I-25 MOBILITY HUB (LONE TREE)

Project Number: 267-0252-499
Project Code: 24278

West and East Pedestrian Ramps at I-25 and Lincoln Ave
Lone Tree, Colorado

Structure Selection Report (SSR)
Structure # F-17-QX

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08/29/2024

Prepared for:
Project Stake Holders

COLORADO Department of Transportation
CITY OF LONE TREE
DOUGLAS COUNTY COLORADO

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Revision Date: 8/29/2024

Table of Contents

Table of Figures

List of Tables

1. EXECUTIVE SUMMARY

1.1 Executive Summary

The Lone Tree I-25 Mobility Hub Design supports Colorado's evolving transportation system by integrating modal choices to move people throughout the network. The Lone Tree I-25 Mobility Hub is located within the City of Lone Tree along the I-25 corridor on the south side of Lincoln Avenue between milepost 191.00 and milepost 193.5 in Douglas County. Transportation centers such as this one emphasize multimodal options, seamless mode-to-mode transitions, real time passenger information, passenger convenience supported by transit-friendly development in surrounding areas. The Lone Tree I-25 Mobility Hub has slip ramps for Bustang bus routes, bus shelters, pedestrian bridge and ramps, and fully connected sidewalks to surrounding areas.

The purpose of this report is to discuss the structural design criteria relevant to the pedestrian ramps connecting the pedestrian bridge to the sidewalks of the surrounding areas and to provide project stakeholders with confidence that the most appropriate structure type is selected. This report is developed in parallel with a similar study for the bridge connecting the ramps over the I-25 mainline.

The following sections of the report discuss alternative structural solutions and provide an overall recommendation with supporting rationale. The structure alternatives listed below are considered in the selection process:

- Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders
- Cast-in-Place Concrete Deck on Steel Girders
- Cast-in-Place Concrete Deck on Prestressed Box Girders

Cost, Maintenance & Durability, and ***Aesthetics*** are the selection criteria factors taken into consideration. In this case, the primary stakeholders of concern are the Colorado Department of Transportation (CDOT) and the City of Lone Tree, hereafter referred to as "Lone Tree". The structure selection of a Cast-in-Place Concrete Deck on Prestressed Box Girders has been identified to minimize cost while providing an aesthetic, low maintenance and highly durable structural system. The Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders score similarly on the Maintenance & Durability factors, yet this structural system scores the highest for cost. The Cast-in-Place Concrete Deck on Steel Girders provides a lower cost option compared to all cast-in-place construction, but it scores lower with Maintenance & Durability factor compared to the Prestressed Box Girder. **Therefore, the selection of a Cast-in-Place Concrete Deck on Prestressed Concrete Box Girders structural system is recommended for this project given the constraints and selection criteria.**

1.2 Project Description

The Lone Tree I-25 Mobility Hub project includes both the northbound and southbound directional movements and hubs on I-25 in the City of Lone Tree, located in Douglas County. This transit improvement project consists of constructing slip ramps along the I-25 northbound off-ramp and southbound on-ramp for use by Bustang transit services, a pedestrian bridge connecting the two transit stops, pedestrian ramps, and sidewalks.

This project intends to provide northbound and southbound mobility hubs along I-25 in the City of Lone Tree for CDOT's Bustang service, allowing the transit service minimal delay to depart and re-enter I-25. Coordination between the Lone Tree I-25 Mobility Hub Project and the ongoing I-25/Lincoln Interchange Project (Advancing Lincoln Avenue) is essential to ensure compatibility between the two improvement projects. Consideration and subsequent collaboration with neighboring developers and stakeholders will be vital to the success of this Project as well.

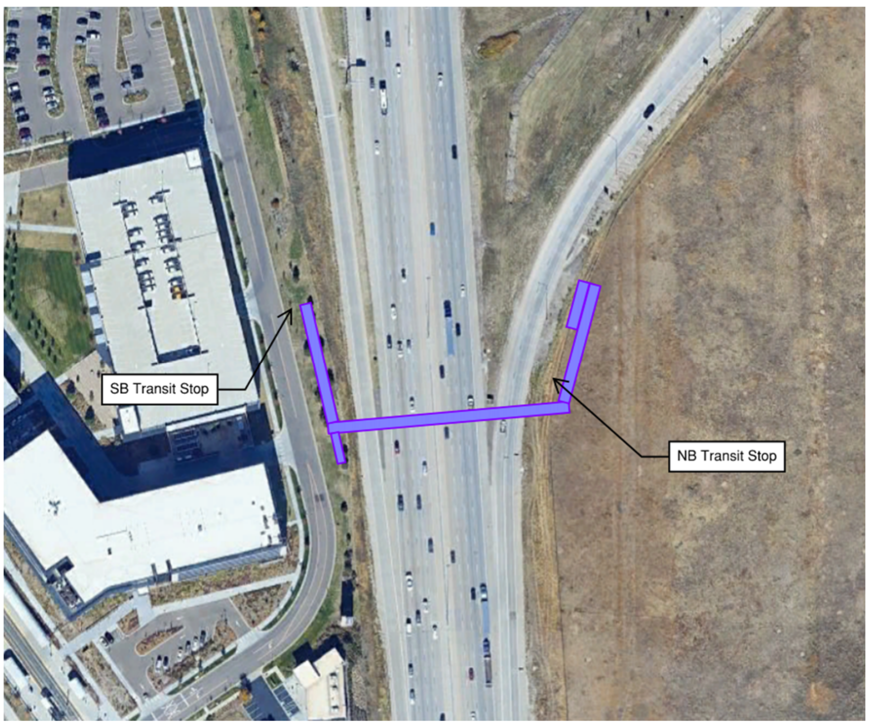


FIGURE 1: STRUCTURE LOCATION OVERVIEW

1.3 Purpose of the Report

The purpose of this Structure Selection Report is to give the project owners confidence when funding the most effective structure type. The report documents critical design considerations, evaluates feasible structure alternatives, and presents structure alternatives for the proposed solution. This report provides information concerning the project location and the proposed structure selection process as required by the Colorado Department of Transportation (CDOT) Staff Bridge, *Bridge Design Manual Section 2.10.*

In addition to the structure selection discussions, this report includes other pertinent information such as project impact on the following areas: environment, roadway, traffic, drainage, ROW, utilities, and any site-specific constraints within the limits of work.

This report aims to advance design to 30% level, including structure selection. Final design, detailing, bidding, and construction follows in subsequent phases.

1.4 Structure Selection Process

The Colorado Department of Transportation contracted with RS&H to prepare a conceptual design of the Pedestrian Bridge and Ramp structures for the Lone Tree I-25 Mobility Hub project. The RS&H team is responsible for delivering structure selection reports and developing final plans, quantities, and cost estimation for the proposed pedestrian bridge and ramps over Lincoln Avenue.

The structure selection process includes recommendation of feasible structures for future evaluation and approval from CDOT. The recommendation is based on a complete review of project constraints, feasible structure solutions, design criteria, cost, constructability, drainage, roadway, traffic, and environmental concerns. The process followed in this report applies to both the west ramp and the east ramp with the assumption that both ramps will logically be constructed using similar structural systems. The bridge over the I-25 mainline may utilize a different structural type than the ramps, however all connecting structures will be coordinated for compatibility.

Listed below is the team involved in developing this document and its approval.

CDOT Region 1:

Program Engineer: Stephanie Alanis, PE
Project Manager: Jiovanna Toppi, EIT
Resident Engineer: Nyssa Beach, PE
CDOT Staff Bridge: Tristan Siegel, PE
CDOT Staff Bridge: Amanda Mascarenas, PE

RS&H:

Project Manager: David Woolfall, PE
Structures Lead: Mike Patton, PE
Deputy Project Manager: Mary Duke, PE

Subconsultants:

San Engineering, LLC: Ramp Structure Design
Pinyon Environmental: Environmental Assessment
Geocal, Inc.: Geotechnical Recommendations
Goodbee & Associates, Inc.: Subsurface Utility Engineering
Clanton & Associates: Lighting and Electrical Engineering
Ironstride Solutions: ITS Engineering
Felsburg Holt & Ullevig: Aesthetics

1.5 Structure Recommendations

The “Structure Selection” chapter of this report details the various structure options considered for analysis. Full design of the selected system has been completed.

The following structure alternatives are under evaluation:

- Alternative 1: Cast-in-Place Concrete Deck on Cast-In-Place Concrete Girders (See Figure 32).
- Alternative 2: Cast-in-Place Concrete Deck on Steel Girders (See Figure 3).
- Alternative 3: Cast-in-Place Concrete Deck on Prestressed Box Girders (See Figure 4).

Schematic typical section details and brief descriptions of each alternative follow. A general layout of the selected option and detailed cost estimates of all options of these alternatives are included in Appendix B.

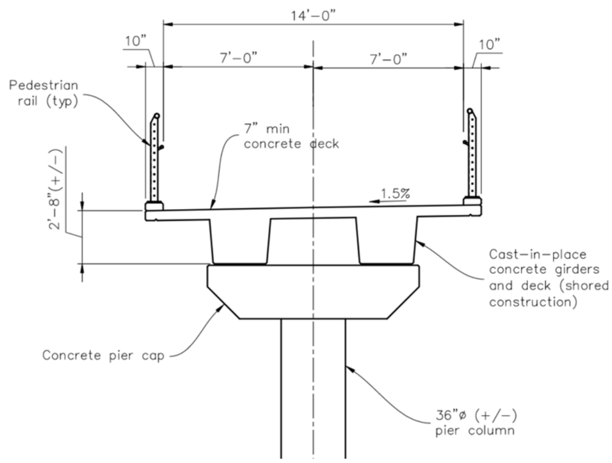


FIGURE 2: CROSS SECTION SCHEMATIC OF ALTERNATIVE 1

A concrete cast-in-place girder and deck offers a conventional approach to construction. The structure will be limited to shorter spans and will involve labor-intensive custom formwork for the cast-in-place deck and girder construction.

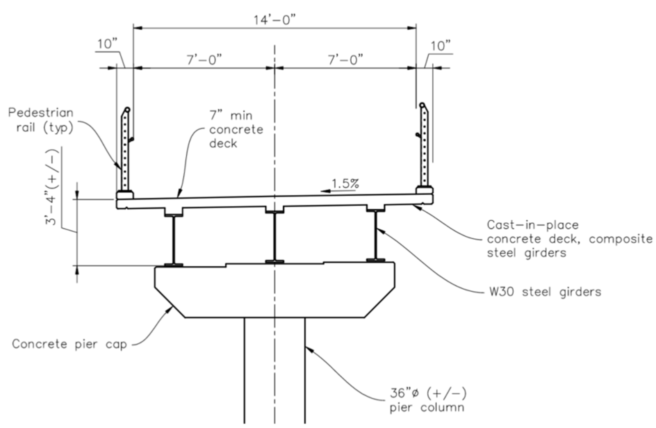


FIGURE 3: CROSS SECTION SCHEMATIC OF ALTERNATIVE 2

A composite steel girder with cast-in-place concrete deck also offers a conventional approach to construction. Special and unique challenges will need to be solved at interfaces with the concrete pier caps, deck drainage, and cast-in-place deck construction. Aesthetics and durability of system have benefits as well as drawbacks, discussed further in Section 4.4.2.

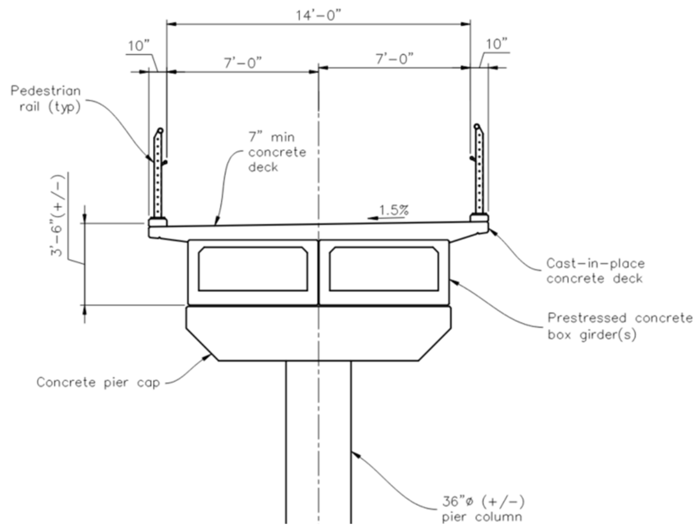


FIGURE 4: CROSS SECTION SCHEMATIC OF ALTERNATIVE 3

A prestressed concrete box girder and cast-in-place concrete deck offers a structural system that is routinely and successfully implemented by CDOT. Special and unique challenges will need to be solved at prestressed box girder interface with the concrete pier cap, and cast-in-place deck construction. These unique conditions are discussed further in Section 4.4.3.

Other structure types were considered but eliminated from further detailed evaluation. These include prefabricated pedestrian trusses and cast-in-place concrete slabs. Aesthetic concerns were the primary reason for elimination of these structure types. Project stakeholders desire a modern look with as much "see-through" transparency of the structure as possible. A conventional prefabricated pedestrian truss was not deemed acceptable aesthetically. Similarly, cast-in-place concrete slab spans would be limited in span length requiring numerous piers which obstruct the structure's transparency. The cast-in-place girder option studied herein provides a similar structural system to slabs but with longer spans and better transparency.

2. SITE DESCRIPTION AND DESIGN FEATURES

2.1 Existing Structures

No structures currently exist in the locations of the pedestrian ramps. No major challenges are anticipated with regards to construction staging, stockpiling, and traffic control.

2.2 Vicinity Map

The below figure shows the features in the immediate project vicinity.

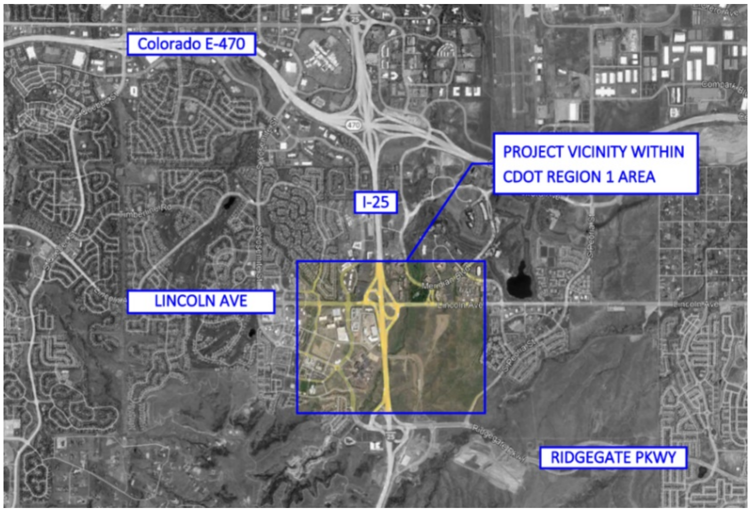


FIGURE 5: VICINITY MAP OF LONE TREE I-25 MOBILITY HUB PROJECT

2.3 Right-of-Way (ROW) Impact

Colorado Department of Transportation owns the I-25 right-of-way. The new pedestrian ramp structure falls within CDOT's right-of-way. The project will require a temporary construction easement and a permanent public use easement from the City of Lone Tree on the south side of Lincoln Avenue. However, none of the structure alternatives under consideration require any right-of-way acquisition to facilitate the construction process.

2.4 Traffic Detour

The need for traffic detours is not anticipated for the construction of the pedestrian ramps.

2.5 Utilities

A utility survey has been completed and coordination with utility companies is ongoing. No significant conflicts with the ramp structures have been identified.

Electrical conduits as well as ITS conduits and pull boxes are being incorporated into the pier columns, deck, and curbs. These conduits will serve pedestrian lights, security cameras, emergency telephones, and informational displays, all mounted to the ramp structures.

2.6 Geotechnical Summary

A site-specific draft geotechnical investigation has been developed by Geocal, Inc. Results indicate that expansive clay soils are present at the site which substantiates the decision to utilize drilled shafts (caissons) for the structures as discussed below.

Deep foundations in the form of concrete caissons (drilled shafts) are the appropriate foundation system for the ramp piers. For the lower portions of the ramps, spread footings or MSE foundations have been considered but decided against for multiple reasons. The lower portions of the ramps will be supported on walls on a caisson and grade beam system, to eliminate to possibility of differential settlement between bridge piers and lower ramps, and also to minimize ground disturbance in consideration of potential paleontological resources which are believed to exist in the area.

Geotechnical recommendations require the extension of caissons to a minimum embedment into bedrock which is relatively deep throughout the site. The resulting quantity of caisson length, particularly the 24-inch diameter caissons at the abutment ramps, is a significant factor in the project construction cost.

2.7 Hydraulics Summary

The ramp structures do not cross any existing or proposed waterways.

Deck drains will be provided at strategic locations on the structures and will include piping to outfall locations. The deck drains will collect surface drainage prior to the drainage reaching the expansion joints, and prior to the drainage reaching plazas or at-grade walkways.

2.8 Environmental Concerns

Environmental studies are being completed by Pinyon Environmental. Nearby commercial properties may be temporarily impacted by noise during construction of the project; however, these impacts did not substantially influence the design alternatives. Aside from recommendations from the Environmental study and elevated construction noise, the structure selection report accounts for the possibility of encountering paleontological resources during construction activities. Open excavation of the site is far more invasive than drilling in discrete locations. The recommendation of caisson foundations is partially in consideration of this issue.

2.9 Roadway Design Features

The ramp structures do not carry vehicular traffic, nor do they cross any roadways. Although an H-5 vehicle is one of the design loads, it is expected that any driven vehicle would encounter challenges navigating up and down the switchback ramp and corners at the upper landings.

The ramp clear width will be 14 feet with 10-inch curbs on either side with pedestrian rail. The ramp structure will include pedestrian rail with a minimum height of 48 inches. The style of pedestrian rail generally matches CDOT’s standard worksheet details for pedestrian rails.

Longitudinal grades have been developed with the intent of compliance with the latest ADA requirements. Specifically, grades of 8.1% over distances of 29 feet, and intermediate landings of 1.67% for distances of 6 feet have been used. This allows for minor field deviations and tolerances to remain within code limits.

3. STRUCTURAL DESIGN CRITERIA

3.1 Design Specifications and Method

The ADA ramp and stair vertical circulation systems connecting to the main overcrossing are unique in that they do not carry vehicular traffic and do not cross travelways. Therefore, many of the typical AASHTO bridge design criteria are not directly applicable to some of the elements of the ramps. That being said, some AASHTO bridge-related criteria are important to consider, such as thermal force effects on the substructures, and ADA criteria for public stairs and railings. Therefore, the design criteria and structural design process will utilize an appropriate mix of local building code design criteria and AASHTO/CDOT design criteria as described below.

Generally, the ramp and stair structures will meet the current requirements in AASHTO LRFD and CDOT Bridge Design Manuals. Where these criteria are do not appropriately apply, as in potential cases of precast stair systems, the International Building Code (IBC) as amended by the authority having jurisdiction which is the City of Lone Tree, will be applied.

The following design specifications are utilized in the design of the proposed structure as applicable. The latest edition of each of these references is used for final design.

- American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications, 9th Edition.
- AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, 2nd Edition
- AASHTO Guide for Development of Bicycle Facilities, Fourth Edition (2012)
- AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition (2017) including 2020 Interim Revisions
- Colorado Department of Transportation (CDOT) - Bridge Design Manual (BDM)
- Colorado Department of Transportation (CDOT) - Bridge Rating Manual
- Colorado Department of Transportation (CDOT) - Bridge Detail Manual
- Colorado Department of Transportation (CDOT) - Staff Bridge Worksheets
- Colorado Department of Transportation (CDOT) - Standard Plans
- Colorado Department of Transportation (CDOT) - CADD Manuals, workflows, and details

The latest edition, at time of final design, of the following construction specifications will be used in preparation of the design documents of the proposed structure as applicable.

- Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction
- Colorado Department of Transportation (CDOT) Standard Special Provisions
- Colorado Department of Transportation (CDOT) Project Special Provisions

3.2 Design Loading

This project will be designed for applicable strength, service, and extreme event limit states as defined by the load groups in the AASHTO LRFD Bridge Design Specifications.

Permanent Loads (DC)
Dead loads shall be as specified in the AASHTO LRFD Bridge Design Specifications. Specific elements contributing to permanent loads include pedestrian rails, light poles, deck, deck blisters, girders, pier caps, pier columns and stairs. A 6 psf load is included to account for a potential deck overlay of 3/4" thickness.

Live Loads (LL)
Pedestrian Loading = 90psf (PL) (Strength I & Service) (non-reducible). Vehicle Loading = H-5 Vehicle as specified by AASHTO LRFD. The I-25 mainline span bridge will be designed with live loading consistent with this. H-5 loading is intended to cover a potential service vehicle, although ramp geometry will make access of any conventional vehicle unlikely. Impact loads transferred from bridge rails are not applicable for the pedestrian ramp structure. Pedestrian rail loads will follow AASHTO requirements.

Earth Loads (EH, LS)
Earth loads will be taken from the load values presented in the Geotechnical Report as obtained from site investigation results. Earth loads and applicable surcharge loads will be applied to the back face of abutments and walls.

Wind Loads (WS)
Wind loads on the structure will be analyzed and designed for in accordance with AASHTO LRFD Bridge Design Specifications.

Thermal Forces (TU)
Thermal Coefficient (Steel) 0.0000065/°F
Thermal Coefficient (Concrete) 0.000006/°F
Temperature Range (Steel) -30°F to 120°F
Temperature Range (Concrete) 0°F to 80°F

Water Loads, Ice Loads (WA, IC)
Water and Ice loads are not applicable to this structure.

Utility Loads on Bridge (DC)
A load of 5 plf will be applied to the composite section for deck drainage and future utilities.

Creep and Shrinkage (CR, SH)
Creep and Shrinkage loading and effects on the structure will be analyzed and designed for in accordance with AASHTO LRFD Bridge Design Specifications.

Materials

Structural Steel	ASTM A992 Grade 50 (Wide Flange)
	ASTM A36 Grade 36 (Channel/Angles)
	ASTM A500 Gr. B (Hollow Structural Sections)
Reinforced Concrete	CDOT Class D, f'c = 4500 psi

CDOT Class BZ, f'c = 4000 psi
Reinforcing Steel ASTM A-615, Grade 60 (Epoxy-Coated)

3.3 Extreme Event Loading

Extreme Event Loading is not applicable to any of the alternatives for this pedestrian ramp.

3.3.1 Earthquake Load

Earthquake load will be analyzed and designed for in accordance with the AASHTO LRFD Bridge Design Specifications and the Geotechnical Report recommendations.

3.3.2 Vehicle Collision

The abutment ramp and piers for the pedestrian ramps are not within the clear zone of I-25. In addition to horizontal distance, various site features will exist between I-25 and the ramp piers including slopes, curbs & gutters, bus stops, plazas, and Type 9 barriers.

3.4 Design Software

The structure is designed and independently checked using the following methods and tools:

- Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders
  - Design – Hand Calculations, Finite Element Modeling, or other similar software
  - Independent Check – Hand Calculations, Finite Element Modeling, or other similar software
- Cast-in-Place Concrete Deck on Steel Girders
  - Design – Hand Calculations, Finite Element Modeling, or other similar software
  - Independent Check – Hand Calculations, Finite Element Modeling, or other similar software
- Cast-in-Place Concrete Deck on Prestressed Box Girders
  - Design - Hand Calculations, Finite Element Modeling, or other similar software
  - Independent Check: Hand Calculations, Finite Element Modeling, or other similar software
- Potential softwares to be utilized include:
  - LEAP Bridge Suite Version 21.02.00.38
  - SAP 2000 Version 15 PLUS
  - Ensoft L-Pile 2018
  - MathCAD Version 14.0
  - Microsoft Excel Version 2404

3.5 Deck Drainage

Deck drainage is an essential part of design for the pedestrian ramp structure. Elevated deck structures have cross-slopes at the walking surface from one side to the other. All structure alternatives have drains designed to keep standing water from collecting on the pedestrian path, or from reaching expansion joint and bearing devices.

Steel girders as well as cast-in-place concrete girders offer great flexibility in configuration of drainage systems, where drains can be located between or directly through girders. Conversely, adjacent prestressed box girders are highly challenging to incorporate deck drainage systems through. Nevertheless, a design is currently has been developed to fit deck drains and downspouts between the pedestrian rail curbs and exterior prestressed box girders.

From an aesthetic standpoint, any of the structure types studied will involve some amount of visible drain piping on the front faces of abutments. This is necessary in order capture and route deck drainage prior to it reaching expansion joints located at abutments.

3.6 Aesthetic Requirements

Colored structural concrete coating or stain will be incorporated into the design aesthetic. Wayfinding and safety signs must also be considered with the pedestrian ramp design.

The structure will be highly visible to the public. The project stakeholders have indicated that the structure should have a modern look, which will be outlined in the Visual Impact Assessment for this project. Specific requirements or guidelines of a modern look have not been provided. However, the team's understanding is that the preference is for the structures to be open and more "see-through" rather than having excessively heavy proportions of major elements. This has been a primary consideration in sizing of superstructure and substructure elements.

Consistency with other pedestrian bridges in the corridor is also important. One of the closest recently-constructed bridge structures is the bridge carrying RTD tracks over I-25 at Sky Ridge Avenue. Several aesthetic details of the ramps are being developed using this structure as a general guide. These details include the use of light and dark concrete stains, pier column reveals, chamfers at construction joints, light corbels, and formliners on abutment ramp walls.

Pedestrian rails are an important aesthetic element and are further discussed in Section 4.3.3.

3.7 Possible Future Widenings

Discussions with the property owners on the east side of I-25 indicate that there may be a desire for future connections to the east ramp, likely at the upper landing. The exact location and configuration of such a connection is unknown at this time. The expectation is that a self-supporting connecting stair or ramp structure may tie into the east landing as a connection to a future building or development. This future connection would involve a modification of the curb and pedestrian rail at the interface, as well as a potential expansion joint if the connecting structure has a long length. At this time, an enlarged upper landing at the east side of the bridge is planned.

4. STRUCTURE SELECTION

To objectively compare various structural solutions, evaluation factors are identified, and assigned a value representing the impact to the project. The evaluation factors identified for the structure selection process are discussed in the following report sections.

4.1 Selection Criteria

The preferred structural solution is determined based on the following factors.

4.1.1 Cost

The selected alternative is a cost-efficient solution meeting the project goals. In addition to the current construction cost, long term maintenance cost is considered in structure selection. Cost estimates of feasible structure alternatives are developed and included in Appendix B.

4.1.2 Maintenance & Durability

The selected alternative is a solution requiring minimal maintenance. Structural elements such as bearing assemblies, expansion joints, structural steel exposed to weathering, and connections under cyclic loading require additional maintenance for the full life cycle of the structural system. Some of the structural alternatives in this report incorporate these features while others do not. Based on experience with similar structures, all structures alternative presented below are considered very durable. Maintenance & Durability factor scores for each structural system alternative are presented in Section 4.11 Summary of Structure Type and Evaluations Table of this report.

4.1.3 Aesthetics

The selected alternative will complement the look and design of the pedestrian bridge structures along the I-25 corridor. During the conceptual design phase, enclosed ramp walkways have been suggested by project stakeholders. However enclosed ramps have been determined to be beyond the scope of the project, and conflict with other aesthetic preferences. The structural site lines are expected to be thin with a low visual impact unless otherwise required. Aesthetics factor scores for each structural system alternative are presented in Section 4.11 Summary of Structure Type and Evaluations Table of this report.

4.2 Rehabilitation Alternatives

Since the proposed pedestrian ramp is a new structure, rehabilitation alternatives are not applicable.

4.3 Structure Layout Alternatives

On a case-by-case basis, structure layout alternatives are considered in conjunction with the structural system alternatives. Configurations of the structure layout heavily depend on economical span lengths of the selected structural system.

4.3.1 Expansion Joints

Configuration of joints allowing thermal expansion and contraction of both the main span bridge as well as the approach ramp spans must be carefully coordinated. The lengths of the main span bridge and the ramps are in orthogonal directions.

Unlike intermediate expansion joints on a multi-span highway bridge which can accommodate longitudinal movement ahead of and behind the joint, joints crossing the decks of these structures will only take up movement of either the main span or the ramp spans. Therefore at each upper landing, joints will be provided on two sides, isolating the landing from the ramp as well as the main span bridge. A view of this condition is shown below:

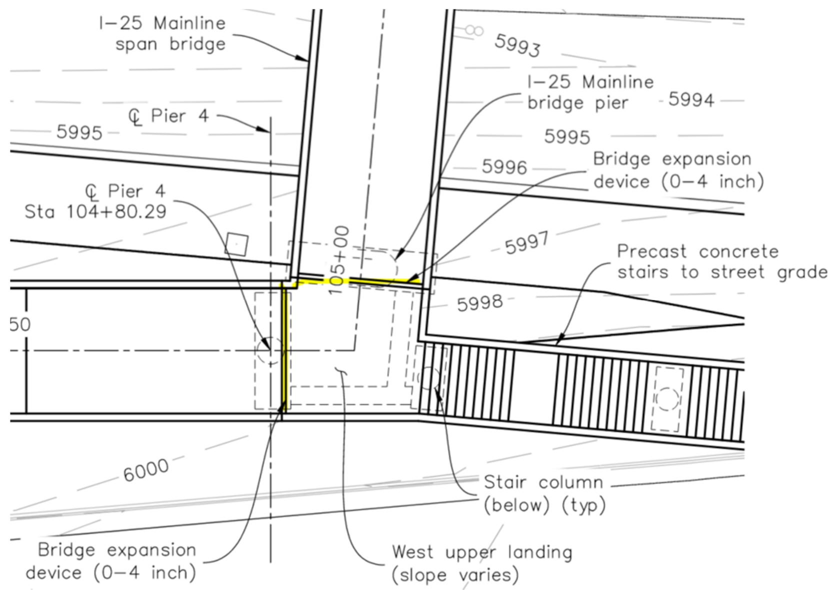


FIGURE 6: EXPANSION JOINT CONFIGURATION AT UPPER WEST LANDING

Expansion joint systems (0-4”) with steel rails and glands will be provided at each end of the multi-span ramp structures, i.e., at the low abutments and the high landings. Cover plates will be provided over the joints for pedestrian safety. An isolation joint with cover plate will also be provided at the interface with the mainline bridge, ensuring movements from the mainline bridge are not unintentionally imposed on the ramp structures.

4.3.2 Access Stairs

The west ramp will include access stairs from the south end, directly to the upper landing. The east ramp may include a stair access in the future depending on development of the area, but at this time stairs on the east side of the highway are not included.

Precast concrete stair construction offers several advantages. Primarily, it eliminates laborious on-site elevated formwork. It also offers a higher degree of precision, being engineered and fabricated in a precast facility. Local precasters in the building industry commonly provide precast stair systems. Below is a sample image of a similar precast stair system in the area.

DRY CREEK RTD STATION

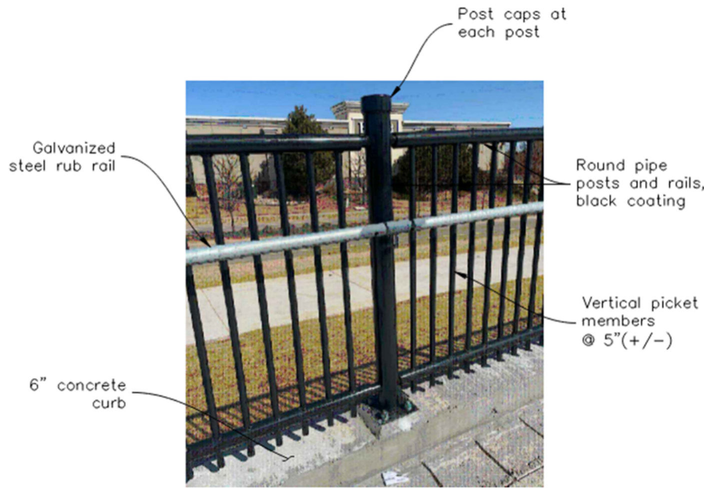
FIGURE 7: EXAMPLE PRECAST CONCRETE STAIR SYSTEMS

4.3.3 Pedestrian Railing

The pedestrian railings along the ramps will be a highly visible element, and a significant portion of the structure cost. The railings need to be AASHTO-compliant, ADA-compliant, CDOT-compliant, and should meet the aesthetic preferences of stakeholders desiring transparency of the structure to as great an extent possible.

Pedestrian rails will be based on CDOT's standard worksheet for pedestrian pipe railing, with customizations to apply to this pedestrian ramp structure. This rail style has been presented to project stakeholders by CDOT. An example installation of this rail type at a nearby bridge is depicted below.

A minimum 48-inch high railing system with a continuous concrete base curb and hand-height rub rail is anticipated for the lengths of the ramps. At the north end of the switchback at the east ramp, a taller rail is being considered, in order to provide additional safety for bicycles traveling down the ramp and having to rapidly slow and change direction.



ACRES GREEN PEDESTRIAN BRIDGE

FIGURE 8: EXAMPLE PEDESTRIAN RAIL IMAGE

4.4 Structural System Alternatives

There are several crossing types which are possible candidates for the proposed structure. The preferred solution would be a structure that performs well based upon the selection criteria mentioned in Section 4.1 above. Feasible structure types need to minimize project cost, be structurally efficient, meet the geometric and clearance requirements, and be able to be safely constructed with common details and be a type with proven long-term structural performance.

4.4.1 Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders

Cast-in-place concrete decks on cast-in-place concrete girders are common structural systems for pedestrian ramps due to their durability and aesthetic versatility. Constructions costs are usually the primary concern associated with this structural system alternative. Advantages and disadvantages of this alternative are discussed considering the criteria defined in Section 4.1.

RED ROCKS AMPHITHEATER

FIGURE 9: EXAMPLE CAST-IN-PLACE CONCRETE PEDESTRIAN RAMPS

Cost Discussion

To develop a conceptual cost of this system, concrete t-beams were calculated based on spans between 40 and 60 feet and an assumption that 2 beams comprise the superstructure. This preliminary design resulted in beams 24” deep and 26” wide, with an 8-inch concrete deck. Additional reinforcing steel and concrete quantities were added to account for the upper landing structures which will be highly complex in geometry. Relatively heavy reinforcement throughout was assumed for costing purposes. Unit costs were applied to calculated material volumes, and adjusted per judgement based on complexity of installation, economy of scale, and other project-specific factors.

Concrete, the primary material for cast-in-place girders, is widely available and cost-effective. Cast-in-place concrete girders often have lower initial construction costs compared to precast alternatives. This is because they can be cast on-site, eliminating the need for expensive transportation of precast segments. The flexibility of on-site casting allows engineers to adapt the design to specific site conditions, potentially reducing costs.

On the other hand, forming and curing time required for cast-in-place concrete can extend project timelines, increasing labor costs. On-site casting demands a skilled workforce, which can be more costly than using precast girders. Formwork in particular, will be extremely involved with this alternative. Custom falsework for the full lengths of the spans will be required. Additionally, such falsework will need to be carefully constructed to accommodate the cambers needed for calculated deflections. Weather conditions can affect the construction schedule, potentially leading to cost overruns.

Maintenance & Durability Discussion

Cast-in-place concrete is known for its longevity and resistance to environmental factors such as corrosion, making it a low-maintenance option. Fewer joints in cast-in-place girders reduce the risk of water infiltration, which can lead to corrosion and deterioration. When damage occurs, cast-in-place girders are often easier to repair compared to precast girders.

While cast-in-place concrete is durable, it can still develop cracks over time, necessitating repair work. With a non-prestressed multi-span system, cracking would be anticipated over piers in negative moment regions. This is a significant drawback compared to other alternatives considered.

Aesthetics Discussion

On-site casting allows for customization in terms of shape, texture, and finish, enabling unique and visually appealing bridge designs. Designers can blend the ramp structure into its surroundings, incorporating elements that complement the local environment.

Additionally, challenges with achieving desired aesthetics require skilled craftsmanship during forming and casting, which may add to labor costs. Special attention is needed to form proper span cambers and to preserve the visual appeal of cast-in-place girders over time.

Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders Summary

Cast-in-place concrete deck on cast-in-place concrete girder construction offers a balance between cost, maintenance, and aesthetics. While providing cost advantages during construction and low maintenance requirements over its lifespan, the aesthetic potential depends on skilled craftsmanship. Cost challenges such as construction time, labor intensity, and weather delays are significant risks to the budget. A strong recommendation for this structural system cannot be awarded with such inherent risks for cost overruns.

4.4.2 Cast-in-Place Concrete Deck on Steel Girders

Cast-in-place concrete decks on steel girders are common structural systems for pedestrian ramps due to their span capabilities and aesthetic versatility. This structural system alternative offers a mix of benefits and challenges. Advantages and disadvantages of this alternative are discussed considering the selection criteria defined in Section 4.1.

LOCATION UNKNOWN

FIGURE 10: EXAMPLE STRUCTURAL STEEL PEDESTRIAN BRIDGES

Cost Discussion

To develop a conceptual cost of this system, composite steel wide-flange beams and decks were calculated based on spans between 40 and 80 feet and an assumption that 3 beams comprise the superstructure. This preliminary design resulted in rolled beams of approximately W36x135 size, with an 8-inch concrete deck. Additional structural steel and concrete quantities were added to account for the upper landing structures which will be highly complex in geometry. Unit costs were applied to calculated material volumes, and adjusted per judgement based on complexity of installation, economy of scale, and other project-specific factors.

Steel girders are often faster to install than cast-in-place concrete counterparts, reducing labor costs and overall project duration. Steel material, although durable, involves more long-term maintenance and inspection life-cycle efforts than either cast-in-place or precast construction, increasing the long term cost requirements for the structure.

Unfortunately, the price of steel can fluctuate greatly, impacting project budgets. Skilled welders and steelworkers are necessary for proper installation, which can increase labor expenses.

Maintenance & Durability Discussion

When properly maintained, steel can be highly resistant to corrosion, which is a common concern for bridges. Steel's smooth surface allows for reasonably easy inspection and detection of potential issues such as corrosion or fatigue cracks. When maintenance is required, steel components can often be repaired or replaced more easily than other materials.

To prevent corrosion, steel girders require periodic repainting or the application of protective coatings, which can be a recurring lifecycle expense. Regular inspections are crucial to identify and address corrosion or other issues promptly.

Aesthetics Discussion

Steel's flexibility allows for innovative and aesthetically pleasing bridge designs, enabling unique shapes and artistic elements. This benefit is particularly useful at corners and landings. Steel can be finished with various coatings and colors, enhancing the bridge's visual appeal. Steel bridges can become iconic landmarks in a city or region, contributing to their aesthetic value. Despite these potential benefits, if the structure is composed of simple and economical wide-flange members, the steel alternative is considered inferior aesthetically to the concrete alternatives.

To achieve long spans, intermediate girder splices may be required, detracting from the aesthetic appeal. Elaborate architectural features and finishes can add to the overall cost of the bridge. Special attention is required to maintain the visual aspects of the bridge over time, including periodic repainting.

Cast-in-Place Concrete Deck on Steel Girders Summary

Steel girders offer a balance between cost, maintenance, and aesthetic considerations. While they may have initial material cost fluctuations, design flexibility can make them a popular choice in construction. However, durability and aesthetic concerns are a drawback with this alternative. Proper maintenance practices are essential to maximize the lifespan and visual appeal of steel bridges, ensuring they remain functional and safe for the traveling public. A strong recommendation for this structural system cannot be awarded with such inherent risks associated with variable material costs and expected maintenance requirements.

4.4.3 Cast-in-Place Concrete Deck on Prestressed Box Girders

Cast-in-place concrete decks on prestressed box girders are a common structural system for bridges in Colorado due to their structural efficiency and durability. Constructions costs with this structural system alternative are competitive with the other alternatives. Advantages and disadvantages of this alternative are discussed considering the selection criteria defined in Section 4.1 above.

COLORADO CENTER BRIDGE

FIGURE 11: EXAMPLE PRESTRESSED BOX GIRDER PEDESTRIAN RAMPS

Cost Discussion

To develop a conceptual cost of this system, composite prestressed concrete box girders and decks were calculated based on spans of approximately 70 feet and an assumption that 2 girders comprise the superstructure. This preliminary design resulted in 26" deep and 72" wide in size, with a 6-inch minimum concrete deck. Additional structural steel and concrete quantities were added to account for the upper landing structures which will be highly complex in geometry. Unit costs were applied to calculated material volumes, and adjusted per judgement based on complexity of installation, economy of scale, and other project-specific factors.

Box girders allow for longer clear spans, reducing the need for additional piers or supports, potentially saving construction costs. The inherent strength of prestressed concrete allows for a reduction in the amount of concrete and steel required, leading to potential cost savings. The durability of prestressed concrete minimizes long-term maintenance expenses and lifecycle costs.

Conversely, the materials and technology used in prestressed concrete can lead to higher initial costs compared to conventional concrete girders. Skilled labor is required for the precision required in prestressing and deck cambering, adding to construction expenses.

Unique construction details will be developed to accommodate the prestressed box girders for this structure. These details include special deck thickness diagrams arising from the need for specific ADA-compliant deck slope changes along the span, above a girder which is essentially a flat surface (including camber and deflections). They will also include sloping bearing seats and/or tapered bearing assemblies to accommodate the slope of the spans which are much steeper than most roadway bridges.

Maintenance & Durability Discussion

Prestressed concrete is highly resistant to cracking and corrosion, reducing the need for frequent maintenance. Prestressed concrete box girders have a reliably long service life, minimizing the frequency of major repairs.

This complex structural system comes with challenges. Prestressed concrete girders may require more specialized inspections to detect potential issues accurately. While maintenance needs are minimal, if repairs are necessary, they can be more complex and costly than other bridge types.

Aesthetics Discussion

Prestressed concrete box girders are limited to straight alignments, but can be fabricated in a variety of depth or width dimensions. The structural efficiency of prestressed concrete allows for shallower superstructures and longer spans which are particularly beneficial at this site where transparency is desired.

Cast-in-Place Concrete Deck on Prestressed Concrete Box Girders Summary

Prestressed concrete box girders strike a balance between cost-effectiveness, low maintenance needs, and aesthetic potential. While initial construction costs may be higher, their durability and structural efficiency can lead to long-term savings. While the structure will require routine bi-annual inspections like any bridge structure, eventual inspection of deterioration, over and above the routine inspection process is not anticipated. A strong recommendation for this structural system can be awarded given overall lower costs for the life cycle of the structure, expected low maintenance, and acceptable aesthetic appeal. Typical sections and configurations of the anticipated ramp spans are included in the General Layout drawings, attached.

4.5 Wall Alternatives

Conventional cast-in-place concrete walls on each end of the pedestrian ramp structure support the initial slope of the ramp and retain soil. The length of walls is roughly 100 feet while the heights will vary from zero to 12 feet. Wall thickness is approximately 10 inches. Typical sections and configurations of the anticipated abutment ramp walls are included in the General Layout drawings, attached.

Mechanically-Stabilized Earth (MSE) Walls have also been considered at the low ends of the ramps, however MSE walls have certain drawbacks at this site. Differential settlement of the MSE walls compared to the caisson-supported ramp spans is a concern at this site with suspected poor soils. Moreover, the east ramp will involve a 180-degree narrow switchback configuration which will be highly complicated with MSE construction.

WADSWORTH AND BOWLES PEDESTRIAN CROSSING

FIGURE 12: EXAMPLE ABUTMENT RAMP WALLS

4.7 Constructability and Construction Phasing

Conceptual design plans and cost estimates are developed for single-phased construction. Because the ramps are not over or within roadways, construction phasing is not expected to be a significant factor.

All three alternatives studied offer conventional construction approaches allowing competitive bidding by many local contractors.

4.8 ABC Design

Accelerated Bridge Construction (ABC) is not considered to be a particular benefit to these structures which are not within roadways, sidewalks or otherwise occupied areas where inconvenience to the public may be expected.

4.9 Maintenance and Durability

Based on experience with design and inspections of bridges throughout the state's highway systems, all structure types studied are highly durable structural systems with proven track records. Expansion joints will only be present at the ends of the multi-span units of each ramp. Jointless composite prestressed girder and deck superstructures in particular, have demonstrated exceptional durability and minimal maintenance and repair requirements through their initial decades of their lifespans.

A particular concern that arises on continuous bridges with bare decks is the development of transverse cracks over intermediate piers where negative moments are highest. Conventional highway bridges with waterproofing membranes and asphalt wearing surfaces do not exhibit such cracks, as they are concealed. However, this type of cracking is expected to be visible on the proposed bare deck. A "traffic coating" slip-resistant overlay has been discussed with project partners, but is not currently specified on the structure. In lieu of a protective overlay, a series of transverse control joints concentrated over the intermediate piers has been specified, as depicted in the image below.

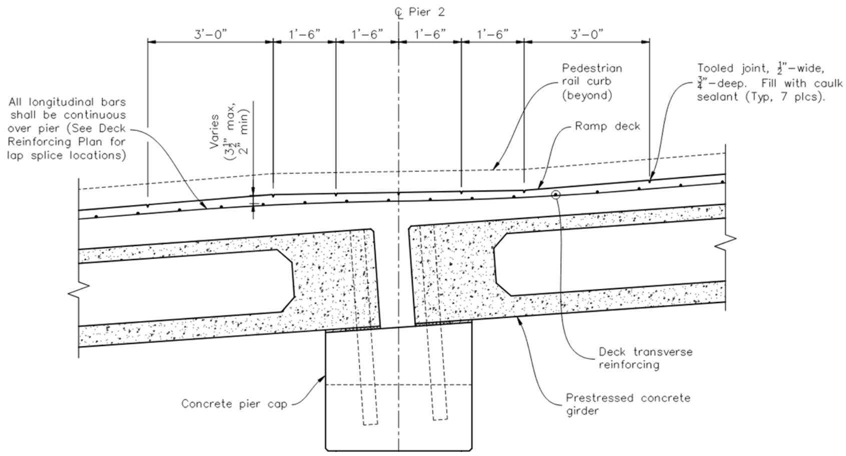


FIGURE 13: CRACK CONTROL DETAIL AT INTERMEDIATE PIERS

4.10 Corrosive Resistance

The recommended structure type is highly resistant to corrosion, as discussed above in Section 4.9. Prestressed concrete is dependably crack-free, even in regions of high moment. Deck cross-slopes and drains are designed to direct and capture surface drainage, minimizing moisture contact with susceptible parts of the structures. All reinforcing, regardless of location, will be epoxy-coated. The design will follow the Geotechnical Report recommendations regarding potential for sulfate attack on Portland cement concrete in direct contact with soil.

4.11 Summary of Structure Type and Evaluations Table

A comparison of the structure alternatives scored based on Cost, Maintenance & Durability, and Aesthetics is presented in Table 1 below. Each selection criteria is on a scale of 1 to 10, with 10 being the best result. The weighted average is the sum of the factored criteria values based on weight factors (shown below the table).

TABLE 1: EVALUATION TABLE

	Maintenance and Durability	Aesthetics	Cost	Weighted Average
Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders	8	7	5	6.15
Cast-in-Place Concrete Deck on Steel Girders	6	5	5	5.15
Cast-in-Place Concrete Deck on Precast Box Girders	8	6	7	6.80

- Weight Factors: Maintenance and Durability: 15%, Aesthetics: 35%, Cost: 50%
- Scale is out of 10

The Cast-in-Place Concrete Deck on Prestressed Box Girders structure alternative receives the highest evaluation score compared to the Cast-in-Place Concrete Deck on Steel Girders and the Cast-in-Place Concrete Deck on Prestressed Box Girders.

4.12 Construction Costs

A summary of the probable estimated construction costs of structure alternatives is presented and discussed within this section. The unit costs used in the cost analysis are based on the CDOT Cost Data Book as well as recent experience in the industry and the total cost includes a 20% contingency to account for potential contingencies.

TABLE 2: CONSTRUCTION COSTS

Alternative	Estimated Structure Cost
I. CIP Concrete Deck on CIP Concrete Girders	$6,215,000
II. CIP Concrete Deck on Steel Girders	$6,194,000
III. CIP Concrete Deck on Prestressed Box Girders	$5,631,000

The total cost of cast-in-place concrete deck and girders, structural steel girders and prestressed concrete box girder options listed above are heavily influenced by the unit cost of structural steel and reinforced concrete. These unit costs must be reviewed, and the total cost recalculated for the same quantities is the project is shelved for significant time.

A detailed estimate for all design alternatives shown in Table 2 is included in the Appendix.

5. STRUCTURE RECOMMENDATION

With the rationale founded in Section 4.1, it is recommended that the Cast-in-Place Concrete Deck on Prestressed Box Girders structural system is selected for the Pedestrian Ramps on the Lone Tree I-25 Mobility Hub. The Cast-in-Place Concrete Deck on Prestressed Box Girders structural system is a cost-effective solution and satisfies long term durability requirements of the Colorado Department of Transportation while maintaining aesthetically pleasing sight lines.

Alternatively, even though the Cast-in-Place Concrete Deck on Cast-in-Place Concrete Girders do provide aesthetic latitude for design and low maintenance requirements, a strong recommendation was not awarded with such inherited risks for cost overruns. In a similar vein, the Cast-in-Place Concrete Deck on Steel Girder did not receive a strong recommendation due material cost fluctuations, aesthetic drawbacks and expected maintenance requirements.

Therefore, the selection of a Cast-in-Place Concrete Deck on Prestressed Concrete Box Girders structural system is recommended for this project given the constraints and selection criteria.

General Layout drawings of the recommended alternative are attached in Appendix A.

Appendix A – Structure General Layouts

GENERAL NOTES:

All work shall be done in accordance with the Colorado Department of Transportation 2023 Standard Specifications for Road and Bridge Construction and the Contract Documents.

Structure excavation and backfill shall be as shown on the plans.

Expansion joint material shall meet AASHTO Specification M213.

All exposed concrete surfaces shall receive a Class 1 final finish to one foot below the ground line. See Sealer and Stain Coating Limits sheet.

A colored Structural Concrete Stain finish will be required on exposed concrete surfaces to one foot below finished ground. For color requirements, see Sealer and Stain Coating Limits sheets.

Grade 60 reinforcing steel is required.

All reinforcing steel shall be epoxy coated unless otherwise noted.

Ⓝ denotes non–epoxy coated reinforcing steel.

The contractor shall be responsible for the stability of the structure during construction.

Stations, elevations, and dimensions contained in these plans are calculated from a recent field survey. The Contractor shall verify all dependent dimensions in the field before ordering or fabricating any material.

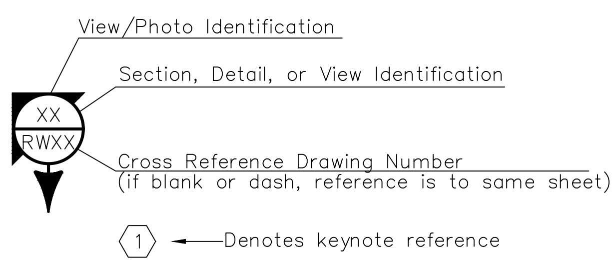
All longitudinal and transverse dimensions are measured horizontally and include no correction for grade.

The information shown on these plans concerning the type and location of underground utilities is not guaranteed to be accurate or all inclusive. The Contractor is responsible for making its own determination as to the type and location of underground utilities as may be necessary to avoid damage thereto. The Contractor shall contact the Utility Notification Center of Colorado at 811 (1–800–922–1987) at least 3 days (2 days not including the day of notification) prior to any excavation or other earthwork.

All provisions for bridge deck concrete shall also apply to abutment ramp top slab concrete.

For structure number installation, see Standard S–614–12.

LEGEND



ABBREVIATIONS

(Per M–100–2 or as shown below)

Abut.	= abutment	ft.	= foot/feet	Shld.	= shoulder
B.F.	= back face	HCL	= horizontal control line	Spa.	= spaced
Brg.	= bearing	ITS	= intelligent transportation systems	Sta.	= station
℄	= center line	Jt.	= joint	sq. mi.	= square mile
Clr	= clear	kip	= thousand pounds	Str.	= structure
Const.	= construction	Max.	= maximum	Typ	= Typical
Cont.	= continuous	Min.	= minimum	UNO	= unless noted otherwise
EF	= each face	MSE	= mechanically stabilized earth	VC	= vertical curve
Elev.	= elevation	No.	= number	VPI	= vertical point of intersection
Eq.	= equally	PGL	= profile grade line	WSEL	= water surface elevation
Est.	= estimated	Proj.	= projection		
Exp.	= expansion	ROW	= right of way		

DESIGN DATA

AASHTO, 9th Edition LRFD, 2020
AASHTO LRFD Guide Specifications for Design of Pedestrian Bridges, 2nd Edition with current interims

Design Method: Load and Resistance Factor Design

Dead Load: Assumes 10 lb/ft for drainage and future utilities

Live Loads: Pedestrian load: 90 psf
Vehicle load: H–5 vehicle

Reinforced Concrete:

Class D Concrete:	f'c = 4,500 psi
Reinforcing Steel:	fy = 60,000 psi
Sulfate Exposure:	Class 0

Caisson Concrete:

Class BZ Concrete:	f'c = 4,000 psi
Reinforcing Steel:	fy = 60,000 psi

Structural Steel:

AASHTO M270 (ASTM A709) Grade 36	fy= 36,000 psi
AASHTO M270 (ASTM A709) Grade 50	fy= 50,000 psi

Precast Prestressed Concrete:

Class PS Concrete:	f'c = (see details)
f's = 270,000 psi	

SEISMIC DESIGN CRITERIA

Earthquake Design method:
Latitude = 39.532804°
Longitude = –104.868055°

Peak Ground Acceleration (PGA): 0.057

Spectral Acceleration Coefficients:

Period (sec)		
0.2	(S_S):	0.122
0.1	(S_1):	0.034

Site Factor (F_{PGA}): 1.2
Site Factor (F_A): 1.2
Site Factor (Fv): 1.7

Modified Peak Ground Acceleration (A_S): 0.068

Modified Spectral Acceleration Coefficients:

Period (sec)		
0.2	(S_{DS}):	0.146
0.1	(S_{D1}):	0.057

Seismic Site Class: C

INDEX OF DRAWINGS (WEST RAMP)

BRIDGE DESCRIPTION

3–span (69'–2", 65'–3⅝", 9'–8¼") pedestrian bridge approach ramp
Prestressed concrete box girders and cast–in–place concrete upper landing
14'–0" clear width
48" pedestrian rail

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

$PLOT_INFO$

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
File Name: LTMH West Ramp.dgn
Horiz. Scale: As Noted Vert. Scale: As Noted
Staff Bridge Branch – Unit 0224 TRS
San Engineering LLC
Civil and Structural Engineering

Sheet Revisions		
Date:	Comments	Init.

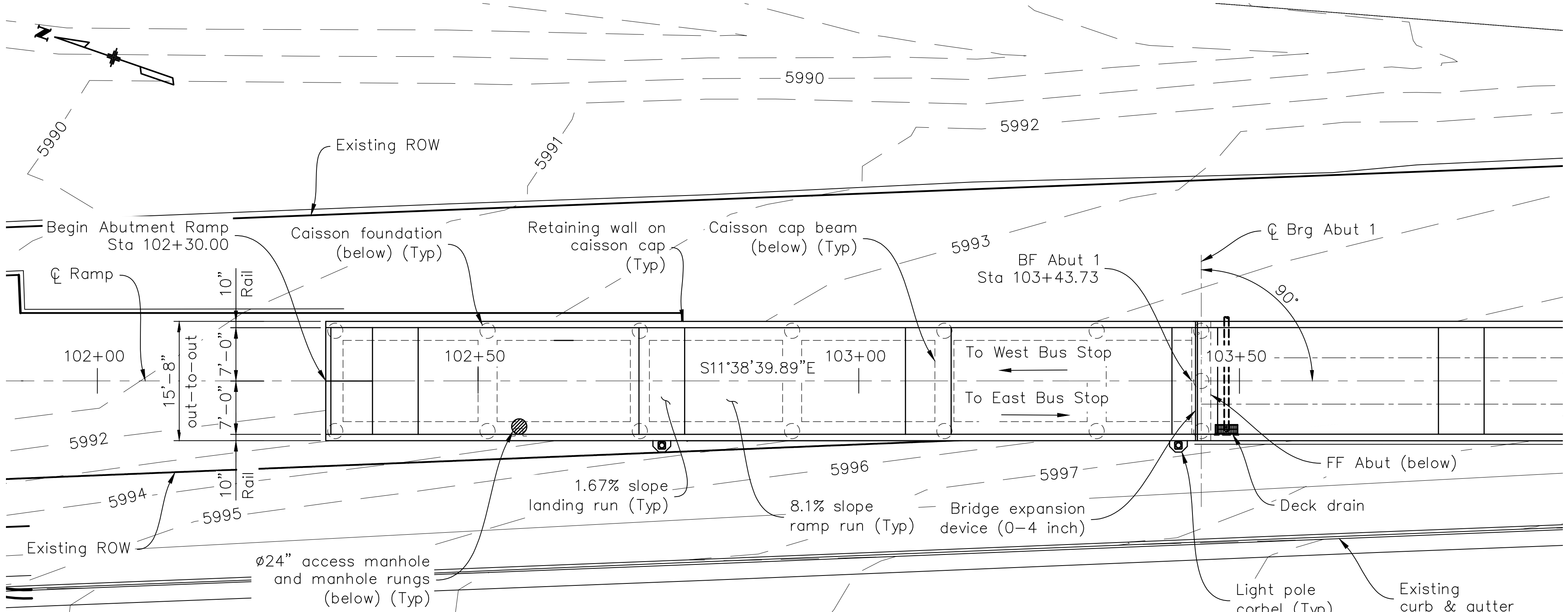
Colorado Department of Transportation
18500 E. Colfax Ave.
Aurora, CO 80111
Phone: (303) 746–8639
Region 1 – South Program NJB

As Constructed
No Revisions:
Revised:
Void:

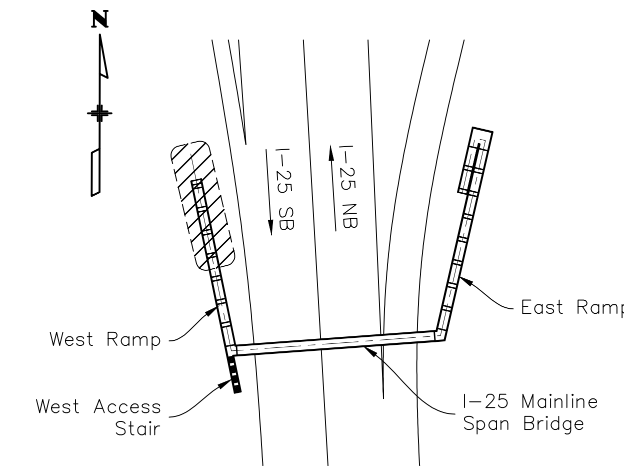
I–25 Mobility Hub (Lone Tree)
West Pedestrian Ramp
General Information

Designer: J. Migliaccio	Structure Numbers	F–17–QX	
Detailer: J. Migliaccio			
Sheet Subset: West Ramp	Subset Sheets: RW01 of 59		
Near: Lone Tree	Sec. 10	Township 6S	Range 67W

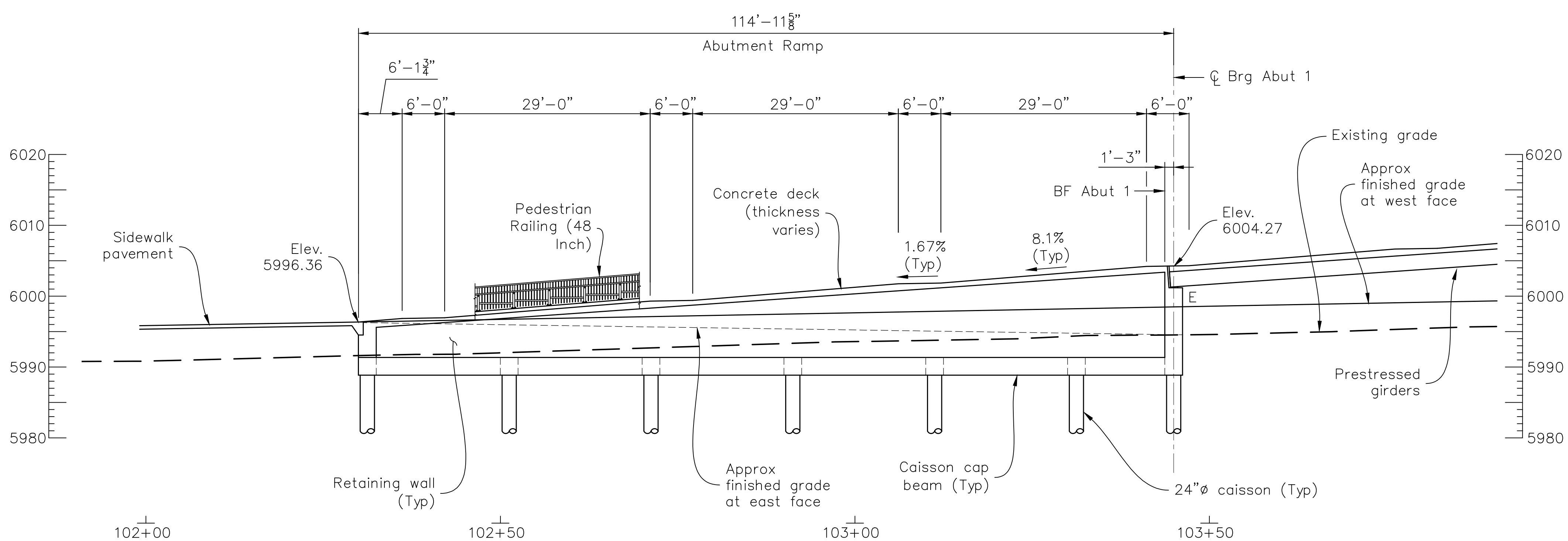
Project No./Code
267 0252–499
24278
Sheet Number
Station 102+30.00 to Station 105+00.26



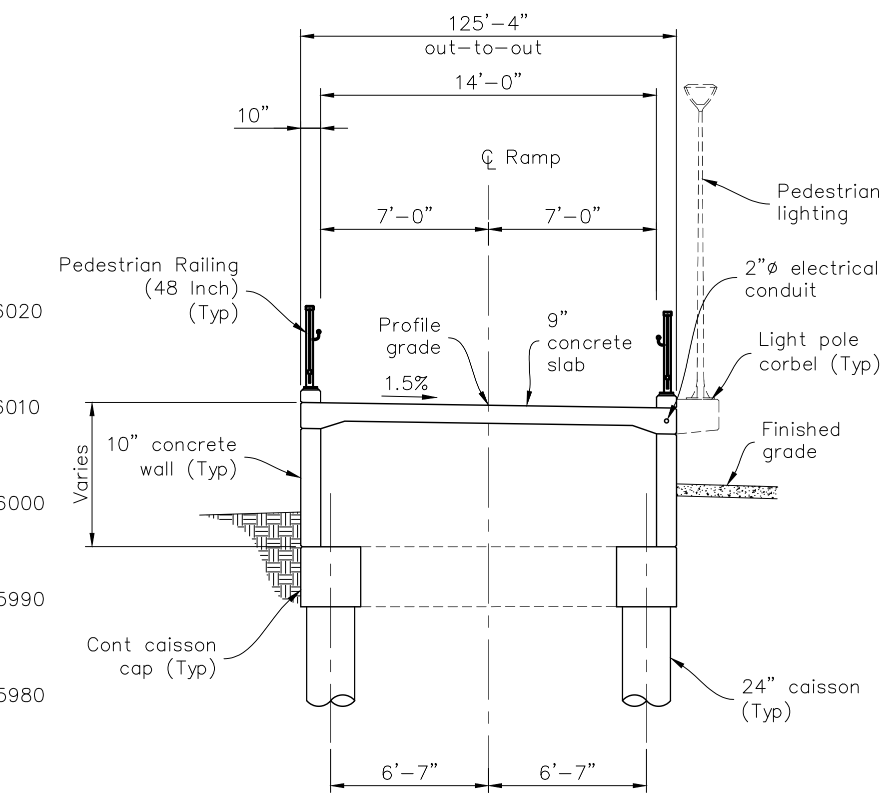
WEST RAMP PLAN



RAMP KEY PLAN



WEST RAMP SECTION



TYPICAL SECTION – ABUTMENT RAMP

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
File Name: LTMH West Ramp.dgn
Horiz. Scale: As Noted Vert. Scale: As Noted
Staff Bridge Branch – Unit 0224 TRS

San Engineering LLC
Civil and Structural Engineering

Sheet Revisions

Date:	Comments	Init.

Colorado Department of Transportation
18500 E. Colfax Ave.
Aurora, CO 80111
Phone: (303) 746-8639
Region 1 – South Program NJB

As Constructed
No Revisions:
Revised:
Void:

I-25 Mobility Hub (Lone Tree)
West Pedestrian Ramp
General Layout (1 of 2)

Designer: J. Migliaccio
Detailer: J. Migliaccio
Structure Numbers: F-17-QX
Sheet Subset: West Ramp
Subset Sheets: RW03 of 59
Near: Lone Tree Sec. 10 Township 6S Range 67W

Project No./Code
267 0252-499
24278
Sheet Number
Station 102+30.00 to Station 105+00.26

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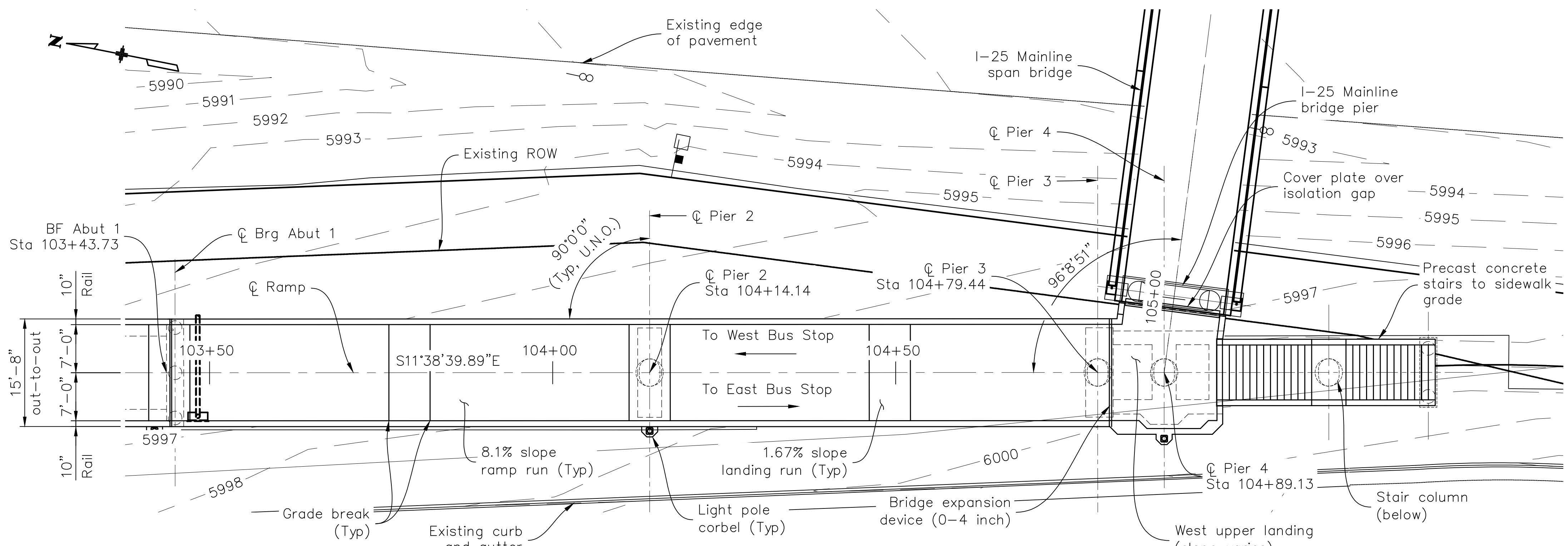

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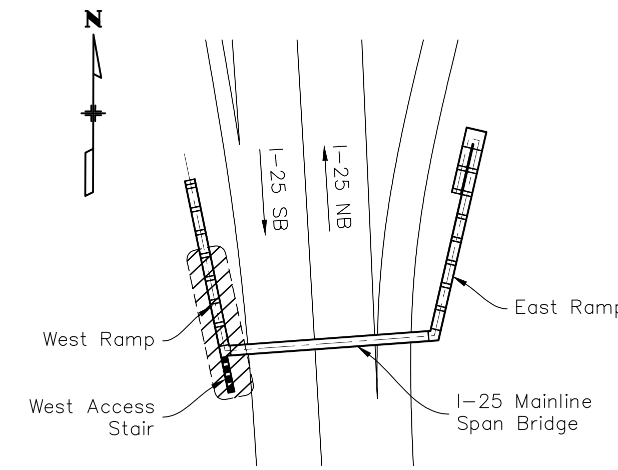
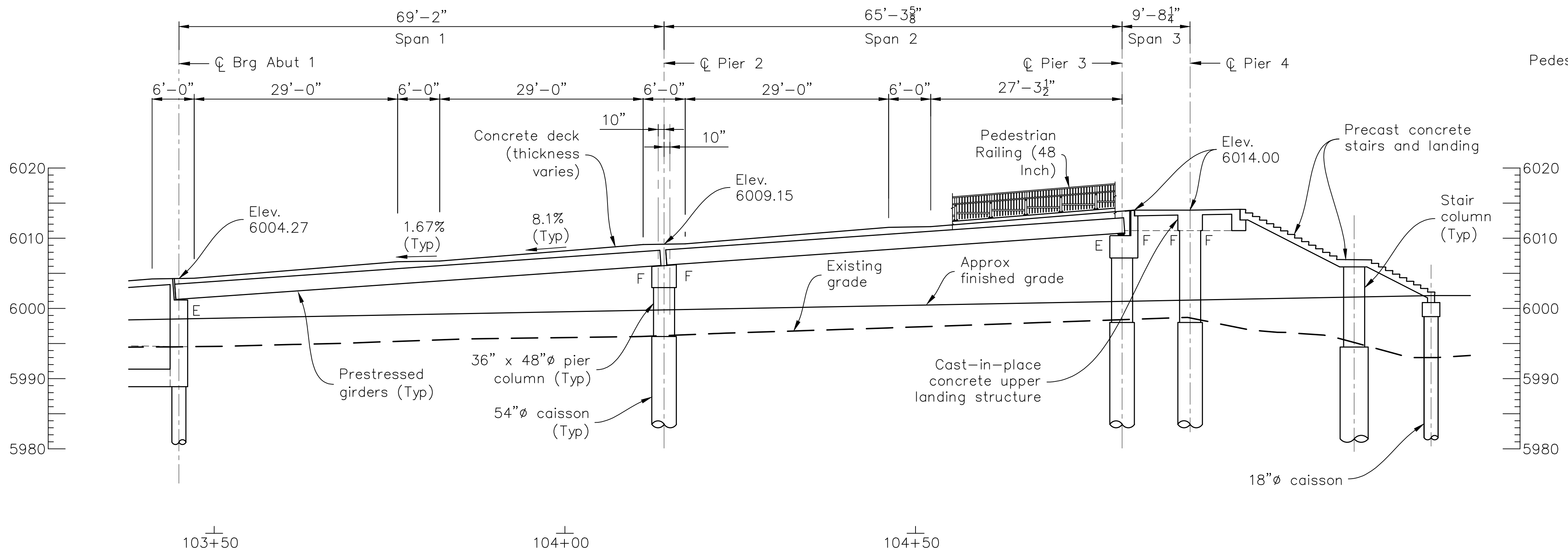
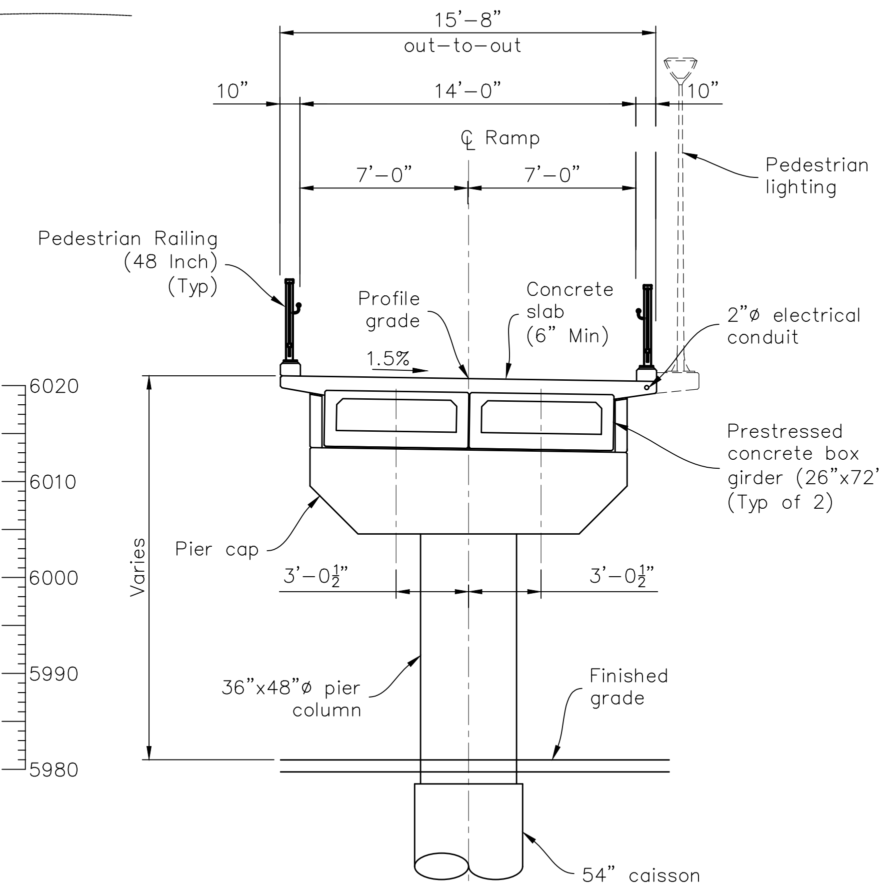


RAMP KEY PLAN



WEST RAMP SECTION



TYPICAL SECTION – SPANS 1 & 2

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
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Staff Bridge Branch – Unit 0224 TRS

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Civil and Structural Engineering

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
18500 E. Colfax Ave.
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Phone: (303) 746-8639

Region 1 – South Program NJB

As Constructed
No Revisions:
Revised:
Void:

I-25 Mobility Hub (Lone Tree)
West Pedestrian Ramp
General Layout (2 of 2)

Designer: J. Migliaccio	Structure Numbers	F-17-QX	
Detailer: J. Migliaccio			
Sheet Subset: West Ramp	Subset Sheets: RW04 of 59		
Near: Lone Tree	Sec. 10	Township 6S	Range 67W

Project No./Code
267 0252-499
24278
Sheet Number
Station 102+30.00 to Station 105+00.26

$PLOT_INFO$

GENERAL NOTES:

All work shall be done in accordance with the Colorado Department of Transportation 2023 Standard Specifications for Road and Bridge Construction and the Contract Documents.

Structure excavation and backfill shall be as shown on the plans.

Expansion joint material shall meet AASHTO Specification M213.

All exposed concrete surfaces shall receive a Class 1 final finish to one foot below the ground line. See Sealer and Stain Coating Limits sheet.

A colored Structural Concrete Stain finish will be required on exposed concrete surfaces to one foot below finished ground. For color requirements, see Sealer and Stain Coating Limits sheets.

Grade 60 reinforcing steel is required.

All reinforcing steel shall be epoxy coated unless otherwise noted.

(N) denotes non-epoxy coated reinforcing steel.

The contractor shall be responsible for the stability of the structure during construction.

Stations, elevations, and dimensions contained in these plans are calculated from a recent field survey. The Contractor shall verify all dependent dimensions in the field before ordering or fabricating any material.

All longitudinal and transverse dimensions are measured horizontally and include no correction for grade.

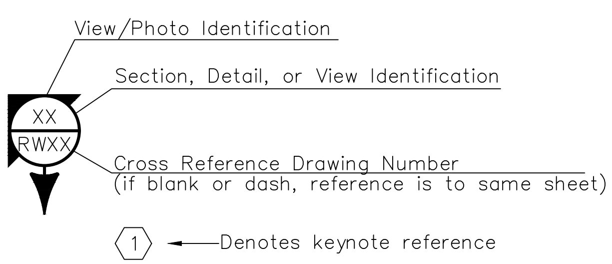
The information shown on these plans concerning the type and location of underground utilities is not guaranteed to be accurate or all inclusive. The Contractor is responsible for making its own determination as to the type and location of underground utilities as may be necessary to avoid damage thereto. The Contractor shall contact the Utility Notification Center of Colorado at 811 (1-800-922-1987) at least 3 days (2 days not including the day of notification) prior to any excavation or other earthwork.

All provisions for bridge deck concrete shall also apply to abutment ramp top slab concrete.

For structure number installation, see Standard S-614-12.

Prior to conducting any excavation, the Contractor and CDOT Project Engineer shall coordinate with the CDOT Paleontologist for any requirements pertaining to archaeological issues at the site.

LEGEND



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(Per M-100-2 or as shown below)

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Brg.	= bearing	ITS	= intelligent transportation systems	Sta.	= station
℄	= center line	Jt.	= joint	sq. mi.	= square mile
Clr	= clear	kip	= thousand pounds	Str.	= structure
Const.	= construction	Max.	= maximum	Typ	= Typical
Cont.	= continuous	Min.	= minimum	UNO	= unless noted otherwise
EF	= each face	MSE	= mechanically stabilized earth	VC	= vertical curve
Elev.	= elevation	No.	= number	VPI	= vertical point of intersection
Eq.	= equally	PGL	= profile grade line	WSEL	= water surface elevation
Est.	= estimated	Proj.	= projection		
Exp.	= expansion	ROW	= right of way		

DESIGN DATA

AASHTO, 9th Edition LRFD, 2020
AASHTO LRFD Guide Specifications for Design of Pedestrian Bridges, 2nd Edition with current interims

Design Method: Load and Resistance Factor Design

Dead Load: Assumes 5 lb/ft for drainage and future utilities
¾" future deck overlay: 6 psf

Live Loads: Pedestrian load: 90 psf
Vehicular load: H-5 vehicle

Reinforced Concrete:
Class D Concrete: f'c = 4,500 psi
Reinforcing Steel: fy = 60,000 psi
Sulfate Exposure: Class 0

Caisson Concrete:
Class BZ Concrete: f'c = 4,000 psi
Reinforcing Steel: fy = 60,000 psi

Structural Steel:
AASHTO M270 (ASTM A709) Grade 36 fy= 36,000 psi
AASHTO M270 (ASTM A709) Grade 50 fy= 50,000 psi

Precast Prestressed Concrete:
Class PS Concrete: f'c = (see details)
f's = 270,000 psi

SEISMIC DESIGN CRITERIA

Earthquake Design method:
Latitude = 39.532804°
Longitude = -104.868055°

Peak Ground Acceleration (PGA): 0.057

Spectral Acceleration Coefficients:
Period (sec)
0.2 (S_S): 0.122
0.1 (S_1): 0.034

Site Factor (F_{PGA}): 1.2
Site Factor (F_A): 1.2
Site Factor (Fv): 1.7

Modified Peak Ground Acceleration (A_S): 0.068

Modified Spectral Acceleration Coefficients:
Period (sec)
0.2 (S_{DS}): 0.146
0.1 (S_{D1}): 0.057

Seismic Site Class: C

INDEX OF DRAWINGS (EAST RAMP)

BRIDGE DESCRIPTION

4-span (11'-1 ½", 65'-3⅝", 70'-0", 68'-3") pedestrian bridge approach ramp
Prestressed concrete box girders and cast-in-place concrete upper landing
14'-0" clear width
48" Pedestrian Rail (Typ); 54 Pedestrian Rail at switchback

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
File Name: LTMH East Ramp.dgn
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Staff Bridge Branch - Unit 0224 TRS
San Engineering LLC
Civil and Structural Engineering

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
18500 E. Colfax Ave.
Aurora, CO 80111
Phone: (303) 746-8639
Region 1 - South Program NJB

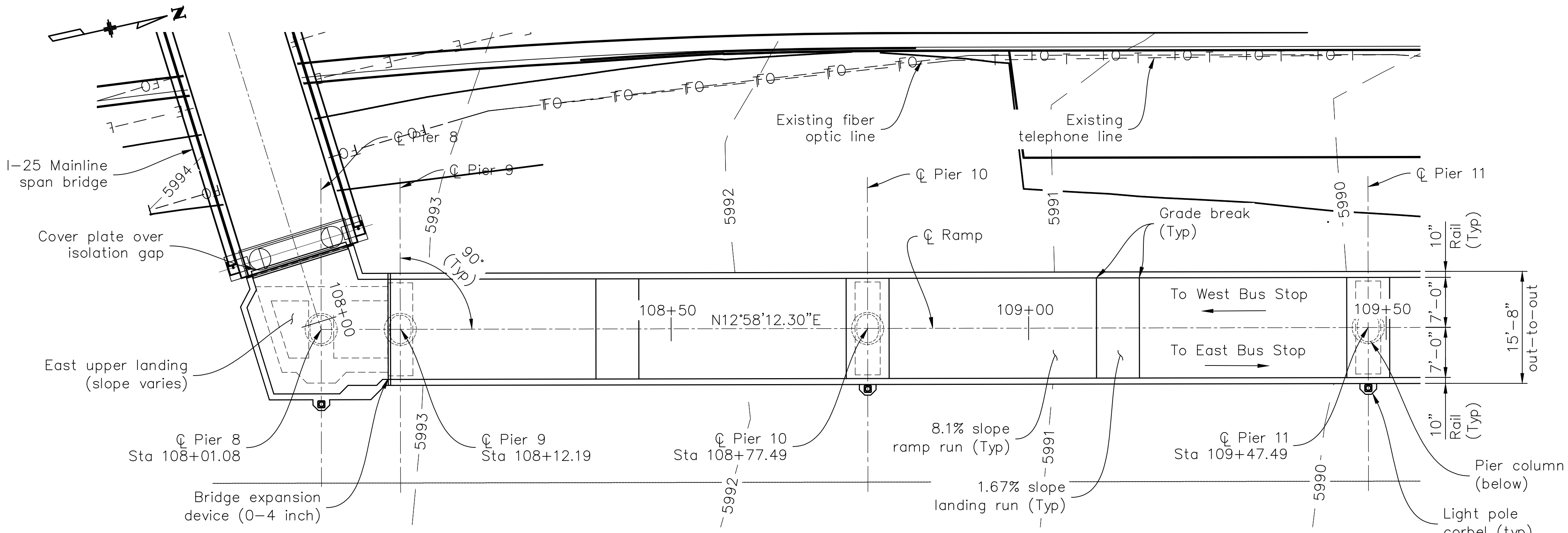
As Constructed
No Revisions:
Revised:
Void:

I-25 Mobility Hub (Lone Tree)
East Pedestrian Ramp
General Information

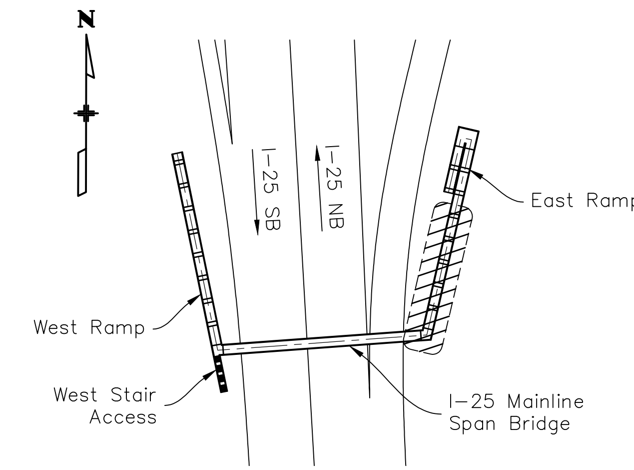
Designer: J. Migliaccio
Detailer: J. Migliaccio
Structure Numbers: F-17-QX
Sheet Subset: East Ramp
Subset Sheets: RE01 of 59
Near: Lone Tree Sec. 10 Township 6S Range 67W

Project No./Code
267 0252-499
24278
Sheet Number
Station 107+90.26 to Station 111+63.49

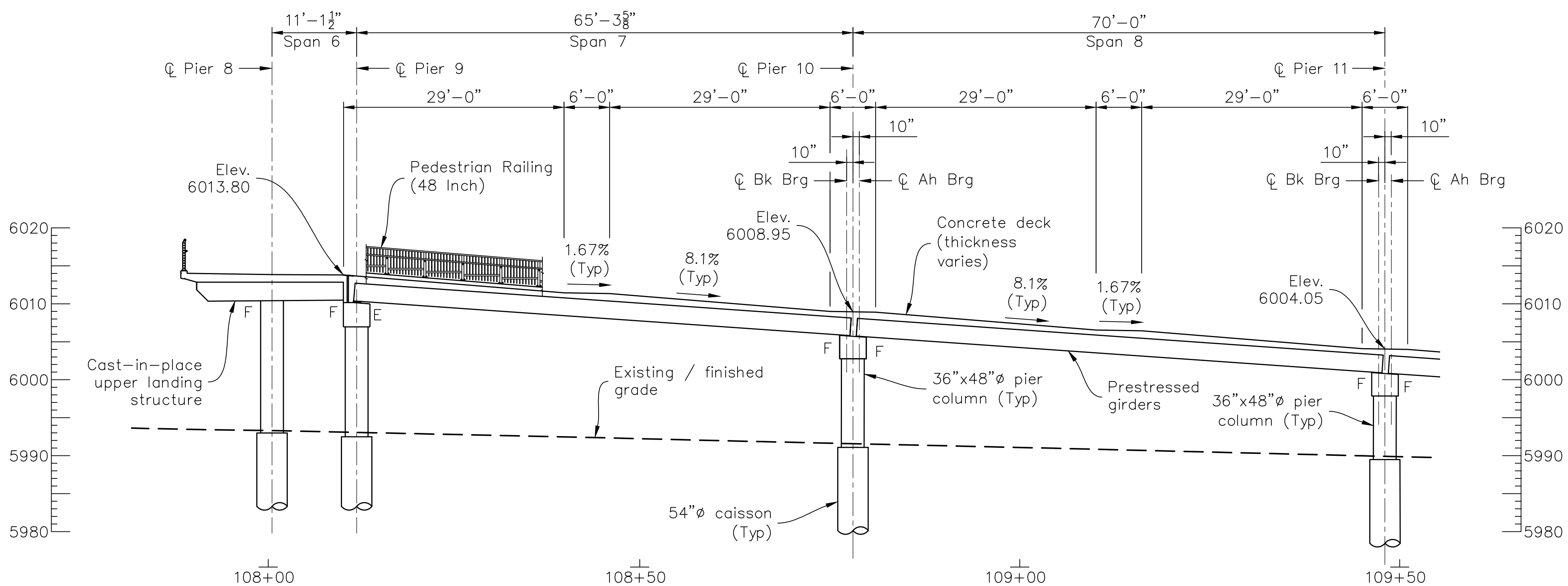
$PLOT_INFO$



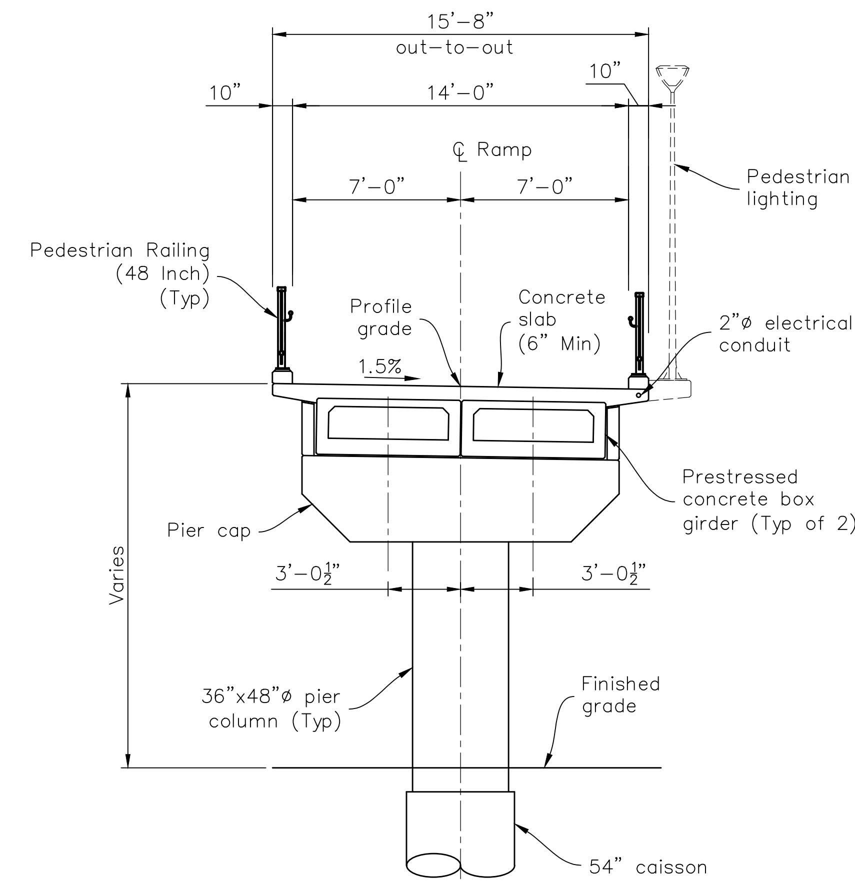
EAST RAMP PLAN



RAMP KEY PLAN



EAST RAMP SECTION



TYPICAL SECTION – SPANS 9, 10, & 11

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
File Name: LTMH East Ramp.dgn
Horiz. Scale: As Noted Vert. Scale: As Noted
Staff Bridge Branch – Unit 0224 TRS
San Engineering LLC
Civil and Structural Engineering

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
18500 E. Colfax Ave.
Aurora, CO 80111
Phone: (303) 746-8639
Region 1 – South Program NJB

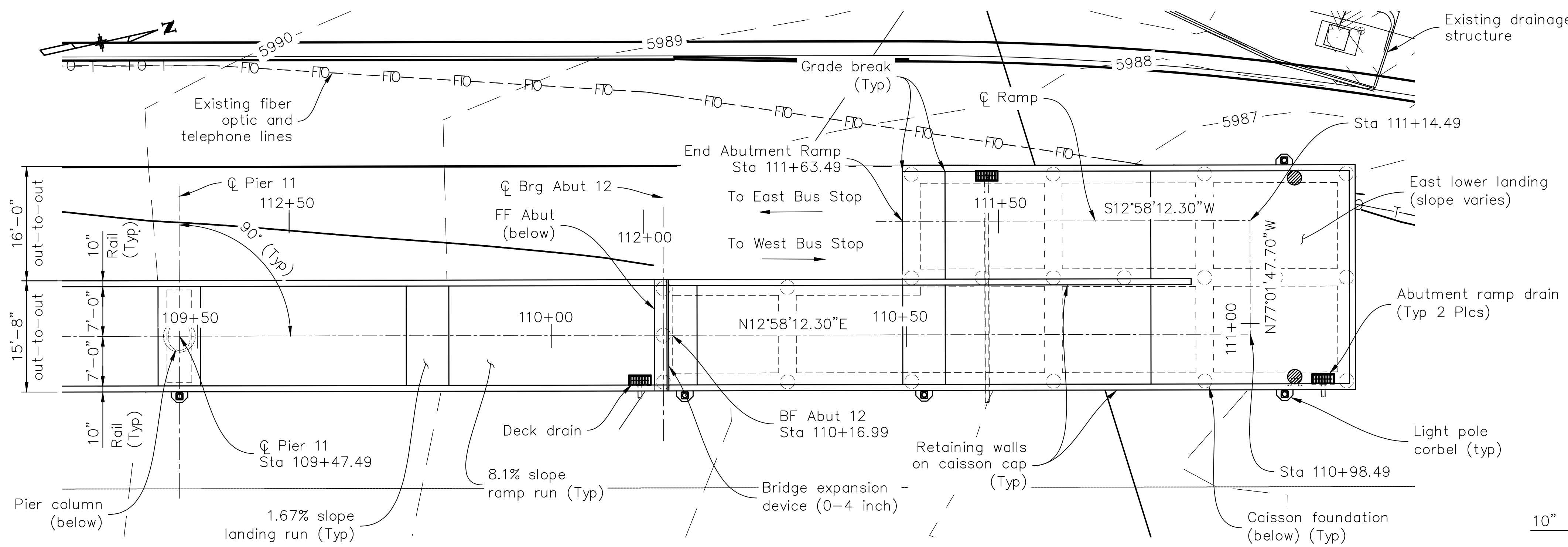
As Constructed
No Revisions:
Revised:
Void:

I-25 Mobility Hub (Lone Tree)
East Pedestrian Ramp
General Layout (1 of 2)

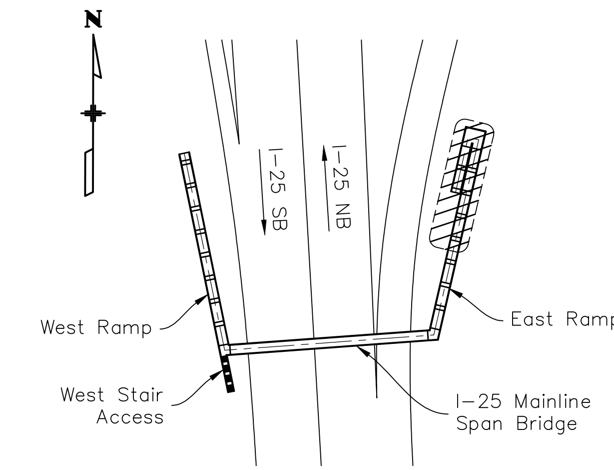
Designer: J. Migliaccio
Detailer: J. Migliaccio
Structure Numbers: F-17-QX
Sheet Subset: East Ramp
Subset Sheets: RE03 of 59
Near: Lone Tree Sec. 10 Township 6S Range 67W

Project No./Code
267 0252-499
24278
Sheet Number
Station 107+90.26 to Station 111+63.49

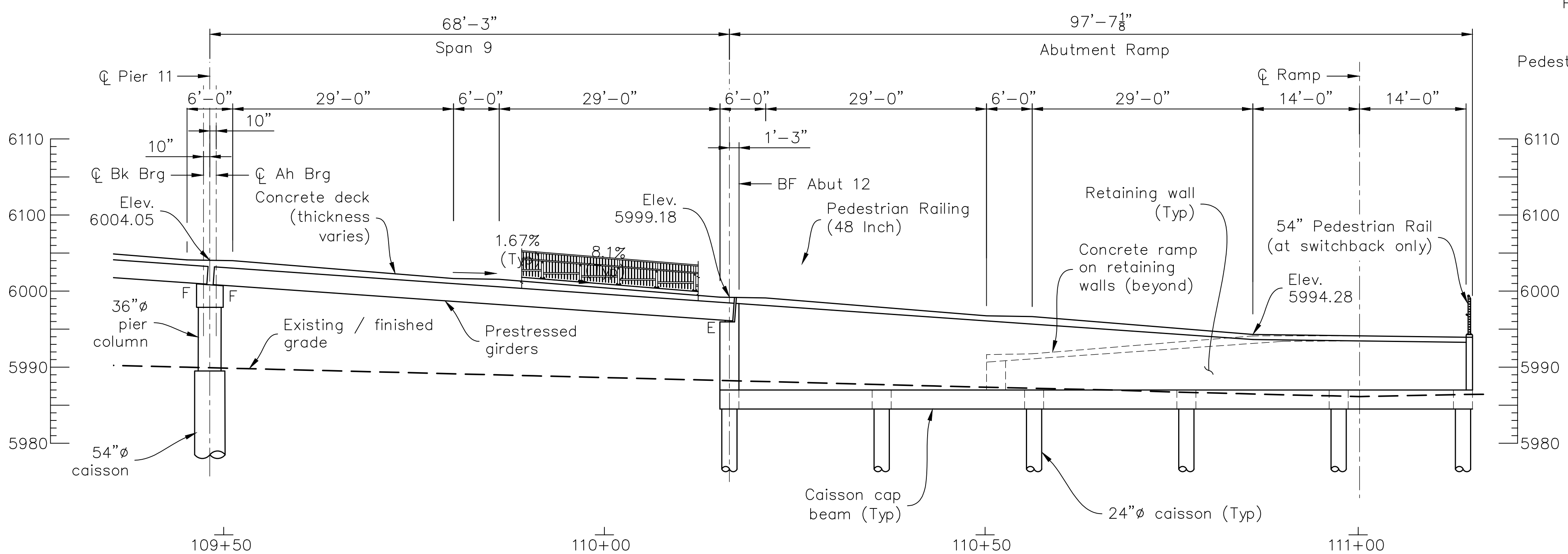
$PLOT_INFO$



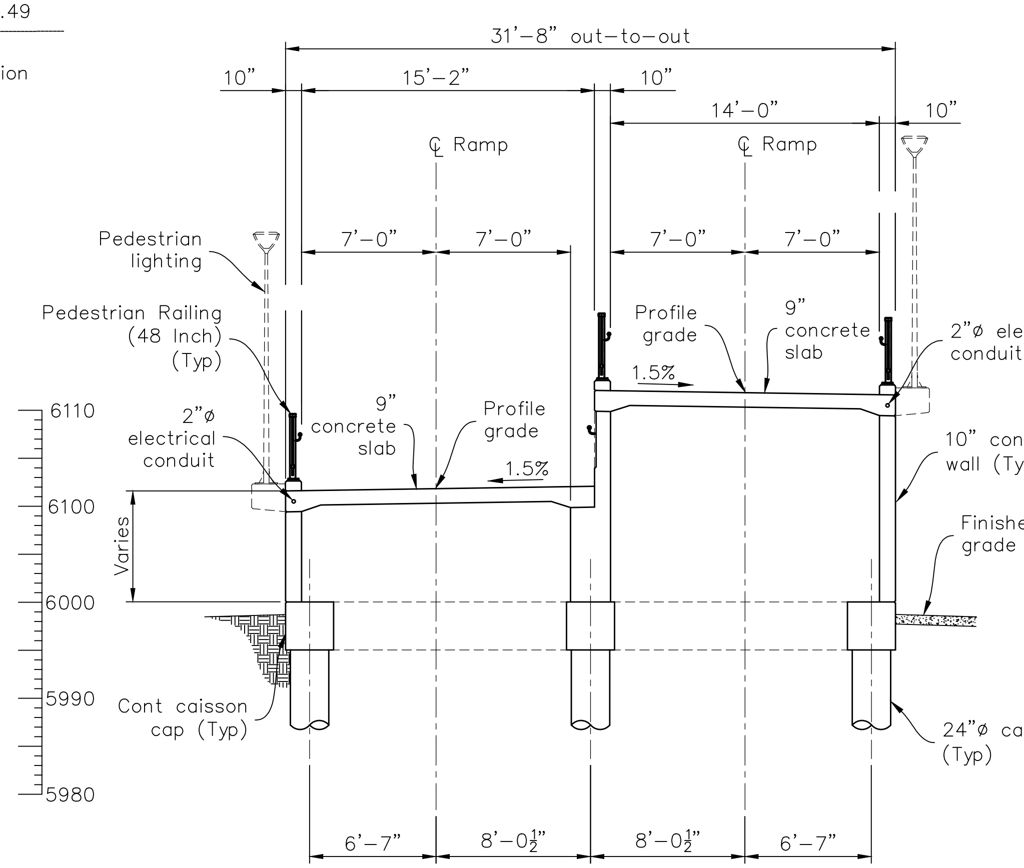
EAST RAMP PLAN



RAMP KEY PLAN



EAST RAMP SECTION



TYPICAL SECTION – EAST ABUTMENT RAMP

INITIALS	DESIGN	DATE	DETAIL	DATE	QUANTITY	DATE
By	JAZ	08/24	MDP	08/24	KCP	08/24
Checked By	JJM	08/24	JJM	08/24	JJM	08/24

All seals for this set of drawings are applied to the cover page(s)

Print Date: 8/29/2024
File Name: LTMH East Ramp.dgn
Horiz. Scale: As Noted Vert. Scale: As Noted
Staff Bridge Branch – Unit 0224 TRS
San Engineering LLC
Civil and Structural Engineering

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation
18500 E. Colfax Ave.
Aurora, CO 80111
Phone: (303) 746-8639
Region 1 – South Program NJB

As Constructed
No Revisions:
Revised:
Void:

I-25 Mobility Hub (Lone Tree)
East Pedestrian Ramp
General Layout (2 of 2)

Designer: J. Migliaccio	Structure Numbers	F-17-QX	
Detailer: J. Migliaccio			
Sheet Subset: East Ramp	Subset Sheets: RE04 of 59		
Near: Lone Tree	Sec. 10	Township 6S	Range 67W

Project No./Code
267 0252-499
24278
Sheet Number
Station 107+90.26 to Station 111+63.49

$PLOT_INFO$

Appendix B – Cost Estimate

Preliminary Cost Estimate - Lone Tree Mobility Hub Ramps

COST SUMMARY BY STRUCTURE ALTERNATIVE

Superstructure

Item	Item Code	Unit	Unit Cost	CIP Slab and Beams	Steel Beam with Composite Deck	PS Box Girder
Concrete Class D, Bridge (Formed Deck, Curb, and Girders)	601-03040	CY	*$2,200.0*	686	0	0
				$1,509,200	$0	$0
Concrete Class D, Bridge (Deck and Curb on Girders)	601-03040	CY	*$1,900.0*	0	405	405
				$0	$769,500	$769,500
Structural Steel	509-00000	LB	*$5.0*	1000	183546	1000
				$5,000	$917,730	$5,000
Prestressed Concrete Box (Depth 32" Through 48")	618-01994	SF	*$200*	0	0	2472
				$0	$0	$494,400
Reinforcing Steel, Epoxy (Deck and Curb)	602-00020	LB	*$3.0*	171500	101250	91125
				$514,500	$303,750	$273,375
Bearing Device	512-00101	EA	*$10,000*	4	6	4
				$40,000	$60,000	$40,000
Precast Pedestrian Stair Structure	621-00650	LS	*$100,000*	1	1	1
				$100,000	$100,000	$100,000
			Subtotal	**$2,168,700**	**$2,150,980**	**$1,682,275**

Substructure

Item	Item Code	Unit	Unit Cost	CIP Slab and Beams	Steel Beam with Composite Deck	PS Box Girder
Concrete Class D,Bridge (Piers)	601-03040	CY	*$1,800*	149	149	149
				$268,812	$268,812	$268,812
Concrete Class D,Walls (Walls,Footings, Grade Beams)	601-03050	CY	*$1,500*	400	400	400
				$600,697	$600,697	$600,697
Reinforcing Steel, Epoxy (Piers)	602-00020	LB	*$3.0*	36335	36335	36335
				$109,005	$109,005	$109,005
Reinforcing Steel, Epoxy (Walls and Footings)	602-00020	LB	*$3.0*	93866	93866	93866
				$281,598	$281,598	$281,598
Drilled Shaft (48 inch)	503-00048	LF	*$1,000*	270	270	270
				$270,000	$270,000	$270,000
Drilled Shaft (24 inch)	503-00024	LF	*$650*	875	875	875
				$568,750	$568,750	$568,750
Structure Excavation	206-00000	CY	*$30*	1061	1061	1061
				$31,844	$31,844	$31,844
Structure Backfill, Class 1	206-00100	CY	*$60*	425	425	425
				$25,529	$25,529	$25,529
			Subtotal	**$2,156,234**	**$2,156,234**	**$2,156,234**

San Engineering LLC
Civil and Structural Engineering
1150 W. Littleton Blvd. Ste. 200 Littleton, CO 80120
(303) 953-9014 www.sanengineeringllc.com

Project: Lone Tree Mobility Hub
Client: RS&H
Subject: Preliminary Cost Estimate - Lone Tree Mobility Hub Ramps
Job Number:
Engineer: SJK
Date: 6/3/2024

Preliminary Cost Estimate - Lone Tree Mobility Hub Ramps

Miscellaneous

Item	Item Code	Unit	Unit Cost	CIP Slab and Beams	Steel Beam with Composite Deck	PS Box Girder
Bridge Expansion Device (0-4 inch)	518-01004	LF	*$1,000*	42	42	42
				$42,000	$42,000	$42,000
Pedestrian Railing (54 inch)	514-00054	LF	*$500*	1556	1556	1556
				$778,050	$778,050	$778,050
Bridge Drain Inlet	513-00606	EA	*$10,000*	3	3	3
				$30,000	$30,000	$30,000
6 Inch Drain Pipe	605-82306	LF	*$60*	75	75	75
				$4,500	$4,500	$4,500
			Subtotal	**$854,550**	**$854,550**	**$854,550**
			Total	**$5,179,484**	**$5,161,764**	**$4,693,059**
			Total w/ 20% Contigency	**$6,215,381**	**$6,194,117**	**$5,631,671**

Legend:

Unit cost (materials + install)
Quantity
Cost
Subtotal

Structure Selection Report QA Checklist

This checklist is to serve as quality assurance of the structure selection process. This checklist must be signed by Staff Bridge Unit Leader or designee prior to submittal of FIR documents to the Region.

Structure Number(s): F-17-QX (West and East Ramps to Mainline Bridge)

Cover Sheet

- ☑ Name of the Project and Site Address
- ☑ Structure(s) Number
- ☑ Property Owner Name and Contact Information
- ☑ Report Preparer Name and Contact Information
- ☑ Seal and Signature of the Designer
- ☑ Submittal and Revision Dates as Applicable

Executive Summary

- ☑ Project Description
- ☑ Structure Recommendations

Site Description and Design Features

- ☑ Existing Structures ☑ N/A: ___
- ☑ Vicinity Map
- ☑ ROW Impact ☐ N/A: ___
- ☑ Traffic Detour ☑ N/A: ___
- ☑ Utilities ☐ N/A: ___
- ☑ Geotechnical Summary
- ☑ Hydraulics Summary ☑ N/A: ___
- ☑ Environmental Concerns ☐ N/A: ___
- ☑ Roadway Design Features
  - ☑ Cross Section
  - ☑ Vertical Alignment
  - ☑ Horizontal Alignment

Structural Design Criteria

- ☑ Design Specifications
- ☑ Loading ☐ N/A: ___
  - ☑ Collision Load
  - ☑ Earthquake Load
- ☑ Deck Drainage ☐ N/A: ___
- ☑ Aesthetic Requirements ☐ N/A: ___
- ☑ Possible Future Widenings ☐ N/A: ___

Structure Selection

- ☑ Selection Criteria
- ☑ Rehabilitation Alternatives ☑ N/A: ___
  - ☑ Inspection Summary
  - ☑ Load Testing Requirements ☑ N/A: ___

Add figures/sketches to the following sections as needed

- ☑ Structure Layout Alternatives
  - ☑ Vertical Clearances
  - ☑ Horizontal Clearances
  - ☑ Skew
  - ☑ Span Configurations
- ☑ Superstructure Alternatives ☐ N/A: ___
  - ☑ Concrete Girder Alternatives
  - ☑ Steel Girder Alternatives
  - ☑ Deck Drains

☑ Substructure Alternatives ☐ N/A:____

- ☑ Abutment Alternatives (GRS, Integral, Semi-integral, etc.)
- ☑ Pier Alternatives

☑ Wall Alternatives ☐ N/A:____

☑ Constructability & Construction Phasing

☑ ABC Design (include pre-scoping ABC rating results from spreadsheet found on the CDOT website)

☑ Maintenance and Durability

☑ Corrosive Resistance

☑ Summary of Structure Type Evaluation Table

☑ Construction Costs (including costs of alternatives)

Other

Discussions of expansion joints, stairs, pedestrian ralings, future connections

Figures and Appendices

☑ Alternative Typical Sections (if not provided in the report)

☑ General Layout of the Selected Structure

☑ Summary of Quantities and Cost Estimate Tables

List of Variances

Requested Variance: ____

Approved? ☐ Yes ☐ No

Requested Variance: ____

Approved? ☐ Yes ☐ No

Requested Variance: ____

Approved? ☐ Yes ☐ No

If you need more space, use an additional sheet(s) of paper.

CDOT Staff Bridge Quality Assurance Sign-off

By signing this checklist Staff Bridge Unit Leader or designee acknowledges approval of the Structure Selection Report findings, recommendations, and all design deviations from the CDOT Structural Standards and design criteria.

____________________	____________________	_______________
Print Name	Signature	Date