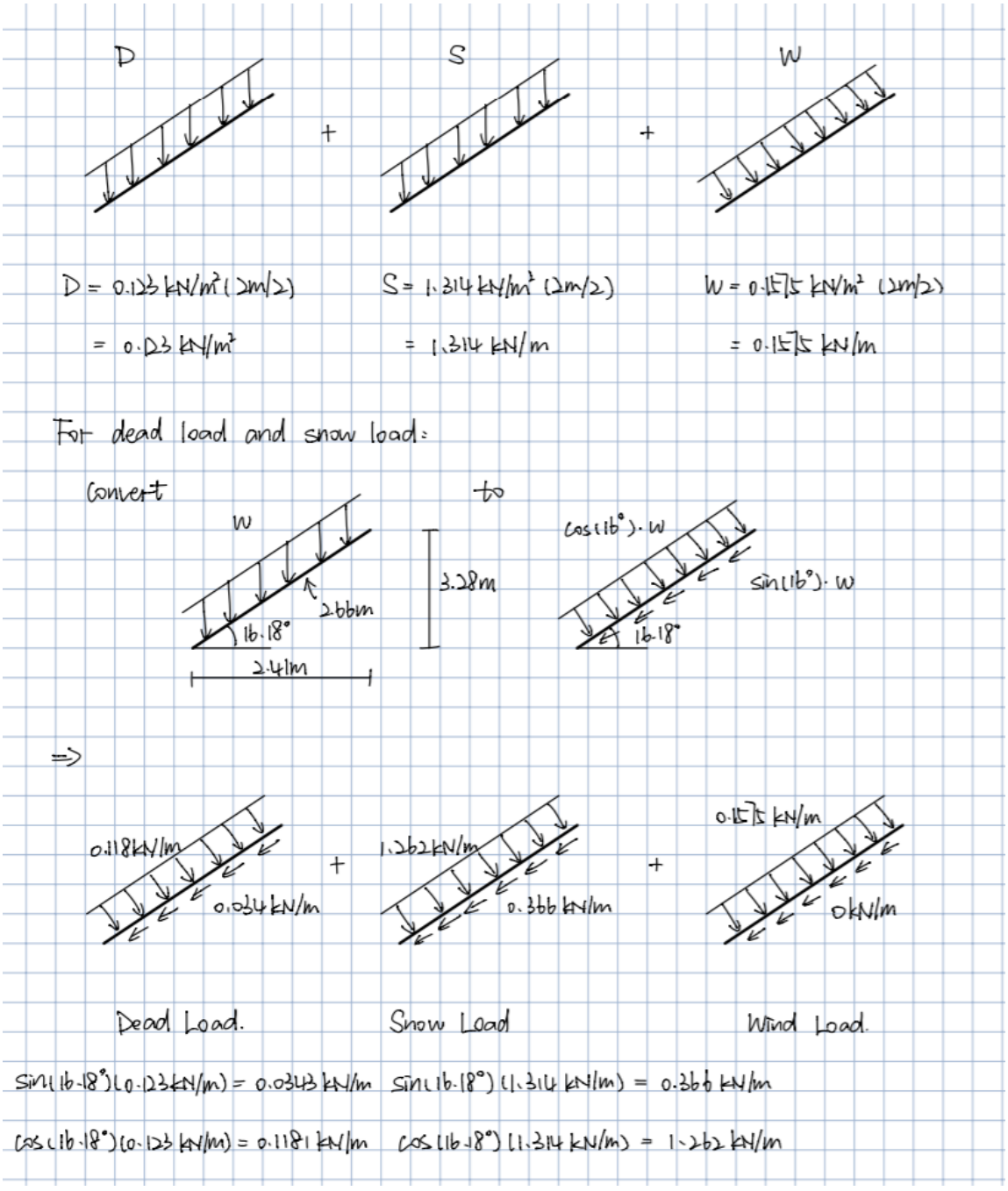
$m = \rho V = 2500\ kg/m^3(0.541\ m^3) = 1353.28\ kg$

$D = mg/A = 1353.28kg(9.81\ N/kg)/[(2)(2.66m)(20.35m)]$

$= 122.625\ Pa = 0.123$ kPa

Live Load:

L = 0kPa


D
S
W
+
+
D = 0.123 kN/m² (2m/2)
= 0.023 kN/m²
S = 1.314 kN/m² (2m/2)
= 1.314 kN/m
W = 0.155 kN/m² (2m/2)
= 0.155 kN/m
For dead load and snow load:
Convert
to
w
2.66m
16.18°
2.41m
3.28m
cos(16°)·w
sin(16°)·w
16.18°
⇒
0.118kN/m
0.034 kN/m
1.262kN/m
0.366 kN/m
0.155 kN/m
0kN/m
Dead Load.
Snow Load
Wind Load.
sin(16.18°)(0.123kN/m) = 0.0343 kN/m
cos(16.18°)(0.123 kN/m) = 0.1181 kN/m
sin(16.18°)(1.314 kN/m) = 0.366 kN/m
cos(16.18°)(1.314 kN/m) = 1.262 kN/m

Demand:

Load Combinations for Ultimate Limit State:

Case 1: $1.4D = 0.196\ kN/m$

Case 2: $1.25D + 1.5L + 1.0S = 1.141\ kN/m$

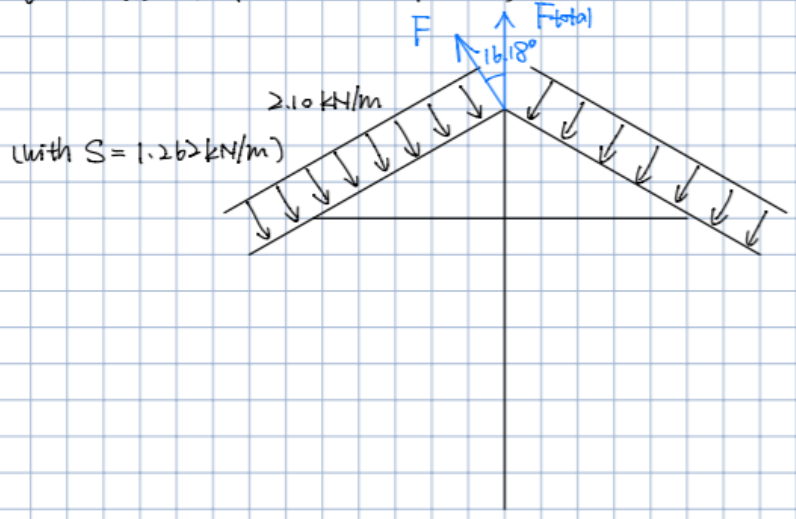
Case 3: $1.25D + 1.5S + 0.4W = 2.10\ kN/m$

Case 4: $1.25D + 1.4W + 0.5S = 0.999\ kN/m$

Case 5: $1.0D + 1.0E + 0.5L + 0.25S = 0.434\ kN/m$

$\Rightarrow$ Case 3 governs

Check the critical roof section (left one):



$$F = \frac{qL}{2} = \frac{2.10\ kN/m\,(2.66m)}{2} = 2.793\ kN.$$

$$F_{total} = \cos(16.18^\circ) \cdot F \quad (2)$$

$$= 5.365\ kN = \text{Compression Demand.}$$

Capacity:

Factored Compressive Resistance Under Axial Load.

$$P_r = \phi F_c A k_{zc} k_c$$

$\phi = 0.8$

The selected wood member is made of Douglas Fir-Larch, Grade SS.

$f_c = 13.8\ MPa$, $E = 12000\ MPa$

$k_D = 1.0$ (standard duration)

$k_H = 1.10$ (Case 2)

$k_{Sc} = 1.0$ (dry-service condition)

$k_T = 1.0$ (dry-service condition)

$F_c = f_c (k_D k_H k_{Sc} k_T)$

$= 13.8\ MPa (1.0)(1.1)(1.0)(1.0) = 15.18\ MPa$

$k_{zc} = 6.3 (dL)^{-0.13}$

$= 6.3 [(260mm)(4600mm)]^{-0.13} = 1.021 \leq 1.3$

$C_c = \frac{4600mm}{260mm} = 17.92$

$k_{SE} = 1.0$ (Dry-service Condition)

$E_{0.5} = 0.82E = 0.82 (12000\ MPa) = 9840\ MPa$

$k_c = \left(1.0 + \frac{F_c k_{zc} C_c^3}{35 E_{0.5} k_{SE} k_T}\right)^{-1}$

$= \left(1.0 + \frac{15.18MPa (1.021)(17.92)^3}{35 (9840MPa)(1.0)(1.0)}\right)^{-1} = 0.794$

$P_r = 0.8 (15.18MPa)\left(\frac{\pi}{4}\right)(260mm)^2 (1.021)(0.794) / 1000$

$= 522.69\ kN \Rightarrow$ Compression Demand $= 5.365\ kN$.

$\Rightarrow$ Pretty Safe !

Appendix B - Stormwater Management Calculation

- VEvaporation = 0.001m x (0.35 x 5100 + 500 + 281.3) = 2.6 cu.m
- VInfiltration = 0.0015 x 24 x (0.35 x 5100 + 500 + 281.3) = 92.4 cu.m
- VGrow-Med = (0.35 x 5100 + 500 + 281.3) x 0.3 x (0.25 - 0.05) = 154.0 cu.m
- Total V capture = 2.3 + 82.3 +137.1 = 249.0 cu.m
- Total V input = (0.65 x 5100) x 72% x 0.06.9 = 159.7 cu.m

Appendix C - Traffic Analysis Data

• Existing Design Simulation

SimTraffic Simulation Summary
Baseline 4/14/2021

Summary of All Intervals

Start Time	3:57
End Time	5:00
Total Time (min)	63
Time Recorded (min)	60
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	1446
Vehs Exited	1444
Starting Vehs	20
Ending Vehs	22
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	718
Travel Time (hr)	27.1
Total Delay (hr)	10.8
Total Stops	1490
Fuel Used (l)	173.9

Interval #0 Information Seeding

Start Time	3:57
End Time	4:00
Total Time (min)	3
Volumes adjusted by Growth Factors.	
No data recorded this interval.	

Interval #1 Information Recording

Start Time	4:00
End Time	5:00
Total Time (min)	60
Volumes adjusted by Growth Factors.	

Vehs Entered	1446
Vehs Exited	1444
Starting Vehs	20
Ending Vehs	22
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	718
Travel Time (hr)	27.1
Total Delay (hr)	10.8
Total Stops	1490
Fuel Used (l)	173.9

1: Agronomy Road & East Mall Performance by approach

Approach	EB	WB	NB	SB	All
Total Delay (hr)	0.4	0.3	0.4	3.1	4.2
Delay / Veh (s)	14.4	11.0	13.7	39.9	26.0
Stop Delay (hr)	0.4	0.2	0.3	3.0	3.9
St Del/Veh (s)	12.4	8.5	10.3	37.8	23.6
Total Stops	108	93	107	265	573
Stop/Veh	1.00	1.01	1.00	0.94	0.97
Travel Dist (km)	11.1	11.5	15.8	28.8	67.3
Travel Time (hr)	0.8	0.6	0.8	3.9	6.0
Avg Speed (kph)	15	19	20	7	11
HC Emissions (g)	4	4	4	11	22
CO Emissions (g)	159	196	181	314	850
NOx Emissions (g)	13	14	12	32	71

2: Thunderbird Blvd & East Mall Performance by approach

Approach	EB	WB	NB	SB	All
Total Delay (hr)	0.3	1.7	0.6	1.9	4.6
Delay / Veh (s)	9.3	20.2	9.9	20.3	16.5
Stop Delay (hr)	0.3	1.5	0.5	1.4	3.6
St Del/Veh (s)	7.5	17.1	7.5	14.8	12.9
Total Stops	69	219	120	261	669
Stop/Veh	0.55	0.71	0.53	0.76	0.67
Travel Dist (km)	13.4	38.0	44.4	52.4	148.3
Travel Time (hr)	0.7	2.8	1.6	3.1	8.2
Avg Speed (kph)	19	16	28	17	19
HC Emissions (g)	5	13	5	17	40
CO Emissions (g)	232	541	165	778	1716
NOx Emissions (g)	17	48	13	62	140

3: Eagles Drive & East Mall Performance by approach

Approach	EB	NB	SB	All
Total Delay (hr)	0.1	0.1	0.4	0.6
Delay / Veh (s)	9.4	1.6	2.6	2.7
Stop Delay (hr)	0.1	0.0	0.1	0.2
St Del/Veh (s)	7.6	0.5	0.5	0.9
Total Stops	50	25	16	91
Stop/Veh	1.00	0.08	0.03	0.11
Travel Dist (km)	5.0	61.0	104.6	170.6
Travel Time (hr)	0.3	1.4	2.6	4.3
Avg Speed (kph)	18	44	40	40
HC Emissions (g)	2	5	18	25
CO Emissions (g)	84	179	883	1146
NOx Emissions (g)	6	13	70	89

4: Stadium Road & East Mall Performance by approach

Approach	EB	NB	SB	All
Total Delay (hr)	0.2	0.3	0.3	0.8
Delay / Veh (s)	8.4	3.1	2.5	3.3
Stop Delay (hr)	0.2	0.2	0.1	0.4
St Del/Veh (s)	7.1	1.9	0.4	1.6
Total Stops	84	46	27	157
Stop/Veh	1.00	0.13	0.05	0.17
Travel Dist (km)	9.3	39.3	111.8	160.4
Travel Time (hr)	0.5	1.3	2.7	4.4
Avg Speed (kph)	19	33	42	37
HC Emissions (g)	3	15	9	27
CO Emissions (g)	152	807	275	1233
NOx Emissions (g)	11	57	24	92

Total Network Performance

Total Delay (hr)	10.8
Delay / Veh (s)	26.8
Stop Delay (hr)	8.2
St Del/Veh (s)	20.4
Total Stops	1490
Stop/Veh	1.03
Travel Dist (km)	717.6
Travel Time (hr)	27.1
Avg Speed (kph)	27
HC Emissions (g)	157
CO Emissions (g)	7362
NOx Emissions (g)	541

Intersection: 1: Agronomy Road & East Mall

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (m)	34.7	34.5	22.0	106.5
Average Queue (m)	13.1	11.6	12.7	40.5
95th Queue (m)	24.4	20.3	19.1	87.2
Link Distance (m)	103.0	124.0	139.3	102.0
Upstream Blk Time (%)				3
Queuing Penalty (veh)				0
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 2: Thunderbird Blvd & East Mall

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	L	TR	LTR	LTR
Maximum Queue (m)	27.8	47.3	29.2	35.2	73.3
Average Queue (m)	12.9	25.3	9.9	20.2	36.3
95th Queue (m)	24.7	41.8	22.6	33.2	59.4
Link Distance (m)	106.3		123.0	198.1	139.3
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)		40.0			
Storage Blk Time (%)		2			
Queuing Penalty (veh)		2			

Intersection: 3: Eagles Drive & East Mall

Movement	EB	NB	NB	SB
Directions Served	LR	L	T	TR
Maximum Queue (m)	15.5	15.4	9.2	22.9
Average Queue (m)	8.5	3.9	2.6	3.7
95th Queue (m)	15.1	12.2	9.2	14.5
Link Distance (m)	100.8		211.5	198.1
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)		40.0		
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 4: Stadium Road & East Mall

Movement	EB	NB	NB	SB	SB
Directions Served	LR	L	T	T	R
Maximum Queue (m)	20.2	22.2	22.7	22.0	9.2
Average Queue (m)	9.7	5.4	4.8	5.4	0.3
95th Queue (m)	15.4	14.7	16.3	16.1	3.0
Link Distance (m)	109.5		112.6	211.5	
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (m)		45.0			15.0
Storage Blk Time (%)				1	0
Queuing Penalty (veh)				0	0

Nework Summary

Network wide Queuing Penalty: 2

• New Optimized Design Simulation

Summary of All Intervals

Start Time	6:57
End Time	7:10
Total Time (min)	13
Time Recorded (min)	10
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	255
Vehs Exited	242
Starting Vehs	33
Ending Vehs	46
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	122
Travel Time (hr)	6.6
Total Delay (hr)	3.9
Total Stops	503
Fuel Used (l)	40.6

Interval #0 Information Seeding

Start Time	6:57
End Time	7:00
Total Time (min)	3

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:00
End Time	7:10
Total Time (min)	10

Volumes adjusted by Growth Factors.

Vehs Entered	255
Vehs Exited	242
Starting Vehs	33
Ending Vehs	46
Denied Entry Before	0
Denied Entry After	0
Travel Distance (km)	122
Travel Time (hr)	6.6
Total Delay (hr)	3.9
Total Stops	503
Fuel Used (l)	40.6

1: Agronomy Road & East Mall Performance by approach

Approach	EB	WB	NB	SB	All
Total Delay (hr)	0.3	0.2	0.1	1.2	1.8
Delay / Veh (s)	43.0	24.7	26.9	99.0	58.7
Stop Delay (hr)	0.3	0.2	0.1	1.2	1.8
St Del/Veh (s)	42.3	22.4	23.5	99.0	57.6
Total Stops	25	26	15	50	116
Stop/Veh	1.00	1.00	1.00	1.11	1.04
Travel Dist (km)	2.5	3.2	2.3	4.8	12.8
Travel Time (hr)	0.4	0.3	0.2	1.4	2.2
Avg Speed (kph)	7	12	14	3	6
HC Emissions (g)	1	1	1	3	5
CO Emissions (g)	33	44	16	45	138
NOx Emissions (g)	3	3	2	6	14

2: Thunderbird Blvd & East Mall Performance by approach

Approach	EB	WB	NB	SB	All
Total Delay (hr)	0.1	0.2	0.1	0.4	0.9
Delay / Veh (s)	15.6	16.6	13.3	24.9	19.1
Stop Delay (hr)	0.1	0.2	0.1	0.4	0.7
St Del/Veh (s)	13.5	13.9	10.0	19.4	15.3
Total Stops	17	29	13	47	106
Stop/Veh	0.63	0.55	0.43	0.72	0.61
Travel Dist (km)	2.7	6.4	5.4	9.8	24.3
Travel Time (hr)	0.2	0.4	0.2	0.7	1.5
Avg Speed (kph)	14	18	24	15	17
HC Emissions (g)	1	2	2	3	8
CO Emissions (g)	37	98	82	137	354
NOx Emissions (g)	3	8	5	12	29

3: Eagles Drive & East Mall Performance by approach

Approach	EB	NB	SB	All
Total Delay (hr)	0.0	0.1	0.3	0.4
Delay / Veh (s)	3.9	7.0	10.9	9.5
Stop Delay (hr)	0.0	0.0	0.1	0.1
St Del/Veh (s)	2.3	2.2	4.3	3.5
Total Stops	3	35	92	130
Stop/Veh	1.00	0.73	1.01	0.92
Travel Dist (km)	0.3	9.7	19.8	29.8
Travel Time (hr)	0.0	0.3	0.7	1.0
Avg Speed (kph)	25	33	28	30
HC Emissions (g)	0	3	3	6
CO Emissions (g)	6	141	145	291
NOx Emissions (g)	0	9	11	21

4: Stadium Road & East Mall Performance by approach

Approach	EB	NB	SB	All
Total Delay (hr)	0.0	0.1	0.5	0.6
Delay / Veh (s)	6.6	9.7	19.1	14.8
Stop Delay (hr)	0.0	0.1	0.3	0.4
St Del/Veh (s)	5.2	5.8	11.9	9.2
Total Stops	14	51	86	151
Stop/Veh	1.00	0.98	1.01	1.01
Travel Dist (km)	1.5	5.8	19.5	26.8
Travel Time (hr)	0.1	0.3	0.8	1.2
Avg Speed (kph)	21	20	23	22
HC Emissions (g)	0	2	5	7
CO Emissions (g)	17	69	203	290
NOx Emissions (g)	1	6	15	23

Total Network Performance

Total Delay (hr)	3.9
Delay / Veh (s)	56.0
Stop Delay (hr)	3.1
St Del/Veh (s)	44.8
Total Stops	503
Stop/Veh	2.03
Travel Dist (km)	122.1
Travel Time (hr)	6.6
Avg Speed (kph)	19
HC Emissions (g)	35
CO Emissions (g)	1629
NOx Emissions (g)	122

Intersection: 1: Agronomy Road & East Mall

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (m)	47.5	28.8	27.3	95.0
Average Queue (m)	30.0	19.6	17.9	71.4
95th Queue (m)	48.2	30.4	30.6	95.9
Link Distance (m)	101.4	122.3	139.4	102.1
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 2: Thunderbird Blvd & East Mall

Movement	EB	WB	WB	NB	NB	SB	SB
Directions Served	LTR	L	TR	L	TR	L	TR
Maximum Queue (m)	35.1	40.2	15.6	8.8	20.8	22.6	59.0
Average Queue (m)	18.1	22.6	5.8	5.2	14.0	15.3	41.8
95th Queue (m)	34.0	42.8	15.7	12.1	21.7	25.4	63.9
Link Distance (m)	104.6		121.4		198.2		139.4
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (m)		40.0		15.0		15.0	
Storage Blk Time (%)		1			10	5	43
Queuing Penalty (veh)		1			3	14	50

Intersection: 3: Eagles Drive & East Mall

Movement	EB	NB	NB	SB
Directions Served	LR	L	T	TR
Maximum Queue (m)	8.9	9.2	9.6	37.3
Average Queue (m)	5.3	7.1	9.4	23.5
95th Queue (m)	12.5	13.0	9.6	35.8
Link Distance (m)	100.8		211.5	198.2
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (m)		10.0		
Storage Blk Time (%)		2	10	
Queuing Penalty (veh)		4	2	

Intersection: 4: Stadium Road & East Mall

Movement	EB	NB	SB
Directions Served	LR	LT	T
Maximum Queue (m)	14.5	33.8	53.3
Average Queue (m)	11.3	21.9	33.7
95th Queue (m)	16.6	32.6	53.3
Link Distance (m)	109.4	112.7	211.5
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (m)			
Storage Blk Time (%)			45
Queuing Penalty (veh)			3

Nework Summary

Network wide Queuing Penalty: 78

Intersection: 2: Thunderbird Blvd & East Mall

Phase	1	2	3	4	5	6	8
Movement(s) Served	SBL	NBTL	WBL	EBTL	NBL	SBTL	WBTL
Maximum Green (s)	5.5	19.5	16.5	25.5	4.0	21.5	46.5
Minimum Green (s)	4.0	10.0	10.0	15.0	4.0	10.0	10.0
Recall	None	Max	Max	None	None	Max	None
Avg. Green (s)	5.5	22.5	16.5	17.0	4.0	25.5	38.0
g/C Ratio	0.04	0.30	0.22	0.23	0.02	0.34	0.50
Cycles Skipped (%)	43	0	0	0	71	0	0
Cycles @ Minimum (%)	0	0	0	14	29	0	0
Cycles Maxed Out (%)	43	100	100	0	29	100	0
Cycles with Peds (%)	0	63	0	86	0	75	57

Controller Summary
Average Cycle Length (s): 75.4
Number of Complete Cycles : 7

Appendix D - Cost Estimation

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

SUMMARY OF PROJECT COST ESTIMATION

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
	DIVISON 0 - General Requirements			**220,771.20**
	Professional Fees			190,320.00
	Disbursments (8% of Professional Fees)			30,451.20
	DIVISON 1 - General Requirements			**312,909.50**
01 10 00	Project Management Fee			272,000.00
01 20 00	Permit Requirements			6,934.50
01 30 00	General Site Requirements			27,500.00
01 40 00	Utility Requirements			6,475.00
	DIVISON 2 - Sitework			**266,490.00**
02 10 00	Demolition of existing curbs, infrastructure, trees relocation/removal etc.			28,815.00
02 20 00	Excavation			3,975.00
02 30 00	Earthwork			233,700.00
	DIVISON 3 - Concrete			**153,070.00**
03 10 00	Concrete Supply			41,025.00
03 20 00	Concrete Reinforcement			1,545.00
03 30 00	Cast-In-Place Concrete			16,500.00
03 40 00	Pre-Cast Concrete			94,000.00
	DIVISON 4 - Masonry			
	Not applicable to scope of project			
	DIVISON 5 - Metals			**11,280.00**
05 10 00	Structural Steel & Metal Joists			11,280.00
	DIVISON 6 - Wood & Plastics			**1,620.00**
06 20 00	Structural Glulams			1,620.00
	DIVISON 7 - Moisture Protection			
	Not applicable to scope of project			
	DIVISON 8 - Openings			
	Not applicable to scope of project			
	DIVISON 9 - Finishes			**20,680.00**
09 10 00	Painting			17,480.00
09 20 00	Canopy Glass			3,200.00

	DIVISON 10 - Specialties			**15,350.00**
10 10 00	Vehicular, Bike, Pedestrain Traffic Signages			3,560.00
10 20 00	Traffic Control Lights			10,540.00
10 30 00	Presence Detectors			1,250.00
	DIVISON 11 - Conveying Systems			
	Not applicable to scope of project			
	DIVISON 12 - Mechanical			**131,375.00**
12 10 00	Utilities Relocation			1,500.00
12 20 00	Storm Drainage			129,875.00
	DIVISON 13 - Electrical			**203,000.00**
13 10 00	Utilities Relocation			1,000.00
13 20 00	Street lights			194,680.00
13 30 00	Signalized traffic lights, presence detectors, control systems electrical routing			7,320.00
	DIVISION 14 - Landscaping			**458,800.00**
14 10 00	General Landscaping			20,000.00
14 20 00	Soil treatment			48,000.00
14 30 00	Trees and shrubs planting			166,000.00
14 40 00	Street Paving			224,800.00
	Insurance (5% of Total Construction)			**78,728.73**
			Subtotal	**1,874,074.43**
	OPERATION & MAINTENANCE (50 YEARS)			
	Permeable Asphalt Road Pavement (Estimated per year)	50	35,220.00	1,761,000.00
	Precast Concrete Slab Sidewalk (Estimated per year)	50	50.00	2,500.00
	General Landscaping	50	13,200.00	660,000.00
	Mechanical	50	300.00	15,000.00
	Electrical	50	500.00	25,000.00
	Miscellaneous	50	800.00	40,000.00
			Subtotal	**2,503,500.00**
	END OF DESIGN LIFE SALVAGE & REIMBURSEMENT			
	Salvage Recycling Revenue (Estimate)			-1,400.00
	Estimated Asset Refurbishment			-78,500.00
			Subtotal	**-79,900.00**
			GRAND SUBTOTAL (CAD)	**4,297,674.43**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

CLASS 'C' COST ESTIMATION

Division 00 00 00 - DESIGN CONSULTING **Subcontractor** N/A

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity (Hours)	Unit Cost (CAD/Hours)	Cost (CAD)
00 00 10	**Professional Fees**			**190,320.00**
00 00 11	*Professional Engineer Services*			
	1 x Specialist Engineer @ $199/hour	240.00	199.00	47,760.00
	2 x Project Engineers @ $162/hour	480.00	162.00	77,760.00
	2 x Technologist @ $135/hour	480.00	135.00	64,800.00
00 00 12	*Review information provided and research*		(Included)	
00 00 12	*Future Traffic Demands Predition*		(Included)	
00 00 12	*Site review and data compilation*		(Included)	
00 00 12	*Conceptual design of road with facilities and utilities*		(Included)	
00 00 12	*Pedestrian weather protection design at Agronomy Road*		(Included)	
00 00 12	*Analaysis of projected changes in land use*		(Included)	
00 00 12	*Stakeholder Engagement Plan*		(Included)	
00 00 12	*Class C Cost Estimate*		(Included)	
00 00 12	*Preliminary Project Schedule Milestones*		(Included)	
00 00 20	**Disbursments (8% of Professional Fees)**			**30,451.20**
00 00 21	*Standard Hardware & Computer Costs*		(Included)	
00 00 22	*Comunication and Messenger Services*		(Included)	
00 00 23	*Travel Expenses*		(Included)	
00 00 24	*Printing & Office Supplies*		(Included)	
		Subtotal (CAD)		**220,771.20**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

CLASS 'C' COST ESTIMATION

Division 01 00 00 - GENERAL REQUIREMENTS **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD/Quant.)	Cost (CAD)
01 10 00	**Project Management Fee**			**272,000.00**
01 10 01	General Contracting Fee		(Included)	
01 10 02	Construction Project Team Fee			
	1 x Site Senior Superintendent @ $90/hour	800.00	90.00	72,000.00
	2 x Site Superintendent @ $60/hour	1,600.00	60.00	96,000.00
	1 x Project Manager @ $80/hour	800.00	80.00	64,000.00
	1 x Project Coordinator @ $50/hour	800.00	50.00	40,000.00
01 20 00	**Permit Requirements**			**6,934.50**
01 20 01	Demolition Permit	1.00	321.00	321.00
01 20 02	Waste Compliance Fee	1.00	350.00	350.00
01 20 03	Excavation Permit	1.00	321.00	321.00
01 20 04	Building Permit	1.00	3,000.00	3,000.00
01 20 05	Street Sign Permit	1.00	349.00	349.00
01 20 06	Noise by-law Exception Permit	10.00	197.00	1,970.00
01 20 07	Traffic Management Plan Review Fees	5.00	66.10	330.50
01 20 08	Final Inspection Fee	1.00	293.00	293.00
01 30 00	**General Site Requirements**			**27,500.00**
01 30 01	Rental - Construction safety barricades, signages, fencing etc.	3.50	2,000.00	7,000.00
01 30 02	Rental - Temporary office, portable toilets and sinks, temporary storage facilities etc.	3.50	40,000.00	20,000.00
01 30 03	Misc Supplies	1.00	500.00	500.00
01 40 00	**Utility Fees**			**6,475.00**
01 40 01	Temporary power supply	3.50	500.00	1,750.00
01 40 02	Temporary water supply	3.50	200.00	700.00
01 40 03	Internet Access	3.50	150.00	525.00
01 40 04	Construction Waste Recycling & Disposal Service	3.50	1,000.00	3,500.00
		Subtotal (CAD)		**312,909.50**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 02 00 00 - SITEWORK **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 4 DECEMBER 2020

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
02 01 00	**Demolition of existing curbs, infrastructure, trees relocation/removal etc.**			**28,815.00**
02 01 01	Demolish and reduce curbs, width of sidewalk along Agronomy Road & trees relocation			
	1 x Excavator + Operator @ $400/hour	0.50	400.00	200.00
	2 x Labourer @ $50/hour	4.00	50.00	200.00
	1 x Disposal Truck @ $150/hour	1.00	150.00	150.00
	Estimated disposal and recycling volume	2.00	10.00	20.00
02 01 02	Demolish and reduce width of median curb north of Thunderbird Blvd intersection			
	1 x Excavator + Operator @ $400/hour	3.00	400.00	1,200.00
	2 x Labourer @ $50/hour	6.00	50.00	300.00
	1 x Disposal Truck @ $150/hour	1.00	150.00	150.00
	Estimated disposal and recycling volume	7.50	10.00	75.00
02 01 03	Demolish and reduce width of median curb at Eagles Drive intersection			
	1 x Excavator + Operator @ $400/hour	4.00	400.00	1,600.00
	3 x Labourer @ $50/hour	12.00	50.00	600.00
	1 x Disposal Truck @ $150/hour	2.00	150.00	300.00
	Estimated disposal and recycling volume	2.00	10.00	20.00
02 01 04	Demolish median curb and trees removal south of Stadium Rd intersection			
	1 x Excavator + Operator @ $400/hour	20.00	400.00	8,000.00
	4 x Labourer @ $50/hour	60.00	50.00	3,000.00
	1 x Disposal Truck @ $150/hour	6.00	150.00	900.00
	Estimated disposal and recycling volume	20.00	10.00	200.00
02 01 05	Demolish median curb, trees removal, parking facilities from Stadium Rd to West 16th Ave.			
	1 x Excavator + Operator @ $400/hour	20.00	400.00	8,000.00
	4 x Labourer @ $50/hour	60.00	50.00	3,000.00
	1 x Disposal Truck @ $150/hour	6.00	150.00	900.00
02 20 00	**Excavation**			**3,975.00**
02 20 01	Excavate and detail foundation footings for overhead pedestrian protection systems			
	1 x Excavator + Operator @ $400/hour	1	400	400.00
	2 x Labourer @ $50/hour	4	50	200.00
	1 x Disposal Truck @ $150/hour	0.5	150	75.00
02 20 02	Excavate and detail foundation footings for all road infrastructure			
	1 x Excavator + Operator @ $400/hour	6	400	2,400.00
	2 x Labourer @ $50/hour	12	50	600.00
	1 x Disposal Truck @ $150/hour	2	150	300.00
02 30 00	**Earthwork**			**233,700.00**
02 30 01	Earthwork Leveling Site Wide preparation for road subbase			
	1 x Excavator + Operator @ $400/hour	10	400	4,000.00
	2 x Labourer @ $50/hour	40	50	2,000.00
	Imported Fill (Sq meters)	5000	18	90,000.00
	7650 sq meters 100mm granular base and 300mm granular subbase	7650	18	137,700.00
		Subtotal (CAD)		**266,490.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 03 00 00 - CONCRETE **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
03 10 00	**Concrete Supply**			**41,025.00**
03 10 01	25 MPa Concrete Supply, Exposure Class: C1	0.50	50.00	25.00
	Concrete Footings and Overhead Pass @ $50/cubic meters	20.00	50.00	1,000.00
	Concrete Curbs along roadside @ $50/cubic meters	600.00	50.00	30,000.00
	Pour bike lane curb @ $50/cubic meters	200.00	50.00	10,000.00
03 20 00	**Concrete Reinforcement**			**1,545.00**
03 20 01	20mm reinforcing bars for concrete foundation @ $4.50/m	10	4.5	45.00
	2 x Labourer @ $50/hour	30	50	1500
03 30 00	**Cast-In-Place Concrete**			**16,500.00**
03 30 01	Concrete Pour			
	1 x Foreman @ $80/hour	50	80	4,000.00
	3 x Carpenter @ $50/hour	150	50	7,500.00
	2 x Concrete Placer, Finisher @ $50/hour	100	50	5,000.00
03 40 00	**Pre-cast Concrete**			**94,000.00**
03 40 01	200mm Non-Reinforced Concrete Drains @ $15/m	1600	15	24,000.00
	2 x Labourer @ $50/hour	200	50	10,000.00
03 40 02	100mm 1'x1' Pecasted Sidewalk Slabs @ $25/unit	25	2400	60,000.00
		Subtotal (CAD)		**136,570.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 05 00 00 - METALS Subcontractor TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS Date 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
05 10 00	**Structural Steel & Metal Joists**			**11,280.00**
05 10 01	Overhead Weather Protection System (Pre-fab/per unit)	2.00	5,000.00	10,000.00
	1 x Iron Fabricator @ $80/hour	10.00	80.00	800.00
	2 x Installer @ $80/hour	6	80.00	480.00
		Subtotal (CAD)		**22,560.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 06 00 00 - WOOD & PLASTICS **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
06 20 00	**Structural Glulams**			
06 20 01	Canopy Supports	1.00	1,200.00	1,200.00
	2 x Carpenter @ $70/hour	6.00	70.00	420.00
			SUBTOTAL (CAD)	1,620.00

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 09 00 00 - FINISHES **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
09 10 00	**Painting**			**17,480.00**
09 10 01	Concrete Support Prep, prime, paint			
	1 x Painter @ $60/hour	8.00	60.00	480.00
	Concrete Bonding Primer @ $20/USG	10	20.00	200.00
	Standard white masonry/concrete painting @ $20/USG	30	20.00	600.00
09 10 02	Street Line Painting			
	1 x Line Printing Machine + Operator @ $220/hour	60	220.00	13,200.00
	2 x Painter @ $50/hour	60	50.00	3,000.00
	Standard white paint for asphalt road line painting @ $50/USG	150	50.00	7,500.00
	Standard yellow paint for asphalt road line painting @ $50/USG	150	50.00	7,500.00
09 20 00	**Canopy Glass**			**3,200.00**
09 20 01	Canopy Glass (Pre-fab)	1	1,000.00	2,000.00
	2 x Installer @ $75/hour	16	75.00	1,200.00
			Subtotal (CAD)	**20,680.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 10 00 00 - SPECIALTIES **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
10 10 00	**Vehicular, Bike, Pedestrian Traffic Signages**			**3,560.00**
10 10 01	Signs @ $60/unit	26.00	60.00	1,560.00
	2 x Installer @ $50/hour	40.00	50.00	2,000.00
10 20 00	**Traffic Control Lights**			**10,540.00**
10 20 01	Thunderbird Int. - SB & WB Left-turn Signalized Light	1	7,000.00	7,000.00
	1 x Traffic Specialist @ $100/hour	1.5	100.00	150.00
	3 x Installer + Scaffolding @ $90/hour	24	90.00	2,160.00
10 20 02	Pedestrian Crossing Lights at Eagles Drive	1	1,000.00	1,000.00
	1 x Traffic Specialist @ $100/hour	0.5	100.00	50.00
	2 x Installer + Scaffolding @ $90/hour	2	90.00	180.00
10 30 00	**Presence Detectors**			**1,250.00**
10 30 01	Presence Detectors	2	500.00	1,000.00
	1 x Traffic Specialist @ $100/hour	1	100.00	100.00
	2 x Installer @ $75/hour	2	75.00	150.00
			Subtotal (CAD)	**15,350.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 12 00 00 - MECHANICAL **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
12 10 00	**Utilities Relocation**			**1,500.00**
12 10 01	Fortis BC Relocation	1.00	500.00	500.00
12 10 02	Metro Vancouver Piping Relocation	1.00	500.00	500.00
12 10 03	Misc Utilities	1.00	500.00	500.00
12 20 00	**Strom Drainage (labour included)**			**129,875.00**
12 20 01	200mm Non-Reinforced Storm Sewer Pipes	427	125.00	53,375.00
12 20 02	Standard CoV Catch Basin	30	1,750.00	52,500.00
12 20 03	Standard 1050mm manhole access	8	3,000.00	24,000.00
			Subtotal (CAD)	**131,375.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 13 00 00 - ELECTRICAL **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
13 10 00	**Utilities Relocation**			**1,000.00**
13 10 01	BC Hydro	1.00	500.00	500.00
13 10 02	Telus/Shaw	1.00	500.00	500.00
13 20 00	**Street Lights**			**194,680.00**
13 20 01	Agronomy Rd - West 16th Ave (spaced approx 12m apart, total length 1600m)	135	1,000.00	135,000.00
	Crane Operated Truck + Operator @ $300/hour	40	300.00	12,000.00
	3 x Electrician @ $70/hour	120	70.00	8,400.00
13 20 02	Stadium Neighbourhood Decorative Street Lights (spaced approx 10m apart, total length 600m)	60	500.00	30,000.00
	Crane Operated Truck + Operator @ $300/hour	16	300.00	4,800.00
	4 x Electrician @ $70/hour	64	70.00	4,480.00
13 30 00	**Signalized traffic lights, presence detectors, control systems electrical routing**			7,320.00
13 30 01	Thunderbird Blvd Intersection	1	3,000.00	3,000.00
	1 x Traffic Specialist @ $100/hour	2	100.00	200.00
	2 x Installer @ $70/hour	16	70.00	1,120.00
13 30 02	Eagles Drive Ped. Crossing	1	3,000.00	3,000.00
			Subtotal (CAD)	**203,000.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PRELIMINARY PROJECT COST ESTIMATION

Division 14 00 00 - LANDSCAPING **Subcontractor** TBD

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

Division	Description	Quantity	Unit Cost (CAD)	Cost (CAD)
14 10 00	**General Landscaping**			**20,000.00**
14 10 01	General Landscaping Sitewide	1.00	20,000.00	20,000.00
14 20 00	**Soil Treatment**			**48,000.00**
14 20 01	Install new engineered soil along road median from Thunderbird Blvd to Stadium Road @ $8/m^2	3000	8.00	24,000.00
	4 x Landscaper @ $50/hour	200	50.00	10,000.00
14 20 02	Soil prep for stadium neighbourhood landscaping @ $8/m^	1500	8.00	12,000.00
	4 x Landscaper @ $50/hour	40	50.00	2,000.00
14 30 00	**Trees and Shrubs Planting**			**166,000.00**
14 30 01	Plant Trees & Shrubs along East Mall Cappadocicum Maple trees - estimated quantity 80 trees	80	2,000.00	160,000.00
	4 x Landscaper @ $50/hour	120	50.00	6,000.00
14 40 00	**Street Paving**			
14 40 01	Street paving along entire East Mall			**224,800.00**
	Pervious Asphalt Topping & Final Lift ($30/square meters)	7200	30.00	216,000.00
	1 x Paving Machine + Operator @ $400/hour	16	400	6,400.00
	3 x Labourer @ $50/hour	48	50	2,400.00
			Subtotal (CAD)	**458,800.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

OPERATION & MAINTENANCE PROJECT COST ESTIMATION

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

O&M	Description	Quantity (Hours)	Cost (CAD/Hours)	Cost (CAD)
1	**Permeable Asphalt Road Pavement (Estimated per year)**			**35,220.00**
1.1	*Repave every 10 years, per year cost*			33,720.00
1.2	*Street surface repairs & crack controls (estimated per year)*			1,000.00
1.3	Road Salt & Deicing (estimated per year)			500.00
2	**Precast Concrete Slab Sidewalk (Estimated per year)**			**50.00**
2.1	Repair as needed (estimated per year cost)			50.00
3	**General Landscaping Maintenance (Estimated per year)**			**13,200.00**
3.1	Landscaping (Trim, cut, prune) trees, shrubs, grass, plants) twice/year			
	2 x Landscaper @ $50/hour	144.00	50.00	7,200.00
3.2	Irrigation (seasonal requirements) est.	200.00	10.00	2,000.00
3.3	Street Cleaning			
	1 x Street Cleaner Machine + Operator @ $250/hour	16.00	250.00	4,000.00
4	**Mechanical Maintenance (Estimated Per Year)**			**300.00**
4.1	Clear and unclog drains and flow channels (once/year)			
	2 x Labourer @ $50/hour	6	50	300.00
5	**Electrical Maintenance (Estimated Per Year)**			**500.00**
5.1	*Recalibrate signalized traffic timing and pattern (as needed)*			
5.2	*Replace faulty street lights (as needed)*			
6	**Misc Maintenance (Estimated Per Year)**			**800.00**
6.1	Street Furnishing repaint, touchups every 5 years. (Touch-up if needed)	8	100	800.00
6.2	Street Signs repaint, touchups (as needed)			
		Subtotal (Annual)		**50,070.00**
		Subtotal (50 Years)		**2,503,500.00**

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

END OF DESIGN LIFE PROJECT COST ESTIMATION

Project EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENUE

Client UBC SEEDS **Date** 16 APRIL 2021

O&M	Description	Quantity (Hours)	Cost (CAD/Hours)	Cost (CAD)
1	**Salvage Recycling Revenue (Estimate)**			**-1,400.00**
1.1	*Concrete Recycling*		-1000	-1,000.00
1.2	*Metal Recycling*		-200	-200.00
1.3	*Wood Recycling*		-200	-200.00
2	**Estimated Asset Refurbishment**			**-78,500.00**
2.1	Street Lights	255	-300	-76,500.00
2.2	Traffic Lights & Signs		-2000	-2,000.00
		Subtotal (Annual)		**-79,900.00**

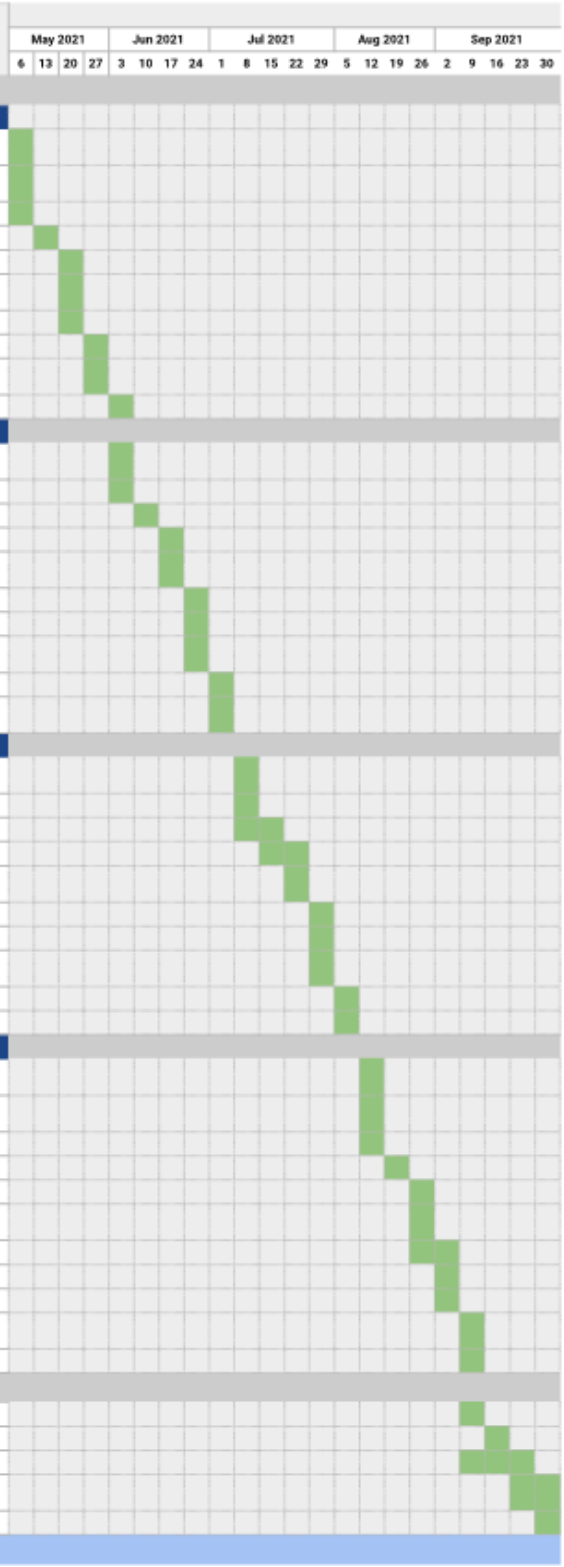
Appendix E - Project Schedule

TEAM 14 URBAN TECH CONSULTANTS
Creative Thinking - Practical Results

PROJECT SCHEDULE

PROJECT EAST MALL REDESIGN BETWEEN AGRONOMY ROAD AND WEST 16TH AVENU
COMPANY TEAM 14 - URBAN TECH CONSULTANTS

	TASK TITLE	START DATE (DD/MM/YYYY)	END DATE (DD/MM/YYYY)
	Project Construction	**01/05/2021**	**10/09/2021**
SECTION 1:	**W 16TH AVENUE - STADIUM ROAD**	**01/05/2021**	**01/06/2021**
1.1	Site Preparations (Hoarding, Trailer Setups, Equipment Mobilization etc)	01/05/2021	02/05/2021
1.2	Temporary Rerouting of Drainage Flow & Civil Connections	02/05/2021	05/05/2021
1.3	Demolition of Existing Curbs and Planters	04/05/2021	07/05/2021
1.4	Excavation & Site Prep Work	08/05/2021	15/05/2021
1.5	Install drains & other mechanical systems	16/05/2021	18/05/2021
1.6	Pour new concrete curb and install precast slabs	19/05/2021	21/05/2021
1.7	Install and reroute civil connections	22/05/2021	24/05/2021
1.8	Repave road	25/05/2021	27/05/2021
1.9	Install Traffic Signs/Bike Racks/Misc Infrastructure	25/05/2021	28/05/2021
1.10	Plant Trees and other landscpaing work	29/05/2021	01/06/2021
SECTION 2:	**STADIUM ROAD - EAGLES DRIVE**	**01/06/2021**	**04/07/2021**
2.2	Temporary Rerouting of Drainage Flow & Civil Connections	01/06/2021	04/06/2021
2.3	Demolition of Existing Curbs and Planters	03/06/2021	06/06/2021
2.4	Excavation & Site Prep Work	07/06/2021	14/06/2021
2.5	Install drains & other mechanical systems	15/06/2021	17/06/2021
2.6	Pour new concrete curb and install precast slabs	18/06/2021	22/06/2021
2.7	Install and reroute civil connections	23/06/2021	25/06/2021
2.8	Repave road	26/06/2021	29/06/2021
2.9	Install Traffic Signs/Bike Racks/Misc Infrastructure	26/06/2021	29/06/2021
2.10	Plant Trees and other landscaping work	30/06/2021	03/07/2021
2.11	Install overhead pedestrian crossing warning lights	03/07/2021	04/07/2021
SECTION 3:	**EAGLES DRIVE - THUNDERBIRD BLVD**	**04/07/2021**	**10/08/2021**
3.2	Temporary Rerouting of Drainage Flow & Civil Connections	04/07/2021	07/07/2021
3.3	Demolition of Existing Curbs and Planters	06/07/2021	09/07/2021
3.4	Excavation & Site Prep Work	10/07/2021	17/07/2021
3.5	Install drains & other mechanical systems	18/07/2021	22/07/2021
3.6	Pour new concrete curb and install precast slabs	23/07/2021	28/07/2021
3.7	Install and reroute civil connections	29/07/2021	31/07/2021
3.8	Repave road	01/08/2021	05/08/2021
3.9	Install Traffic Signs/Bike Racks/Misc Infrastructure	01/08/2021	02/08/2021
3.10	Plant Trees and other landscpaing work	03/08/2021	06/08/2021
3.11	Install new traffic lights, presence detectors	07/08/2021	10/08/2021
SECTION 4:	**THUNDERBIRD BLVD - AGRONOMY ROAD**	**10/08/2021**	**10/09/2021**
4.1	Site Preparations (Hoarding, Trailer Setups, Equipment Mobilization etc)	10/08/2021	10/08/2021
4.2	Temporary Rerouting of Drainage Flow & Civil Connections	10/08/2021	13/08/2021
4.3	Demolition of Existing Curbs and Planters	14/08/2021	16/08/2021
4.4	Excavation & Site Prep Work	17/08/2021	24/08/2021
4.5	Install drains & other mechanical systems	25/08/2021	27/08/2021
4.6	Pour new concrete curb and install precast slabs	28/08/2021	29/08/2021
4.7	Install and reroute civil connections	30/08/2021	01/09/2021
4.8	Install overhead weather protection cover	02/09/2021	04/09/2021
4.9	Repave road	05/09/2021	06/09/2021
4.10	Install Traffic Signs/Bike Racks/Misc Infrastructure	05/09/2021	06/09/2021
4.11	Plant Trees and other landscpaing work	07/09/2021	10/09/2021
	Project Completion	**10/09/2021**	**30/09/2021**
	Traffic Signalized Test	10/09/2021	13/09/2021
	Calibration & Minor Adjustments	14/09/2021	15/09/2021
	Final Cleanup	10/09/2021	20/09/2021
	Final Review of Maintenance & Standard Operation Procedures (SOP)	20/09/2021	29/09/2021
	Project Closeout	30/09/2021	30/09/2021
	PROJECT OVERALL COMPLETION	**01/05/2021**	**30/09/2021**



Appendix F - Construction Specifications

1. Concrete

1) Concrete Walks, Curbs and Gutters

1. Materials
    a. Polyvinyl Chloride (PVC) or Acrylonitrile Butadiene-Styrene (ABS) plastics shall meet the requirements of the latest revision of CAN / CSA 182.1. Pipe shall be available in 3m lengths with nominal diameter of 100mm and perforations as detailed in Section 4.1.4 of CAN / CSA 182.1 for leach field pipe. The pipe will include bell and spigot design suitable for solvent welding, where required. The pipe shall have an SDR of 28 or lower and 700kPa at 5% deflection.
    b. Perforated Corrugated Metal Pipe (PCMP) shall conform to the latest revision of AASHTO M36. PCMP shall consist of 18- gauge (minimum 1.214mm) metal with 6.35mm minimum diameter rivets or the seam may be formed by welding. Helical corrugated pipe will be acceptable if it has corrugations 6.35mm deep by 38mm wide. Perforations shall consist of two groups of two lines each. The holes shall be not less than 6.35mm nor more than 11.1mm in diameter and shall be located in the inside ridges of all corrugations. The lines of holes shall be approximately 25mm apart and the outer rows of holes shall be not more than 67.5˚ from the centre line of the non-perforated segment.
2. Formework
    a. At lanes, crossings and other similar locations, formwork shall be left in place until the concrete has attained sufficient strength to bear traffic loads without edge damage. Sufficient strength generally means minimum 20MPa in concrete strength unless otherwise allowed by the City Engineer.
3. Control Joints
    a. Walks 1.5m, 1.8m, and 2.0m in width shall be marked off in panels 1.5m, 1.8m, or 2.0m long respectively unless otherwise directed by the City Engineer. Control joints to control and minimize cracking shall be installed to the satisfaction of the City Engineer. The scoring pattern of the sidewalk is governed by the distance between features such as tree pits and water valve boxes. Keep the scoring pattern as square as possible for the sidewalk panels.
    b. Whenever there is a sidewalk feature, such as a tree pit or water valve box, presented, the scoring pattern must follow through from the main sidewalk scoring pattern. A cut is generally spaced between two adjacent sidewalk panels as long as it provides balanced scoring pattern between features.
4. Finishing
    a. Cutting and marking tools shall have a cutting edge not less than 25mm in depth and the edge of the panel shall be rounded to a 6mm radius. Trowel edge to be as close to flush as possible with broom finish. The broom finish shall extend to the edge of the panel.
    b. Finished curb and gutter shall have a smooth and uniform surface, true to line, grade, and section and shall be free from voids, sags, bumps, or other irregularities to the satisfaction of the City Engineer.

c. All control joints are to be sawcut only (no trowel marks) and shall be done 24 hours after the pour to avoid any cracking.
d. All score lines are to be trowelled only.

5. Protection
    a. Protect freshly finished concrete from dust, rain or frost by using tarpaulins or other suitable protective coverings after final set. Keep clear of finished surface.

2) Cast-in-Place Concrete

City of Vancouver Mix 1503:

Property	Specification
Typical Use	Pavement, Crossings, Curb and gutter, and Sidewalk
Cement Type	GUL (HE if required)
Maximum Aggregate Size	20mm
Slump	80mm±30mm
Air Content	5% - 8%
Strength Accelerator	As needed
Hot Water	When required
Exposure Class	C2
Compressive Strength	Min. 20MPa for traffic loading unless otherwise allowed by the City Engineer and 32MPa at 28-day

2. Earthwork

1) Shrub and Tree Preservation

1. Existing trees
    a. Temporary storage sites of construction material or soil excavate shall be as far from neighbouring trees as possible.
    b. Street trees may not be removed, moved, or otherwise impaired, interfered with, or injured without prior approval from the City Engineer. Only City Arborists, or arborists authorized by the Contract Administrator, may prune or remove street trees.
2. Raising Grade Around
    a. The Contractor may not alter the existing grade within the drip line of a street tree, except to raise the grade by no more than:
    • 5cm within a 1m radius around the trunk.
    • 10cm between the 1m radius and the drip line of the tree.
3. Pruning
    a. No tree branches or roots may be pruned or cut without prior approval by the City Engineer. Branches and roots are to be cut with a sharp axe or saw with

the Contract Administrator present. Cutting roots with excavating equipment such as a backhoe, excavator, or Gradall bucket is not acceptable.

b. If branches unavoidably obstruct Work activities, or if they are in such proximity that they are likely to be damaged, the Contractor shall request an inspection by the Contract Administrator to determine the course of action.

4. Work Adjacent to Trees
    a. Site access shall be planned with consideration for avoiding conflicts with street trees. Alternate access routes may be required to protect street trees.
    b. Where required by the City Engineer or City Arborist, alternative root preserving techniques such as hydro-vacuum excavation or hand digging is to be used.
    c. Soil compaction reducing techniques such as weight displacement plates or thick wood mulch (20 – 30cm) may be required by the City Engineer if street tree rooting area is likely to be affected by vehicular movement.

2) Dust Control

1. Haul Routes
    a. Haul Routes along and across any public traveled way shall be kept free and clean of all rubbish and debris, including spillage, resulting from construction operations. Water or dust palliative, or both, shall be supplied as necessary to prevent dust nuisance, to the satisfaction of the Contract Administrator.
    b. Any vehicle exiting the Site that is handling loose material or travelling over loose material shall be inspected to ensure no debris is on the vehicle or between the tires.
    c. If the Site is not adequately controlled for dust, or kept clean to the satisfaction of the Contract Administrator, the City may do the Work at the Contractor's expense. Flushing of debris into City catch basins is not permitted without the express written consent of the City Engineer.
    d. A truck wheel wash station may be required to be installed at the Contractor's expense as per Section 01 57 01 Environmental Protection if tracking occurs.

3. Roads and Site Improvements

1) Granular base

a) 19mm Minus Combined Crushed Aggregate Fill (Mulch) (City of Vancouver Aggregate #9) as per Section 31 05 17 Aggregates and Granular Materials.

2) Signage

1. Signs
    a. Sign blanks shall be of sign-grade aluminum with a thickness of 2mm for the following traffic sign sizes:
        • 300mm x 300mm
        • 300mm x 450mm
        • 450mm x 600mm
        • 600mm x 600mm
        • 300mm x 600mm
        • 450mm x 450mm
        • 600mm x 600mm
        • 750mm x 600mm

- 600mm x 900mm
- 750mm x 750mm
- 900mm x 900mm
- 600mm x 1050mm
- 800mm x 1200mm

b. All side-mounted street name sign blades shall be fabricated from 178mm tall sign-grade aluminum with a thickness of 3.15mm and covered with Type 1 reflective sheeting.
c. Overhead street name signs shall be fabricated from 356mm tall sign-grade aluminum with a thickness of 3.1mm and covered with Type 9 reflective sheeting.
d. Object marker signs and keep right signs shall be fabricated from 10mm thick corrugated plastic and covered with Type 4 reflective sheeting.
e. Temporary stopping prohibited signs shall be fabricated from a fiberglass-reinforced polyresin material with a thickness of 1.5mm. Reflective sheeting is not required for this type of sign.
f. For colour contrast and sign layout, comply with the guidelines and requirements of MUTCDC, which sets forth procedures in manufacturing effective traffic and highway control and information signs.

2. Sign Font
   a. ClearviewHwy font shall be used for all overhead information signs, overhead street name signs, standard street name signs, and construction signs.
3. Sign Installation Hardware
   a. All sign installation hardware (nuts / bolts and washers) must be stainless steel 18-8 S / S.
   b. All sign installations must use (band-it) strapping C20599 201 stainless steel 15.9 mm width and 0.76mm thickness.
   c. Lamp standard side mount hardware must be stainless steel N-70-D021 mounts.
   d. Pipe clamps are to be HS-1-SS 3/8 RP centermount.
4. Sign Post Bases
   a. Ericsson Mfg. concrete single-post pyramid bases 24 and 37 KG, or Approved Equal.
5. Sign Pipe
   a. When steel utility poles such as street light poles and traffic signal poles are not available, sign supports shall be 60mm 13-gauge gator galvanized steel posts in 3.0m/3.7m/4.6m lengths (subject to requirements) comes with 9.5mm up from bottom.
   b. Pipe plastic to be CSA SCH 80 PVC.

4. Topsoil and Finish Grading

1) Products

1. Growing Medium
   a. Growing medium shall be free from subsoil, plants or their roots, building materials, wood, non-composted wood, wood waste, woody plant parts, insect pests, plant pathogenic organisms, chemical pollutants or substances at levels toxic to plants, stones (in excess of 10mm in maximum dimensions), foreign objects, and other extraneous materials that detract from the desirable

physical and chemical properties required for landscaping purposes. All soil products supplied to the City are to be free of Neonicotinoids.

b.

Properties	Soil Amendment	Street Turf Mix	Street Shrub Mix	Bioretention Soil (Park Turf Mix)
C:N	25:1-10:1	20:1-10:1	20:1-10:1	20:1-10:1
%OM	40-65%	3-10%	10-20%	10-20%
%Sand	15-35%	30-60%	30-60%	70-85%
%Silt	5-15%	10-35%	10-35%	5-15%
%Clay	7-17%	5-15%	5-15%	0-15%
Tot. Silt & Clay	15-30% max	40% max	40% max	20% max
Acidity (pH)	4.5 - 8.0	6.0 - 7.0	4.5 - 6.5	4.5 - 8.0
Max Particle Size	100% passing 0.5” sieve	100% passing 0.5” sieve	100% passing 0.5” sieve	100% passing 0.5” sieve
Nitrogen (N)	2	4	2	4
Phosphorus (P) (ppm)	390	324	443	324
Potassium (K) (ppm)	2681	1956	2114	1956
EC	n/a	n/a	n/a	n/a
SAR	8.8%	2.22%	2.34%	2.22%

c. Growing medium shall be free from nuisance, noxious and invasive weeds and seeds or parts thereof.
d. Growing medium shall be free of pathogens harmful to humans, including but not limited to Fecal Coliforms, Salmonella and E. coli.
e. If engineered soil is specified on the Drawings, the growing medium shall be as per Section 32 91 22S Engineered Soil.

2) EXECUTION

1. Processing Growing Medium
   a. Screening:
   .1 Standard (Single Screen) – 100% passing through a 12.7mm screening machine (unless otherwise specified in the table in 2.10.5 of this Section).
   .2 Optional Double screen – 100% passing through a 9.52mm screening machine.

.3 Double screening is weather dependent and can only be done in dry weather or after 2 to 3 consecutive dry days.
.4 Screening of soil must have occurred within one week of delivery.

b. Peat moss shall not be used

2. Placing Growing Medium
    a. The growing medium shall be moderately compacted (e.g. 90% density) with a slight crown to account for near-term settlement.
    b. Boulevard soil shall be placed at a minimum depth of 300mm in turf areas. A minimum depth of 450mm shall be placed in planted areas of the boulevard.
    c. Underground utilities and conduits shall maintain their required minimum granular cover as specified by the utility. In these areas, at least 150mm of boulevard growing medium shall be placed over the granular cover (300mm preferred); the thickness shall be as per the Contract Documents.
    d. In areas with poor draining subgrade soils, curb drains shall be installed adjacent to the sidewalk or at the back of curb according to the Contract Documents, Section 03 30 20 Concrete Walks, Curbs and Gutters and as per Standard Detail Drawing C6.1.
3. Applying Fertilizers
    a. Add fertilizers to bring growing medium fertility within ranges set out in this Section, and as recommended by testing of the growing medium.
4. Finished Grading
    a. The desired crossfall through a grass or planted boulevard to the curb is 4%; the allowable crossfall of a grass or planted boulevard shall be between 2% and 6% or as otherwise approved by the City Engineer. If there is settlement in the boulevard during the two-year Warranty Period, the areas must be re-graded / top-dressed to prevent trips (settlements over 6mm), particularly at the edge of curb and edge of sidewalk.

3) Planting of Trees, Shrubs and Ground Covers

1. Drainage Control
    a. If indicators of poor drainage are detected before or during the time of planting, notify the City Engineer.
    b. When planting where Park Board has determined that a drainage correction is impossible or impractical, the root collar shall be planted higher in relationship to the surrounding soil by 7.5 to 10cm.
2. Inspection and Testing
    a. All tree plantings must be inspected by the Parks Board. Inspection is to be coordinated through the Contract Administrator with a minimum 72 hours' advance notice. One week advance notice is preferred.
3. Plant Material
    a. Preference will be given to plant materials grown in Pacific Northwest America.
    b. All trees shall be nursery field grown and be balled and burlapped or in wire basket. Trees may not be container grown. Shrubs, perennials and other similar plants may be container grown.
    c. All trees shall be:
    • on a single leader, with the lowest branch being at least 2m high on the stem

- of 6cm caliper or greater if deciduous
- of 2.5m height or greater if coniferous

d. All trees shall be free of:
- pest and disease
- pernicious weeds in the root ball
- injury, or other defects
- girdling roots

e. Where planting projects require more than 10 trees, the City Engineer reserves the right to select and tag optimal specimens at the source or wholesale nursery.

f. Minimum root ball diameters for coniferous trees are:

Height	Tall and columnar	Tall and broad
200cm	50cm	60cm
250cm	55cm	70cm
300cm	70cm	85cm

g. Minimum root ball diameters for deciduous trees are:

Caliper	Root ball diameter
6cm	60cm
7cm	70cm
8cm	80cm
9cm	90cm
10cm	100cm
12.5cm	110cm
15cm	120cm

4) EXECUTION

1. Subgrade Preparation
   a. Excavation of the subgrade shall be only as necessary to permit the bottom of the rootball to sit on undisturbed material or compacted fill such that the top of the rootball remains at the proper finished grade. If material below the rootball has been disturbed, recompact all material to prevent settling of the root ball in the hole.
   b. All digging in the street boulevard for street trees must be done by hand. No mechanical equipment is to be used to dig the holes (i.e. no backhoes and post hole diggers).
   c. Wherever possible, the hole shall be dug with sloping sides. The preferred angle is 45˚.
2. Planting
   a. When the backfill has been placed up to 2/3 of the rootball height, basket ties shall be cut and the top 1/3 of the burlap and basket folded back downwards.

Remove container from grown stock before planting. No burlap or wire shall be showing above the finished grade. Ties must be pushed back into the lower portion of the hole.

b. A 10cm raised saucer, of inside diameter equal to the outside diameter of the root ball, shall be constructed around the perimeter of the rootball to enhance water infiltration.
c. Ensure tree is planted in the exact centre of the specified planting station straight and true.
d. Root barriers must be installed at the time of planting whenever a tree is installed within 2m of a sidewalk or other hardscape feature – excluding roads; or where specified on the Drawings. Root barriers shall be installed as per manufacturer's specifications.

3. Watering
    a. Trees shall be immediately and adequately watered after planting.
4. Mulching
    a. Mulch shall be placed inside the berms of the saucer, to a depth of 7cm – 9cm. The mulch shall be kept away from the tree trunk.
5. Guarantee/ Maintenance
    a. The Two-year Warranty Period will apply for landscape work. Contractor to guarantee all materials and workmanship for a period of two full years from date of Total Performance, unless specified otherwise in the Contract Documents.

5. Traffic Signals

1) Products

1. Traffic and Pedestrian Signals
    a. Traffic signal heads shall be polycarbonate and pedestrian signal heads shall be aluminum and conform to the latest TAC and ITE standards and specifications. Housing and visor colour shall be yellow. Tunnel or cowl visor shall be provided as defined. Each pedestrian signal head shall be designed for a 450mm bi-modal LED display with countdown display. All primary and tertiary signal heads shall have yellow polycarbonate backboards with 75mm border of yellow prismatic retro-reflective sheeting (3M™ Scotchlite™ Diamond Grade™ VIP Reflective Sheeting Series 3990 or Approved Equal).
    b. Fire signal heads shall have special yellow backboards as shown on Standard Detail Drawing E5.17. All fire signal backboards shall have a 75mm border of white prismatic retro-reflective sheeting (3M™ Scotchlite™ Diamond Grade™ VIP Reflective Sheeting Series 3990 or Approved Equal).
2. Pedestrian / Cyclist Pushbuttons
    a. Where noted on the Drawings, pedestrian pushbuttons shall be Polara APS or Novax type.
    b. Cyclist pushbuttons shall have white background and black raised characters. Button mechanism is to be raised style with mounting fully external to the pole (recessed button will not be accepted).
3. Illuminated Crosswalk Signs
    a. Crosswalk internal illumination and downlight shall be LED.
4. Advance Warning Signs

a. Advance warning signs shall have illustration details in yellow prismatic retro-reflective sheeting (3M™ Scotchlite™ Diamond Grade™ VIP Reflective Sheeting Series 3990 or Approved Equal). Signal heads shall be 200mm, or 300mm if determined necessary, yellow aluminum or polycarbonate with amber LED's and cowl visors.

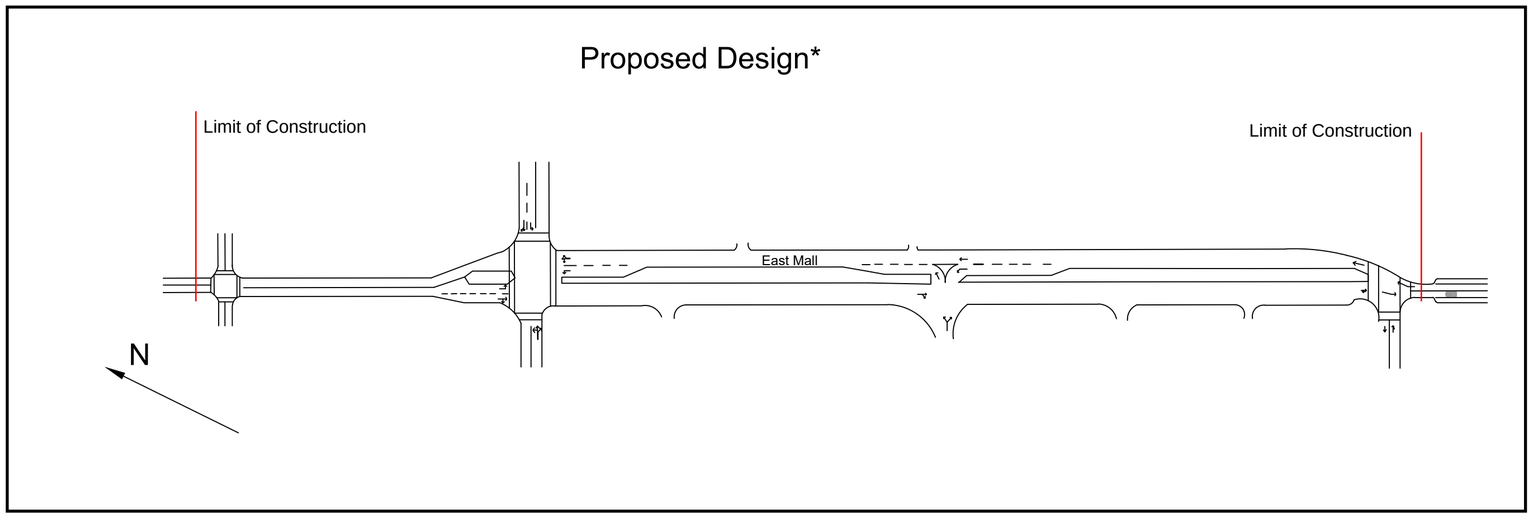
5. Street Name Signs
    a. Street name, restriction, mandatory, or other specified signs shall be safety cabled to the pole arm using 2.4mm galvanized steel aircraft cable or galvanized safety chain (5mm galvanized regular link grade 30) on both ends of the sign which shall be looped through small holes in the street name sign and fastened at both ends of sign to the signal arm.

2. EXECUTION

1. General
    a. When tying into or upgrading an existing installation, maintain the existing traffic signal(s) in operation at all times. Where the signal operation can't be maintained, the Contractor shall provide traffic control and flagging to meet City requirements and to maintain safe and efficient traffic flow. The City's Electrical Operations shall make all connections and terminations to existing City installations and infrastructure; a minimum of 5 Days advanced notice is required.
2. Concrete Bases
    a. Refer to Standard Detail Drawings CE1.1 to CE1.7 for poured-in-place concrete base details. All concrete bases shall be poured-in-place type, unless approved by the City Engineer.
3. Traffic and Pedestrian Signal Head Mounting
    a. Install signal and pedestrian heads as per Standard Detail Drawings E5.2 and E5.9A to E5.9B.
    b. Traffic signal heads and pedestrian signal heads shall be completely obscured with proper signal head covers designed for the purpose from the time of installation until the system is in operation. Traffic signal head lenses and pedestrian signal head lenses and reflectors shall be cleaned prior to signal start-up.
    c. Primary traffic signal heads shall be minimum 5.0m and maximum 6.0m from the bottom of the primary traffic signal head backboard to the finished road grade below and have galvanized safety cable or chain installed.
    d. Secondary traffic signal heads shall be minimum 2.3m from finished grade to the bottom of the signal head.
    e. Use Traffic Signal Yellow touch-up paint to repair any spots where the original finish is scratched.
    f. Secondary and pedestrian signal head mounting arms at skewed intersections are to be drilled in the field to achieve optimum viewing angles.
    g. Where signal heads are single-point attached to the signal arm with spring cushion type hangers, the back of primary heads shall have a C-channel bolted to the head to attach the safety cable or chain to the signal arm.. Chains shall be bolted to the arm.

Appendix G: Construction Drawings

DRAWING INDEX



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University of British Columbia
SEEDS Sustainability Program
(Social Ecological Economic Development Studies)

EAST MALL REDESIGN BETWEEN
AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	

Drawing Title

Key Plan

Revision	Drawing Number
0	001

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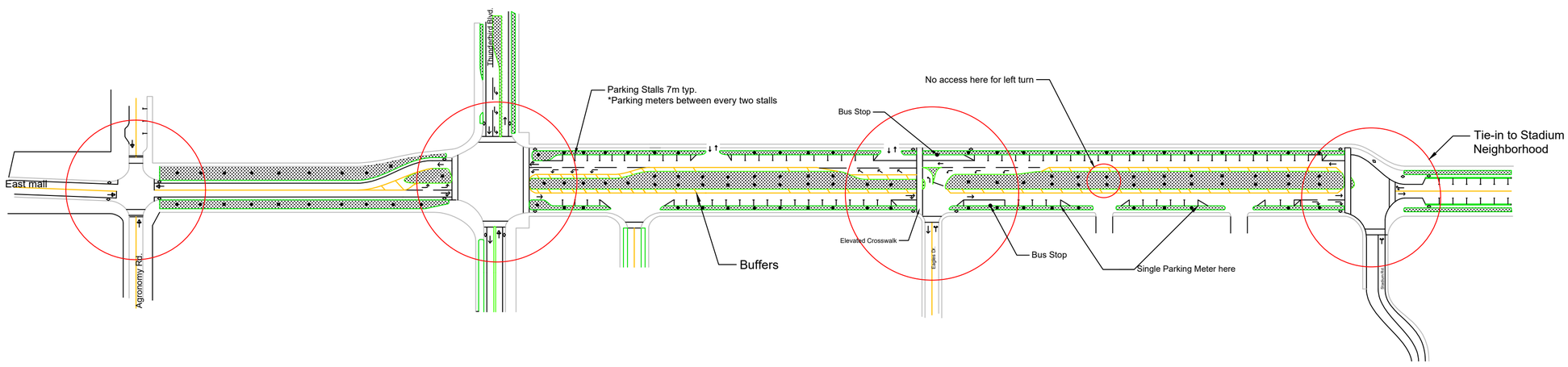
N



*Double parking meter between every two stalls, except for when single is needed (as indicated)

*For dimensions between intersections refer to profile drawings

Green Space

Bike Lane

Parking Stall

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EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1mm = 1770**

Drawing Title

OVERVIEW LAYOUT PLAN

Revision	Drawing Number
0	001

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Gerald McGavin Bldg

Agronomy Rd.

Existing Parking Stalls and Meters (Do Not touch)

N

Single Parking Stall

Refer to DWG

Starbucks

Existing Tree

8000

1800
typ.

7070

B2

A2

Pedestrian cover (refer to DWG 301)

East Mall

1500

3500

7500

4500

A1

B1

1800

8000 typ.

50
Km/hr

Plant new tree

Foundation location for canopy (Refer to survey documents)

Pulp and Paper Centre

UBC Centre for Advanced Wood Processing

Bike lane sign and symbol on pavement at this location

Only bike lane symbol on pavement at this location

*Do not disturb existing trees

Please refer to survey document for exact location of foundation

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EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	1mm = 221 mm

Drawing Title

AGRONOMY RD INTERSECTION

Revision	Drawing Number
0	102

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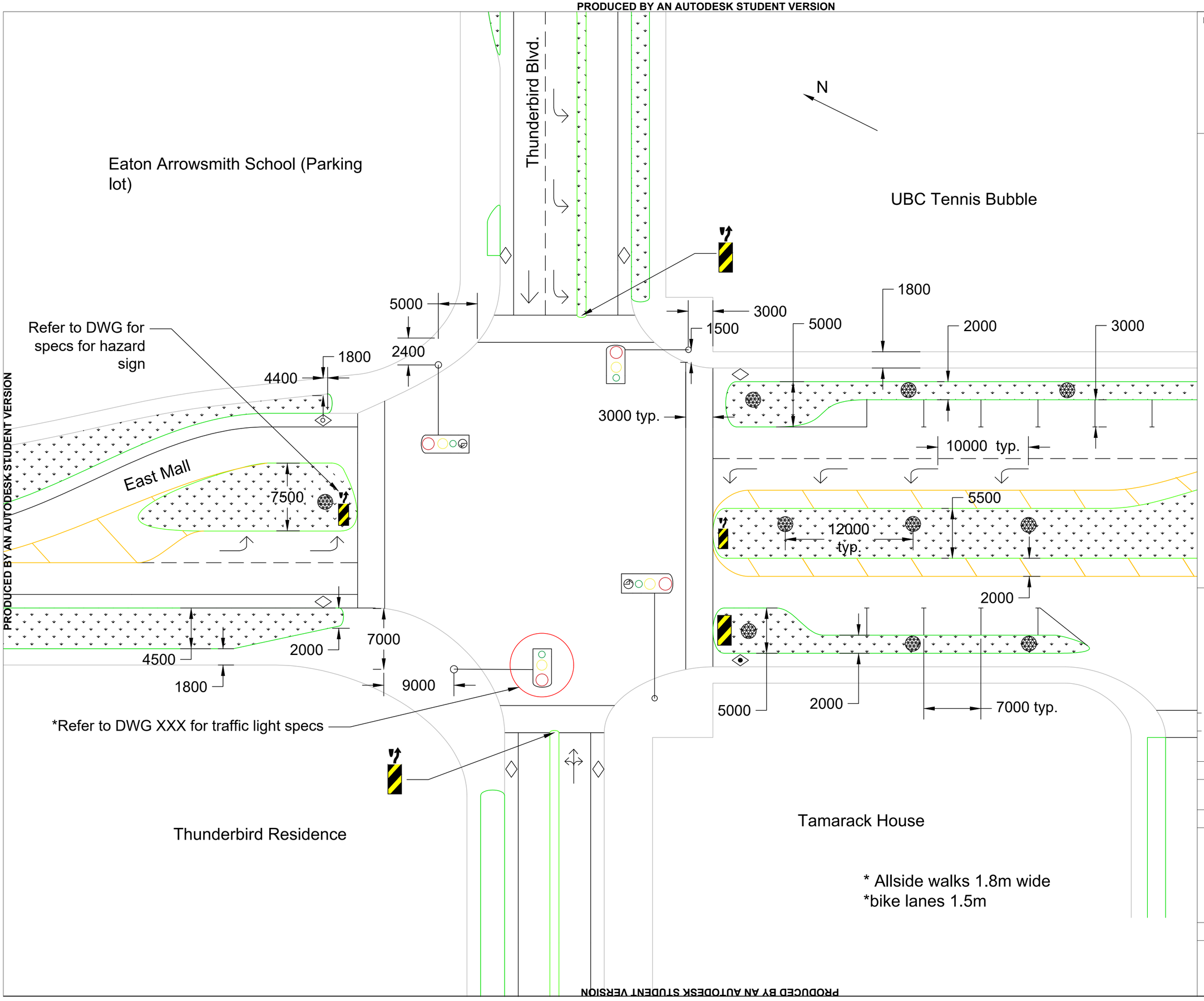
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE



Drawing Date	Drawing Scale
12 APRIL 2021	1mm = 258 mm

Drawing Title

Thunderbird Blvd. Intersection

Revision	Drawing Number
0	103

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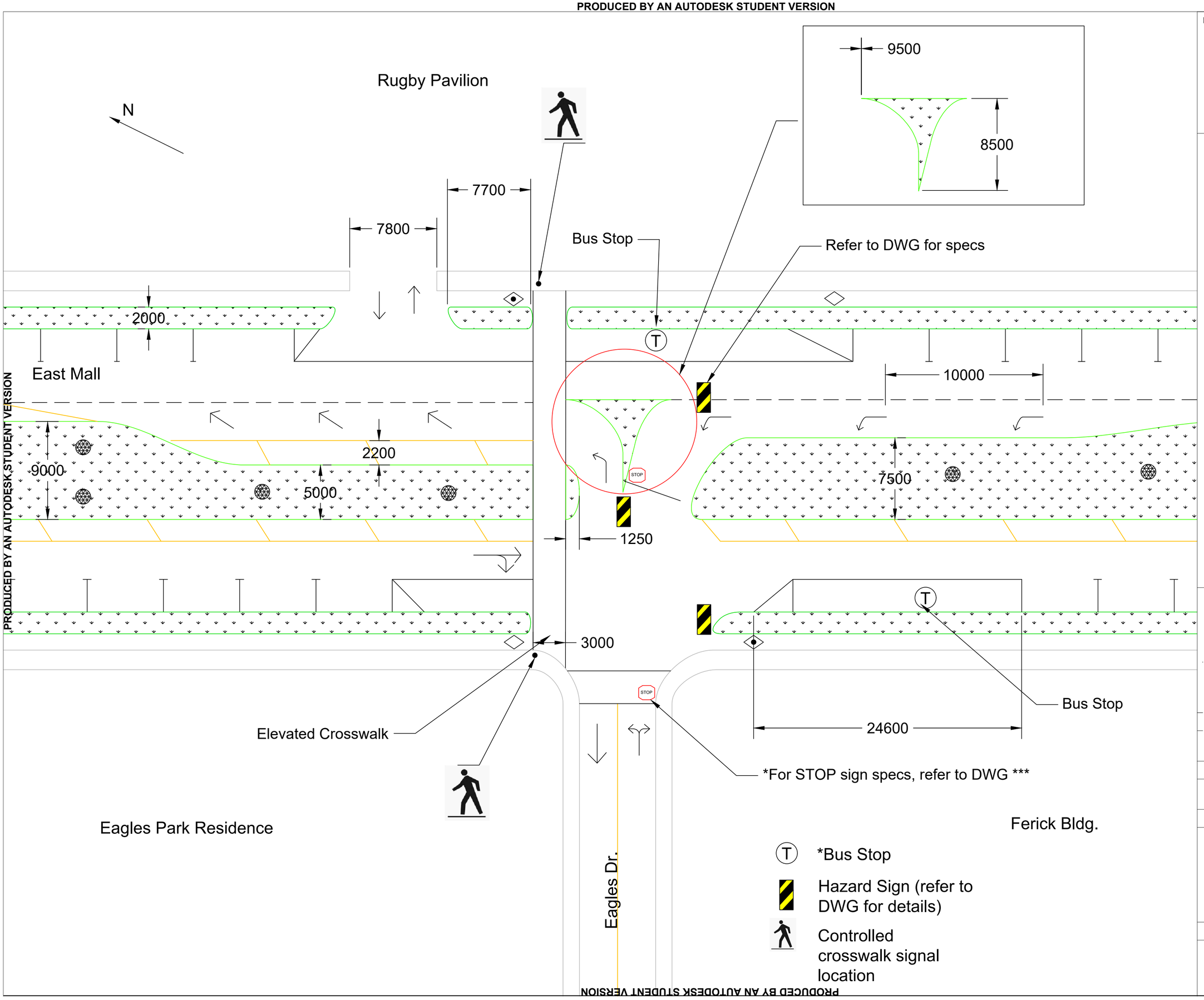

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EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

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Drawing Date	Drawing Scale
12 APRIL 2021	1mm = 216 mm

Drawing Title

Eagles Dr. Intersection

Revision	Drawing Number
0	104

Warren Feild

N

50
Km/hr

2000

13000

Bike Lane
widens to 2m

Stadium Neighborhood

East Mall

3000

9000

7000

8000

5000

25760

3090

STOP

Forintek

Thunderbird Blvd.

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AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	1mm = 224 mm

Drawing Title

Stadium Rd. Intersection

Revision	Drawing Number
0	105

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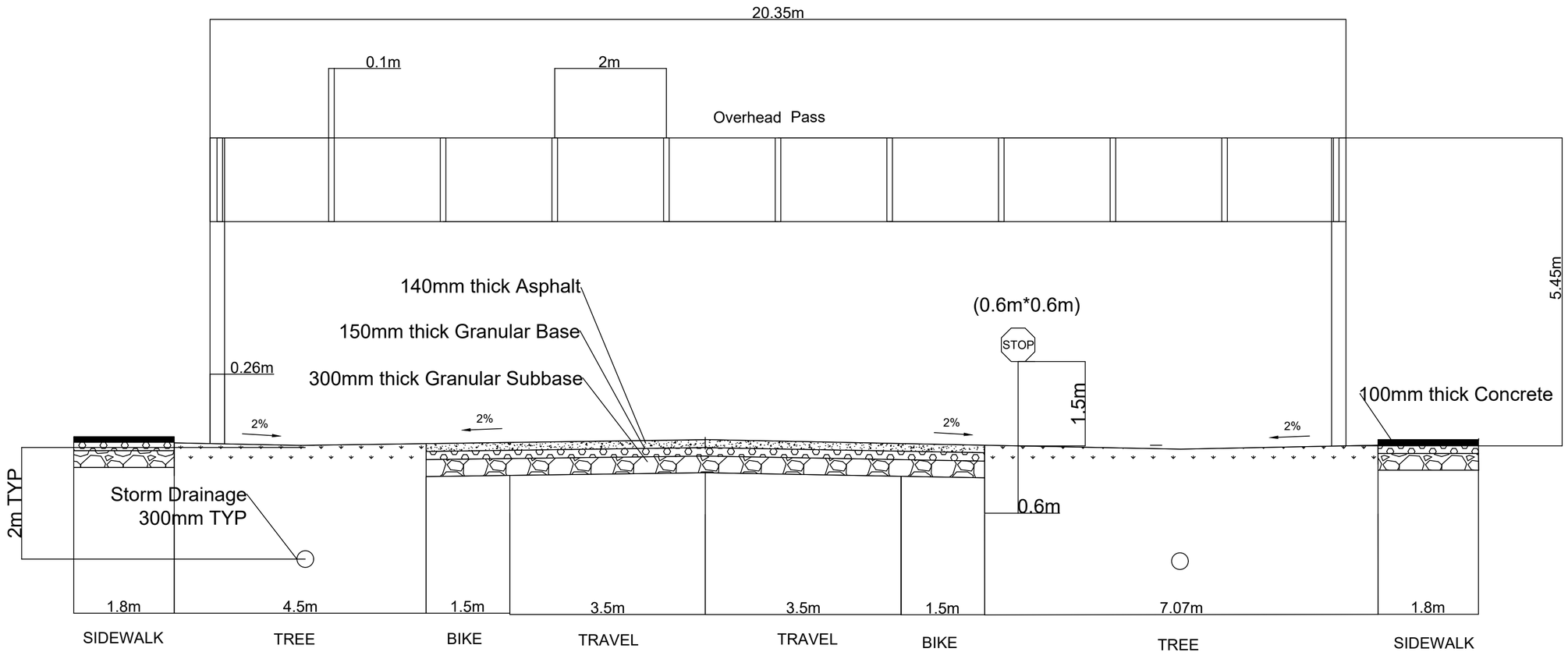

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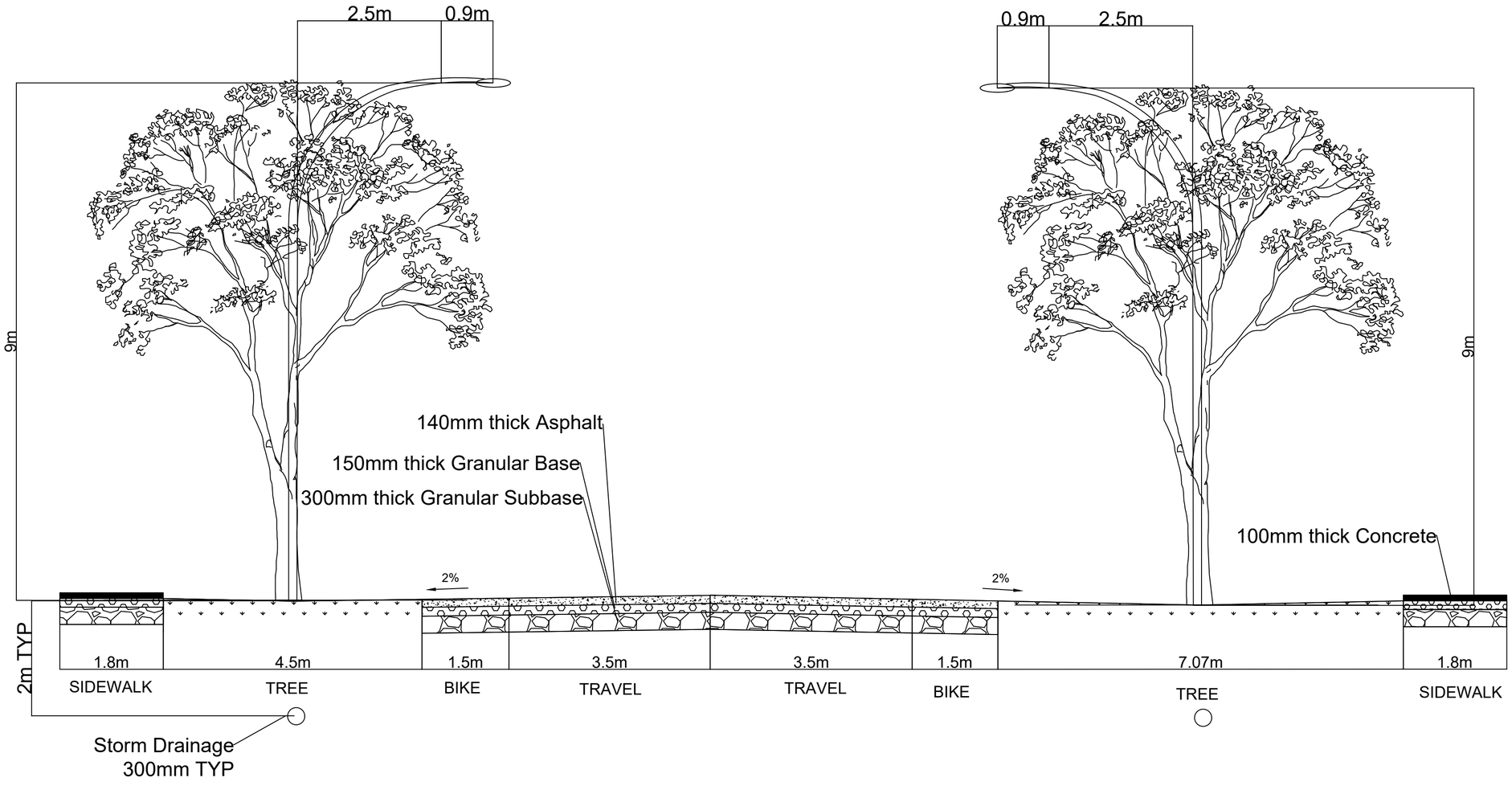
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:1.5**

Drawing Title

AGRONOMY RD INTERSECTION

Revision	Drawing Number
0	201



0m 1m 2m

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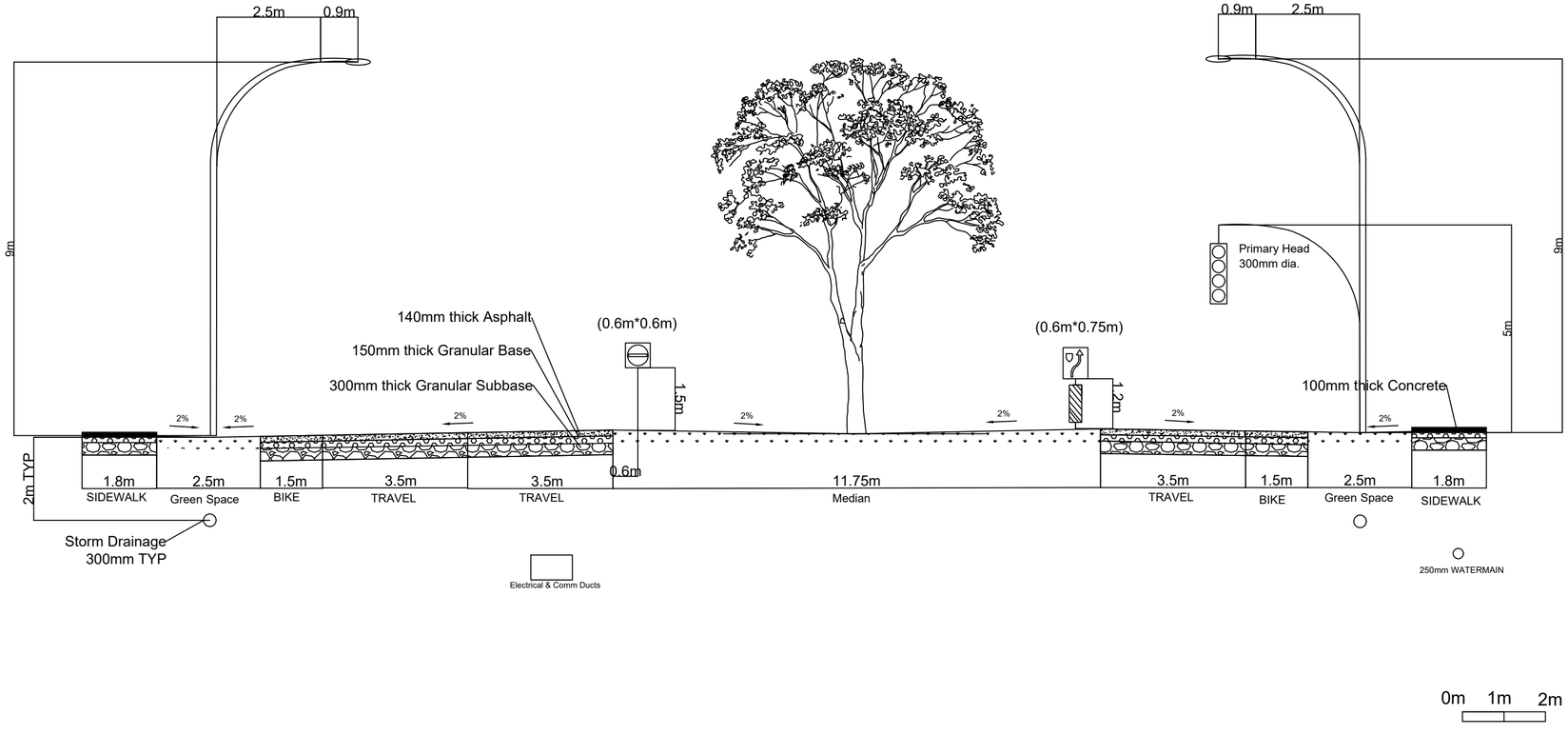
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:1.5**

Drawing Title

AGRONOMY RD TO THUNDERBIRD BLVD

Revision	Drawing Number
0	202



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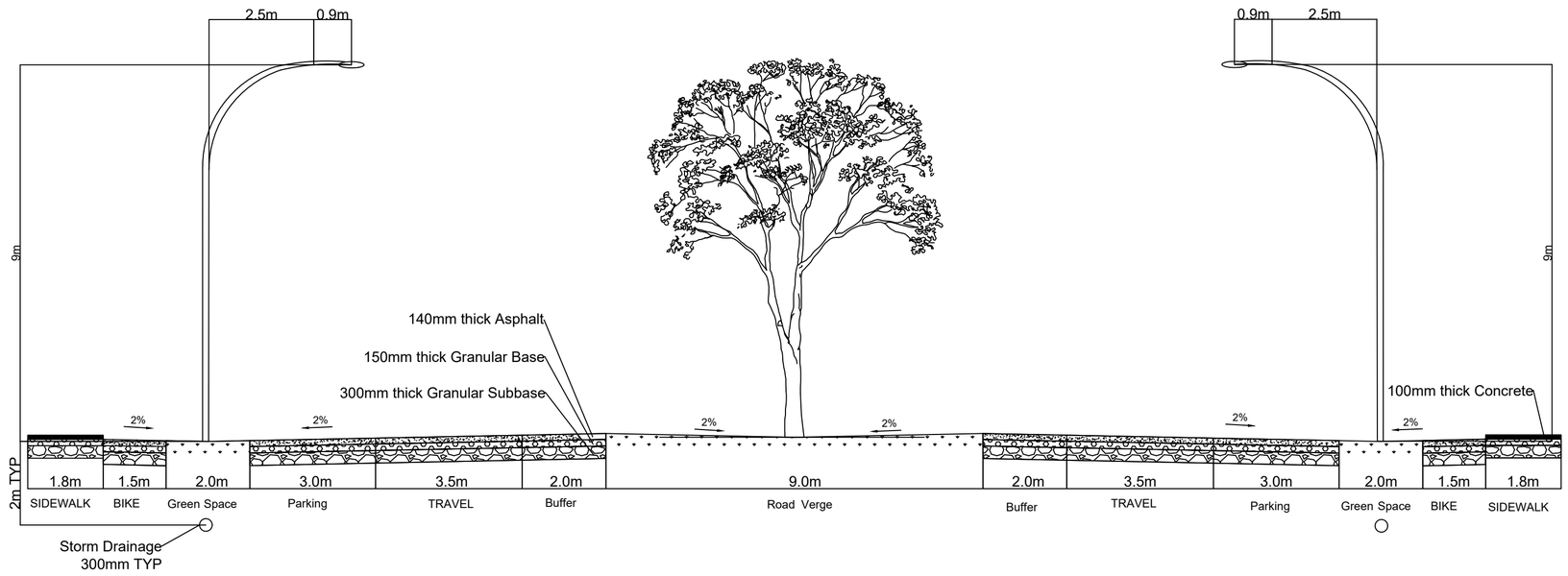
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:2**

Drawing Title

THUNDERBIRD BLVD INTERSECTION

Revision	Drawing Number
0	203



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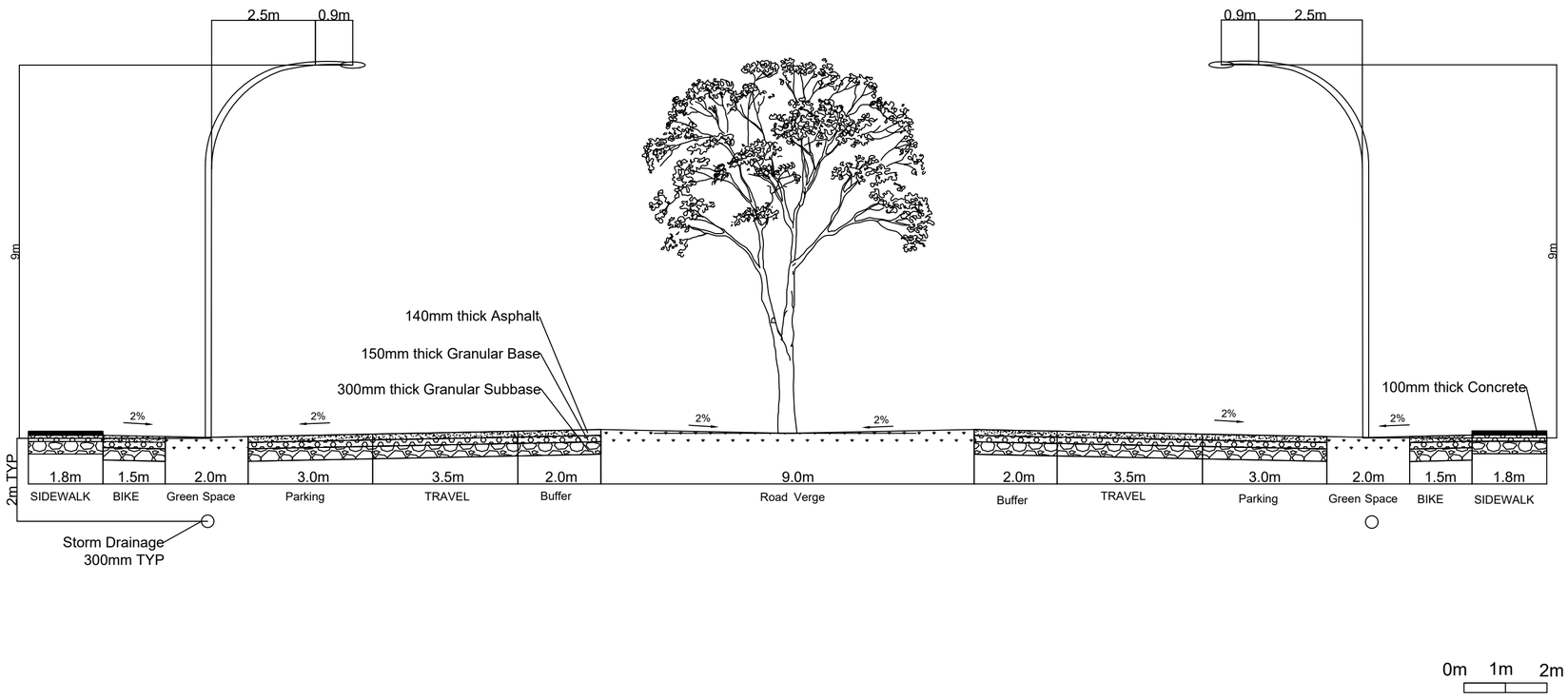
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:2**

Drawing Title

THUNDERBIRD BLVD TO EAGLES DR

Revision	Drawing Number
0	204



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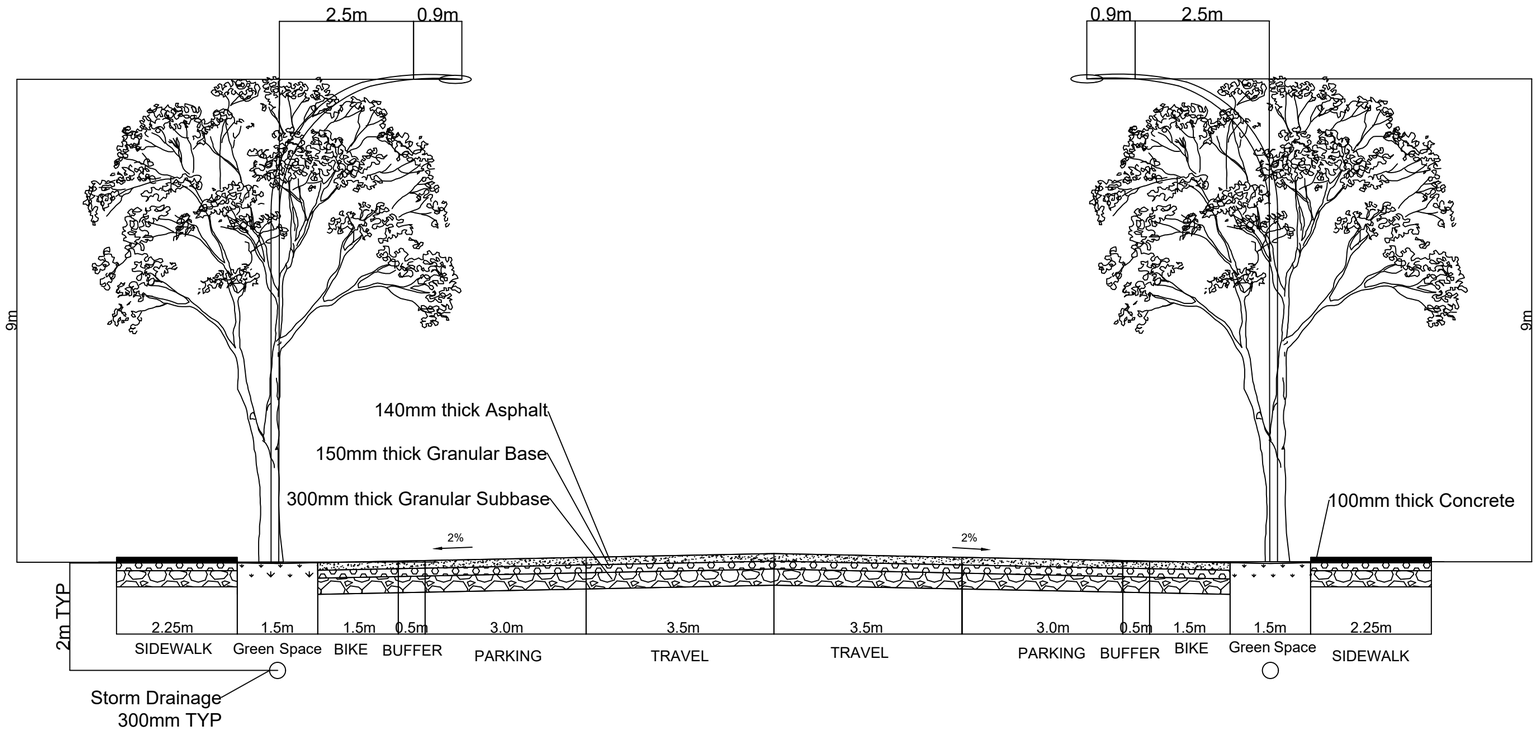
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:2**

Drawing Title

EAGLES DR TO STADIUM RD

Revision	Drawing Number
0	205



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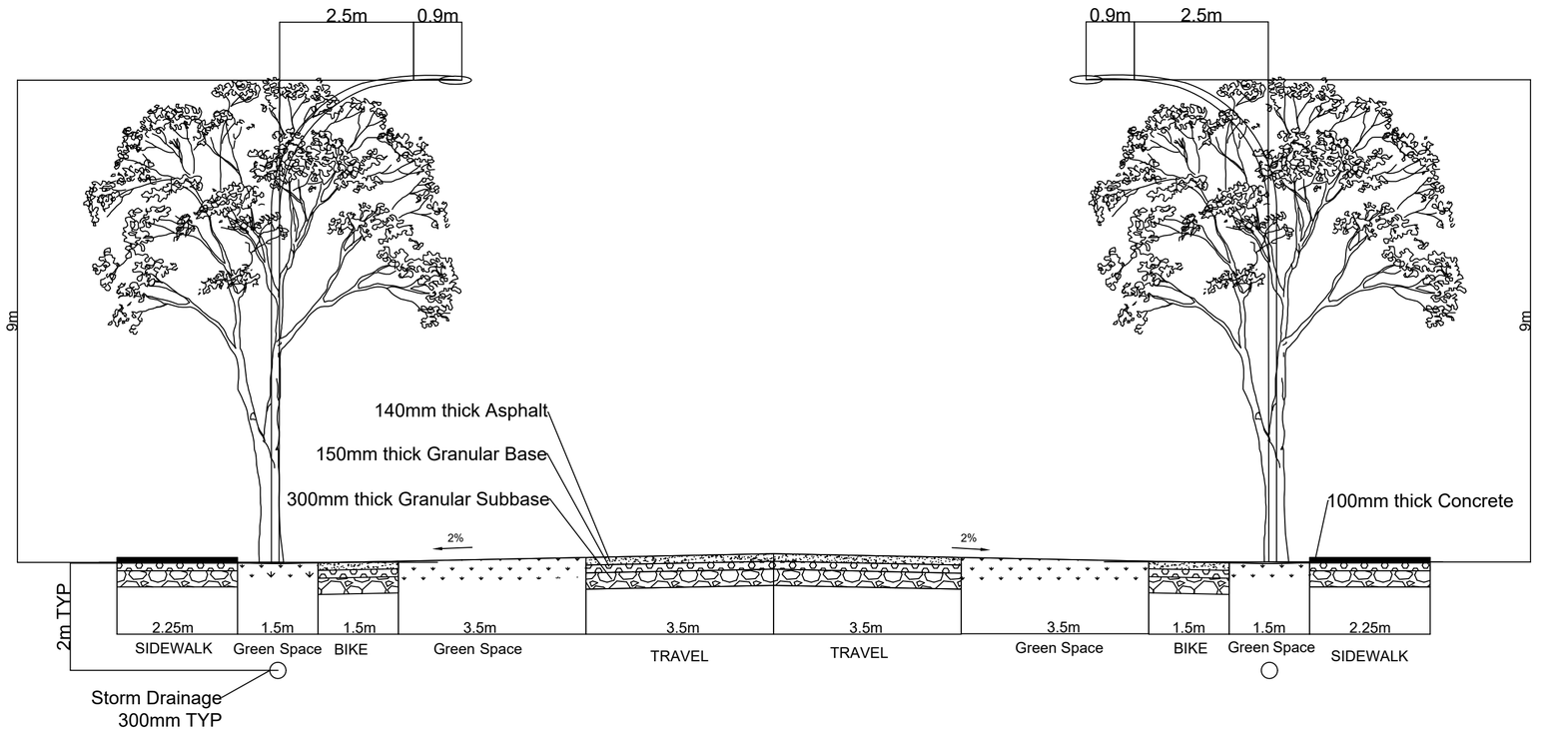
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1:2**

Drawing Title

STADIUM RD TO W16TH AVE

Revision	Drawing Number
0	206



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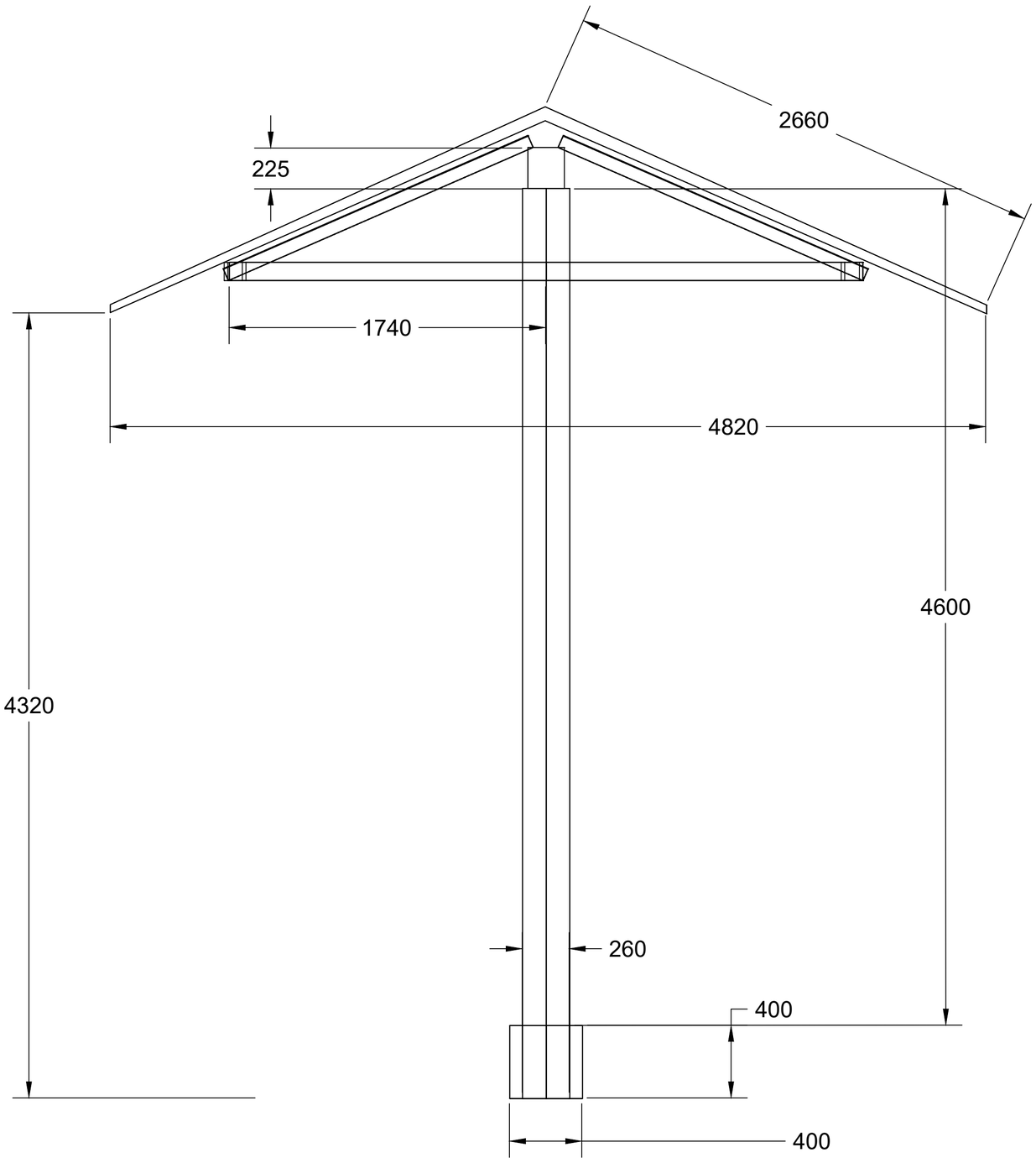
EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
13 APRIL 2021	**1:2**

Drawing Title

W16TH AVE INTERSECTION

Revision	Drawing Number
0	207



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EAST MALL REDESIGN BETWEEN
AGRONOMY ROAD & WEST 16TH AVENUE

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Drawing Date	Drawing Scale
12 APRIL 2021	1mm = 41 mm

Drawing Title

Canopy Design
Front View

Revision	Drawing Number
0	301

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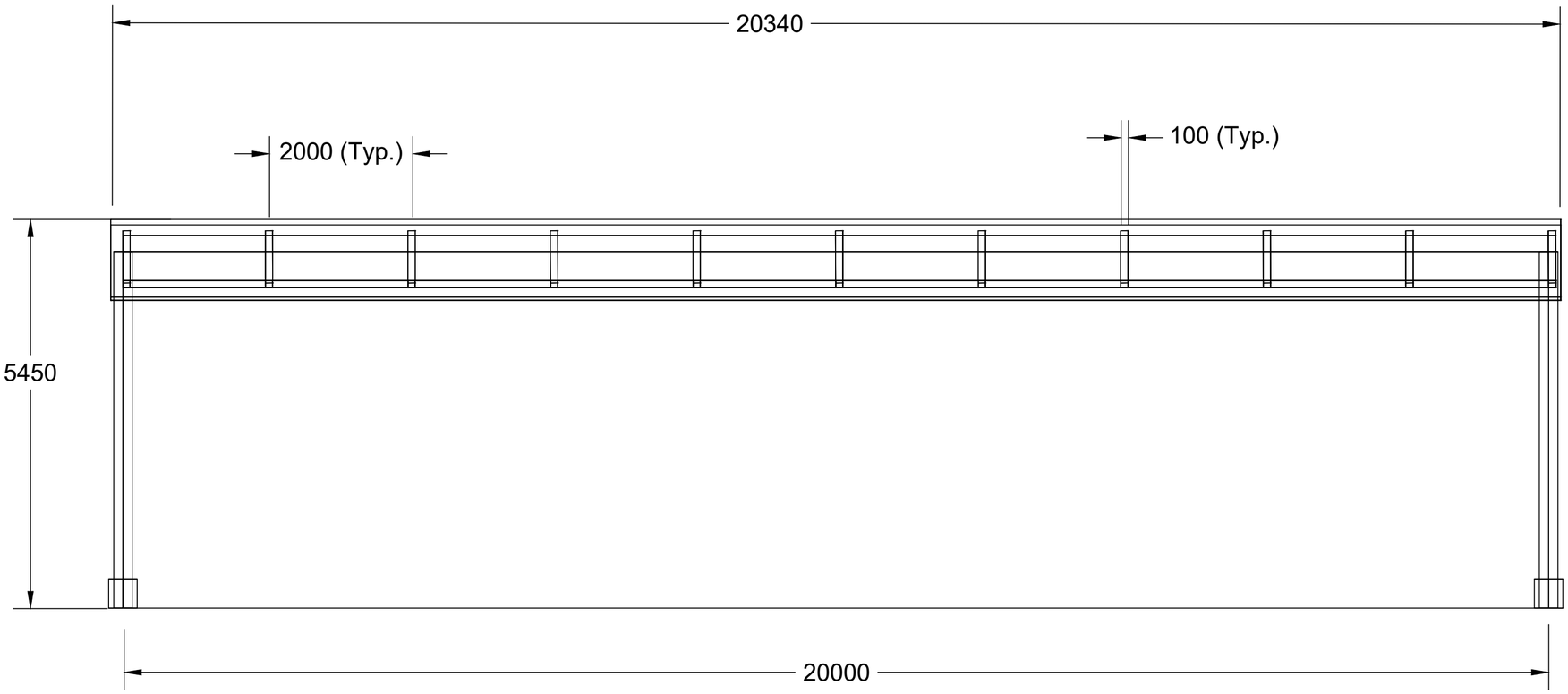

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EAST MALL REDESIGN BETWEEN AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1mm = 134 mm**

Drawing Title

Canopy Design Side view

Revision	Drawing Number
0	302

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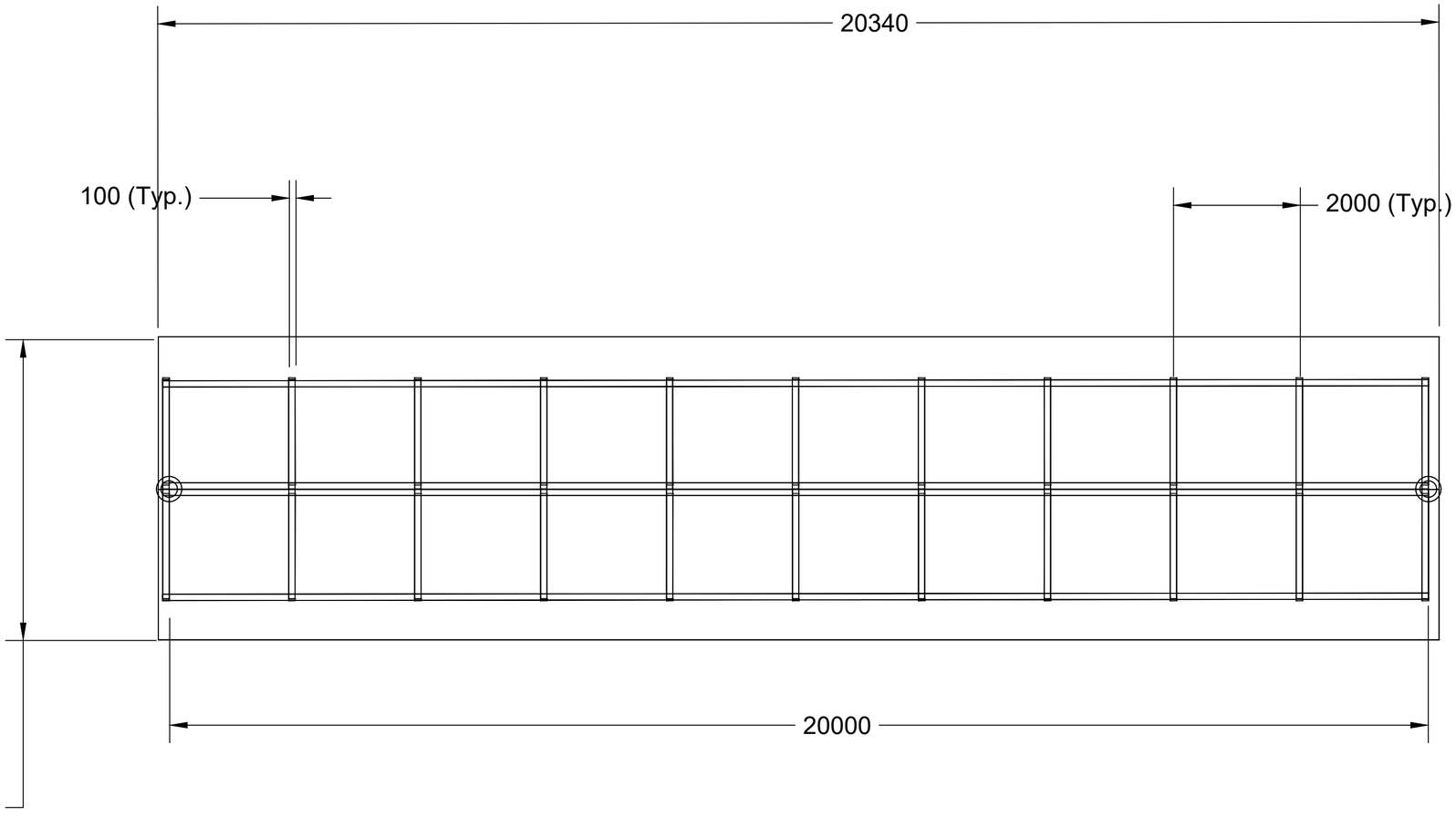

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EAST MALL REDESIGN BETWEEN
AGRONOMY ROAD & WEST 16TH AVENUE

Drawing Date	Drawing Scale
12 APRIL 2021	**1mm = 97 mm**

Drawing Title

Canopy Design
Plan View

Revision	Drawing Number
0	303

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PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION