HYDRAU-TECH, INC.
ENGINEERING & SOFTWARE

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February 25, 2020

Benjamin Kenney, P.E.
President
Engineering Operations LLC.
5575 S. Sycamore Street Suite 235
Littleton, CO 80120

Subject: EPC009104.37A Bridge Deck Drainage Design Recommendations

Dear Mr. Kenney,

Hydrau-Tech, Inc. has performed a bridge deck drainage analysis for the proposed new construction of a reinforced concrete bridge deck for El Paso County Structure EPC009104.37A. Following the guidelines in Federal Highway Administration's Hydraulic Engineering Circular-21 Manual, American Association for State Highway Transportation Officials' Drainage Design Manual, and Colorado Department of Transportation's Drainage Design Manual, the analysis resulted in four curb inlets on each side of the bridge (for a total of 8). This drainage configuration will provide adequate bridge deck drainage for AASHTO bridge deck drainage design storm event of an appropriate duration complying with CDOT's Drainage Design Manual inlet configuration. According to our design, each curb inlet is 1 ft long and 6 in high and are equally spaced approximately 24 ft apart along the bridge curb and drains the bridge deck safely away from the piers. Engineering Operations' proposed 2% cross grade from crown to curb should be carried through the curb inlets to allow for proper drainage of the bridge deck as shown in the inlet detail. We believe that this design recommendation will improve bridge deck drainage by preventing pooling and help prevent deterioration of the superstructure elements. The spread widths resulting from this design are in accordance with AASHTO and CDOT recommendations.

Finally, the proposed bridge deck drainage design will not have any adverse environmental impacts or introduce any effluents to the existing bridge and roadway drainage system and to the Black Squirrel Creek that the bridge crosses.

The attached document provides the bridge deck drainage design procedure used for developing the curb inlet drainage design and identifies input parameters used in sizing and spacing the inlets.

If you have any questions, please feel free to contact me.

Best Regards,

Albert Molinas, Ph.D., P.E.
President, Hydrau-Tech Inc.

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Bridge EPC009104.37A Deck Drainage Design

This drainage analysis document was developed to provide records for El Paso County detailing the bridge deck drainage design for the proposed concrete deck and curb installation for Structure EPC009104.37A. This document provides descriptions of the analysis and associated design input parameter selections used in sizing elements of the bridge deck drainage system.

Introduction

Structure EPC009104.37A is located in El Paso County on Elbert Road approximately 5 miles east of Black Forest. Structure EPC009104.37A is a 3 span steel stringer, continuous/metal plank floor. The existing structure's metal deck has experienced significant deterioration largely due to a lack of drainage from the existing bridge deck. The existing metal deck is being replaced with a reinforced concrete slab deck with reinforced concrete curbs and bridge rails. To properly drain the bridge deck, curb inlets are proposed spaced at specified intervals along the bridge on both sides of the roadway. This document describes the data collection and drainage analysis procedures used for designing the inlet system. Figure 1 shows an aerial view of the project site. Figure 2 shows the condition of the existing bridge deck.

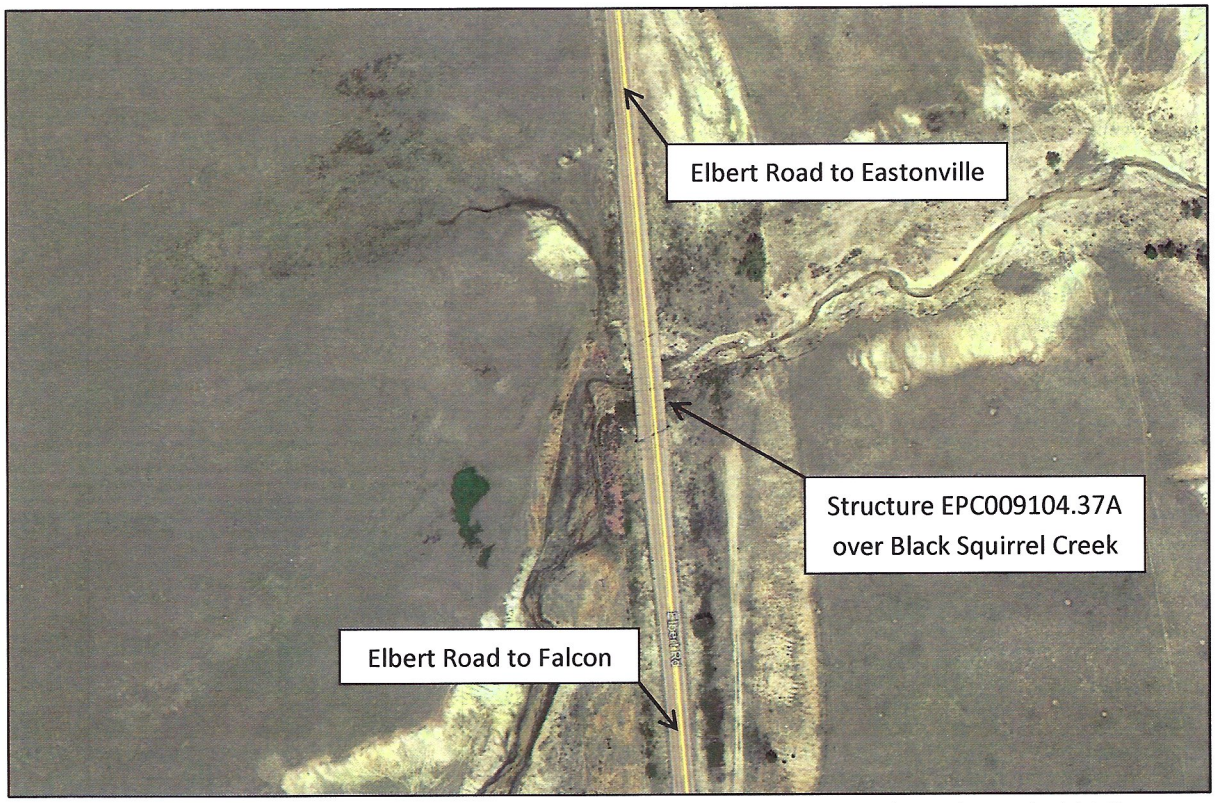

Figure 1. Vicinity Map for Structure EPC009104.37A in El Paso County (Google Earth, 2017)

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Figure 2. Structure EPC009104.37A existing bridge deck condition. (Engineering Operations, 2018)

Design Approach

Regional Hydrology

In order to develop and design an appropriate deck drainage system, hydrologic characteristics of the watershed including drainage area, surface runoff characteristics, and rainfall intensities were determined. Precipitation frequency estimates and associated information are required to determine the discharge for a design storm event. National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 precipitation frequency data was obtained for the area of interest and was used in developing rainfall Intensity-Duration-Frequency (IDF) curves. The IDF curves corresponding to various return frequency rainfall events of different intensities and durations for Structure EPC009104.37A are presented in Figure 3.

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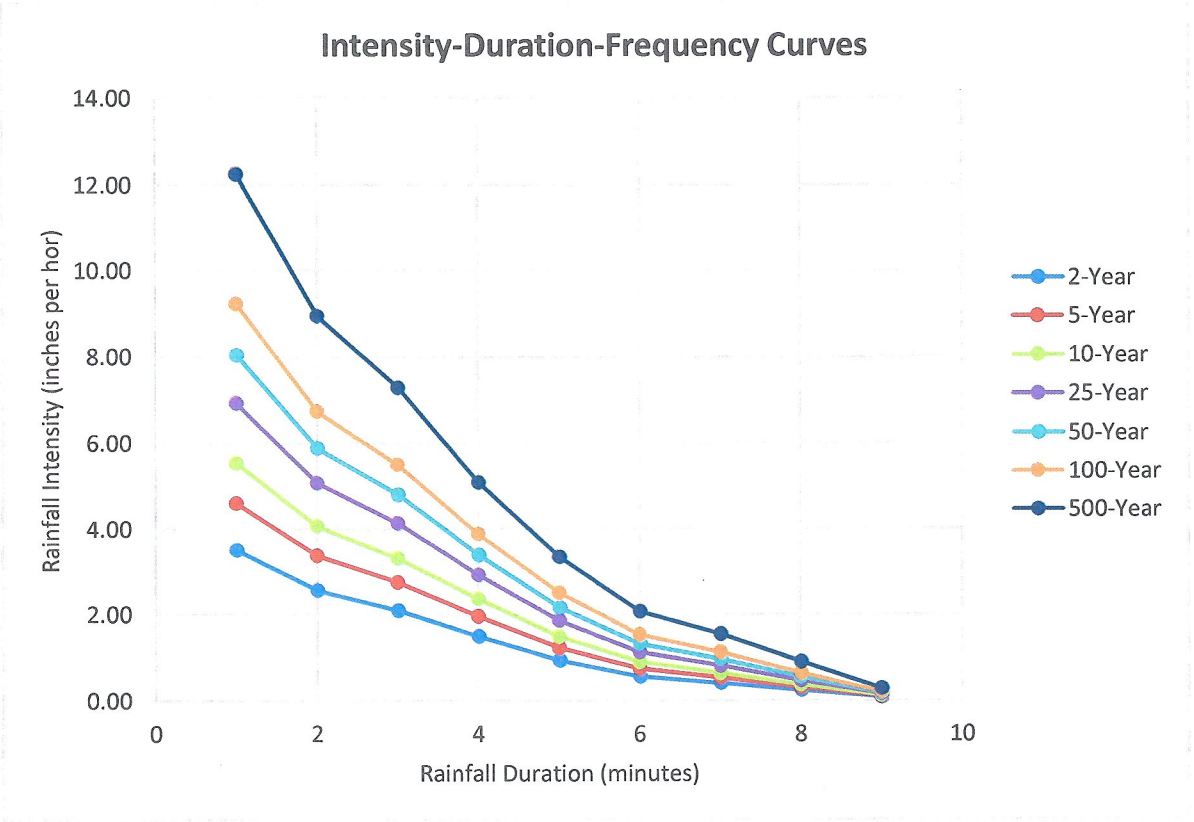

Figure 3. Intensity Duration Frequency Curves for Structure EPC009104.37A

Drainage Area

The area that drains to the bridge was determined from as-built drawings, proposed new construction drawings provided by Engineering Operations (eO), and LiDAR data available through the Colorado Hazard Mapping & Risk Portal. Since the Structure EPC009104.37A is located on a sag vertical curve, in addition to the bridge deck, portions of the adjoining roadway leading to the bridge also contribute to the total area that needs to be drained. In order to determine the drainage area contribution from adjoining roadways, the longitudinal and cross slope of the roadway was determined. The length of roadway segments leading to the bridge on both sides was set equal to the width of the roadway, or 18 ft (6' shoulder + 12' lane). This assumption is believed to be conservative since the longitudinal slopes of the approaching roadways are flatter than the cross slope of the road, resulting in shorter contributing segments. Using areas of approach roadways and the area of the bridge deck a total discharge to be drained corresponding to design frequency storm event was determined. The design drainage discharge for each side of the bridge corresponds to half of the total discharge.

Rainfall Event

Following the guidelines in FHWA's Hydraulic Engineering Circular (HEC) 21 for design of bridge deck drainage, a time of concentration was computed for a 10-year rainfall event iteratively. This time of concentration was used in selecting the duration of the design rainfall event. Using the 10-year rainfall intensity at Structure EPC009104.37A produced an approximate time of concentration equal to the 5

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minute duration. The 10-year, 5-minute intensity rainfall event was also recommended for bridge deck drainage design in Colorado Department of Transportation's (CDOT) Drainage Design Manual (DDM, 2019). AASHTO DDM also recommends using a 25-year event as a check storm event to assure safe operation of the drainage system.

Inlet Discharges

Design discharge for deck drainage is determined using the rational method (Q=CiA; where C=runoff coefficient, 0.9, i=rainfall intensity, A=drainage area) with a 10-year, 5-minute rainfall intensity from the IDF curve given in Figure 3 and by using the drainage area computed as described previously. Using a drainage area of 0.057 acres and a rainfall intensity of 5.53 in/hour, a total discharge of 0.28 cfs was computed for one side of the bridge. This discharge is drained by placement of inlets along the curb. A curb inlet size of 1 ft wide by 0.5 ft high was selected for the design using CDOT's DDM. Since each inlet along the curb drains varying watersheds (deck areas), total discharge past each inlet is reduced in the direction of flow. The number of curb inlets is determined by computing accumulated inlet capacities along the curb until the total discharge is drained. This iterative process of computing number of inlets and their spacing resulted in 4 curb inlets at approximately 24 ft intervals. Incremental discharges to be drained by each inlet for the design and check storm events based on 24 ft intervals are presented in Table 1.

Table 1. Computed incremental discharges at various inlets along the curb from north to south

Discharge to Curb Inlets (cfs)		
Inlet Number	10-Year, 5-Minute	25-Year, 5-Minute
1	Q_{i1}=0.068	Q_{i1}=0.085
2	Q_{i2}=0.049	Q_{i2}=0.062
3	Q_{i3}=0.050	Q_{i3}=0.064
4	Q_{i4}=0.117	Q_{i4}=0.147
Total	Q_t=0.28	Q_t=0.36

Based on the calculated spread and flow depths at each inlet location, the capacity for each inlet was determined using the weir equation provided in AASHTO's DDM. Using a clogging factor of 10%, the capacity of each curb inlet was determined to be Q_i=0.216 cfs which can safely drain incremental discharges to each inlet listed in Table 1.

Spread Widths

The spread width is defined as the top width of the gutter flow. CDOT DDM specifies safe spread widths at various roadway classifications. For Structure EPC009104.37A, for greater than 45 mph, the recommended spread width by CDOT (and AASHTO) is shoulder width plus 3 ft. The present design spread widths were checked for the design storm and check storm events for compliance with CDOT and AASHTO recommendations. Spread for the 10-year, 5-minute design storm event, and 25-year, 5-minute design storm event were determined to be 6.7 ft 9.5 ft, respectively as opposed to the recommended 9 ft for the design event and 12 ft for check event.

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Summary and Conclusions

In order to adequately provide drainage for the proposed concrete slab deck for Structure EPC009104.37A, curb inlet drains are proposed. A 10-year, 5-minute storm event was chosen as recommended by AASHTO and CDOT for the design storm event resulting in a total discharge of 0.28 cfs that needs to be drained. Using 4 curb inlets with an opening size of 1 ft in length and 0.5 ft in height, discharges arriving at each inlet were determined. Comparing these incremental discharges contributing to each inlet with the calculated discharge capacities of each inlet show that the 4 curb inlets with an approximate spacing of 24 ft provide adequate drainage for both the design and check storm events. The 4 curb inlet configuration also provides a spread width that is within the CDOT and AASHTO recommended limits for Structure EPC009104.37A for both the design and check storm events.

The proposed bridge deck drainage design, since it does not divert any additional highway runoff, will not have any adverse environmental impacts or introduce any effluents to the existing bridge and roadway drainage system and to the Black Squirrel Creek that the bridge crosses.

Drainage Letter

Design Engineer's Statement:

This grading and erosion control plan was prepared under my direction and supervision and is correct to the best of my knowledge and belief. Said plan has been prepared according to the criteria established by the County for grading and erosion control plans. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this plan.

[Name, P.E. # Albert Molinas, PE # 37314]

1/1/2021
Date

El Paso County:

County plan review is provided only for general conformance with County Design Criteria. The County is not responsible for the accuracy and adequacy of the design, dimensions, and/ or elevations which shall be confirmed at the job site. The County through the approval of this document assumes no responsibility for completeness and/ or accuracy of this document.

Jennifer Irvine, P.E.
County Engineer / ECM Administrator

27 APRIL 2021
Date