MIDTOWN CORRIDOR
GENERAL BRIDGE MANAGEMENT PLAN

Prepared for:

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Photo by CJ Hibbard, circa 1915, Minnesota Historical Society

EXECUTIVE SUMMARY

Under the direction of the Hennepin County Regional Rail Authority (HCRRA) and Minnesota Department of Transportation (MnDOT) State Aid and Cultural Resources Unit (CRU), Olson & Nesvold Engineers (ONE) and its project partners (Gemini Research, SRF Consulting Group, Braun Intertec, and MacDonald & Mack) have assembled this general bridge management plan for 37 bridges standing within the portion of the Midtown Corridor that is included within the 2.8-mile Chicago, Milwaukee and St. Paul (CM&StP) Railroad Grade Separation Historic District. Appended to this report are individual reports for the 37 bridges included in the study. The general management plan provides guidance on the bridges in the historic district as a whole. This includes a description of the process used to assemble the reports and a discussion of rehabilitation activities that meet the Secretary of the Interior's Standards for the Treatment of Historic Properties. It also includes recommendations for the prioritization of construction projects. Provided in this plan's appendices are reference documents that should be reviewed as individual bridge projects are developed in preliminary and final design.

The bridges in the CM&StP Historic District are a subset of state- and locally-owned historic bridges in Minnesota that are the subject of an ongoing historic bridge preservation effort led by MnDOT in cooperation with the Federal Highway Administration (FHWA), State Historic Preservation Office (SHPO), and numerous other partners. Specifically, the bridges in the historic district are among approximately140 historic bridges statewide that are owned by agencies other than MnDOT. This study of bridges in the CM&StP Historic District is part of a broader effort – the Minnesota Local Historic Bridge Study – which has a goal of analyzing the condition of and creating preservation recommendations for all locally-owned historic bridges in the state as well as take other steps to encourage their preservation. The goal is to, as much as possible, rehabilitate the bridges following the Secretary of the Interior's Standards for the Treatment of Historic Properties. Another goal is to identify for MnDOT the funding needs required for the preservation of historic bridges so that projects may be planned for and programmed. This study's individual bridge reports and general management plan are part of this effort.

To prepare this general management plan and its accompanying individual reports, the team reviewed historic bridge plans, historic photos and pertinent reference documents. Past material testing and geotechnical information was reviewed as well. Several field visits to the corridor were performed to review current conditions of all bridges. Multiple corridor visits were performed by historians, engineers, and concrete material specialists reviewing the bridges collaboratively. In addition, numerous project team meetings were held to analyze field data, refine recommendations and vet options to rehabilitate the bridges in ways that meets the Secretary of the Interior's Standards for the Treatment of Historic Properties.

Individual bridge management plans were assembled for the 27 bridges contributing to the historic district. The contributing bridges were built between 1912 and 1917. The condition of the contributing bridges ranges from very poor to good (2 bridges were recently rehabilitated). Each individual report contains a set of suggested Stabilization, Preservation, and Maintenance activities. These recommendations are consistent with the process used by MnDOT for the other bridges in the Minnesota Local Historic Bridge Study. The preservation activities were selected to provide a service life of 30 years and assumed each bridge would remain in its current functional use. Any work on the bridges should proceed according to the Secretary of the Interior's Standards for the Treatment of Historic Properties and the "Guidelines for Bridge Maintenance and Rehabilitation Based on the Secretary of the Interior's Standards" as adapted by the Virginia Transportation Research Council (included herein).

The estimated programming cost for construction work on the contributing bridges amounts to $41M. Soft costs associated with project delivery (preliminary design, final design, construction support) are estimated to be on the order of 20% of construction costs or $8.2M. Using 2014 dollars a total programming cost of $50M is recommended. Having this information along with the information from MnDOT's Minnesota Local Historic Bridge Study will help MnDOT determine the funding needs to preserve historic bridges.

Shorter bridge reports were assembled for the 10 noncontributing bridges in the corridor. These bridges were constructed in the past 30 years and are typically in good condition. Very little and very minor rehabilitation work was identified for these bridges to provide 30 years of additional service.

TABLE OF CONTENTS

1. Project Introduction

Under the direction of the Hennepin County Regional Rail Authority (HCRRA) and MnDOT State Aid and CRU, Olson & Nesvold Engineers (ONE) and its project partners have assembled this general historic bridge management plan for the 37 bridges standing within the portion of the Midtown Corridor that is included within the 2.8-mile Chicago, Milwaukee and St. Paul (CM&StP) Railroad Grade Separation Historic District. The street names, MnDOT bridge numbers, and SHPO inventory numbers for each of these bridges are provided at the end of this section. Appended to this report are individual reports for the 37 bridges included in the study. The general management plan provides guidance on the bridges in the historic district as a whole. This includes a description of the process used to assemble the reports. It also includes recommendations for the prioritization of construction projects. Provided in this plan's appendices are reference documents that should be reviewed as individual bridge projects are developed in preliminary and final design.

Any work on bridges in the historic district should proceed according to the Secretary of the Interior's Standards for the Treatment of Historic Properties and the "Guidelines for Bridge Maintenance and Rehabilitation Based on the Secretary of the Interior's Standards" as adapted by the Virginia Transportation Research Council (included herein). Prior to designing repairs or conducting testing, the bridge owner should verify whether there have been any updates to the boundaries of the historic district or whether any more adjacent historic properties have been identified (see Master Map in Bridge Overview section).

The CM&StP Railroad Grade Separation Historic District

The Chicago, Milwaukee and St. Paul (CM&StP) Railroad Grade Separation Historic District was built in 1912-1917. It extends east-west across much of South Minneapolis from Humboldt Avenue on the west to just east of Cedar Avenue on the east. It is about 42 blocks long and is aligned parallel with 29th Street. Built by the CM&StP Railroad in cooperation with the City of Minneapolis, the project consisted of the excavation of a 2.8-mile-long, 22 foot deep grade separation trench; expansion of rail facilities within the trench; construction of 37 concrete bridges one block apart to carry urban streets across the trench; and reconstruction of the shipping and receiving facilities of numerous trackside industries. The project incorporated an existing bridge on Hennepin Avenue, bringing the total number of bridges crossing the trench to 38. The project also built a bridge on the south wall of the trench at 29th Street between Colfax and Dupont Avenues to provide private access to the tracks. The railroad tracks that once ran the course of the district have been replaced by a bituminous bicycle and pedestrian trail that was constructed in two phases in 2000 and 2004. The current study includes all bridges in the historic district except a bridge added in the 1960s to carry I-35W. The bridges in the current study include 27 contributing bridges (i.e., the original bridges constructed in the 1912 to 1917 timeframe) and 10 noncontributing bridges (replacement bridges, all of which were built in the last 30 years).

Context of the Study

This study of the bridges standing within the portion of the Midtown Corridor that is included within the 2.8-mile CM&StP Historic District is part of a several-year cooperative effort, led by MnDOT in partnership with the Federal Highway Administration (FHWA) the State Historic Preservation Office (SHPO), and others to promote the preservation of historic bridges across the state.

Minnesota's historic bridges are protected by several statues. Section 106 of the National Historic Preservation Act of 1966 requires that federally-funded or -licensed projects take historic properties into consideration during planning and implementation. Section 106 defines "historic" properties as properties listed on, or eligible for, the National Register of Historic Places. (Properties could be individual sites or historic districts.) Section 4(f) of the Transportation Act of 1966 requires that federal undertakings avoid "use" of an historic property unless there is no prudent and feasible alternative to the use and the undertaking includes all possible planning to minimize harm. The Minnesota Historic Sites Act requires state agencies to consult with the Minnesota Historical Society (MHS) (home of the SHPO) when undertaking or licensing projects that may impact listed historic properties and seek avoidance of adverse effects.

MnDOT, FHWA, SHPO, and other agencies developed a Section 106 Programmatic Agreement on Pre-1956 Historic Bridges in Minnesota that established a several-pronged historic bridge preservation initiative. (Final execution of the Agreement was in 2008). As part of this effort, in 2006 MnDOT completed the *General Management Plan for Historic Bridges in Minnesota*. According to the plan, the preferred option for the treatment of a historic bridge is rehabilitation for continued vehicular use on-site, with the rehabilitation following the Secretary of the Interior's Standards for the Treatment of Historic Properties. In 2006 MnDOT completed individual management plans for about two dozen state-owned bridges for which MnDOT was committed to long-term preservation. In 2013 MnDOT completed a policy statement on seeking Design Exceptions and Variances for historic bridges, a practice encouraged by the Programmatic Agreement (see the policy in Appendix D).

Minnesota Local Historic Bridge Study
In 2012 MnDOT began a study of the approximately 140 locally-owned historic bridges across Minnesota, an initiative also directed by the Programmatic Agreement. The bridges covered by this Midtown Corridor study are a subset of the state's locally-owned historic bridges, and this study fits within the overall program. The Minnesota Local Historic Bridge Study is designed to encourage the preservation of these structures statewide by compiling historic and engineering information on each bridge, analyzing its condition, and preparing a set of recommended treatment activities for each bridge (for which funding will be sought at the state level), as well as completing other efforts to promote the bridges' preservation. According to the 2006 Management Plan for Historic Bridges in Minnesota, the preferred option for the treatment of an historic bridge is rehabilitation for continued vehicular use on-site, with the rehabilitation following the Secretary of the Interior's Standards for the Treatment of Historic Properties. This study's individual bridge reports and general management plan are part of this effort.

Project Goals and Methods

The study was conducted by an interdisciplinary team lead by Olson & Nesvold Engineers, PSC. The team was comprised of bridge engineers from Olson & Nesvold Engineers and SRF Consulting Group, Inc., historic concrete specialists from Braun Intertec and Wiss Janney Elstner Associates, an historical architect from MacDonald & Mack Architects, and historian and cultural resource consultants from Gemini Research.

The goal of the project is to proactively approach preservation of the Midtown Corridor bridges by assessing current conditions and proposing a set of treatment alternatives that address structural deficiencies, deteriorating historic fabric, and bridge longevity while at the same time protecting the historic character and integrity of the bridge and, in turn, that of the CM&StP Grade Separation Historic District. The identified activities follow the Secretary of the Interior's Standards for Rehabilitation and accompanying Guidelines, as well as best practices outlined in *Preservation of Historic Concrete* (the National Park Service's Preservation Brief 15).

Only existing bridges, excluding the I-35W bridge were evaluated as part of this study. Buildings, walls, and other structures within and adjacent to the trench and its bridges were excluded.

The work was performed between September 2013 and December 2014. A kick-off meeting attended by major agency stakeholders was held in October 2013.

The team evaluated existing data, collected new information to fill in gaps, and conducted visual field investigations. Original construction plans were available for most of the bridges. Site visits occurred in December 2013 and in May, July, and October 2014. In addition, numerous team meetings were held to analyze field data, refine recommendations and vet options to rehabilitate the bridges in a way that meets the Secretary of the Interior's Standards for Rehabilitation. Drafts of key documents were reviewed by staff from HCRRA, Hennepin County Public Works, the City of Minneapolis, MnDOT CRU, and MnDOT State Aid.

For the 27 original bridges in the corridor (all of which are contributing to the historic district), individual bridge management plans were prepared. For the 10 replacement bridges in the corridor (the noncontributing bridges), only an individual bridge summary report was prepared. The 37 bridges are listed in a table in Section 3.0 and are identified on this report's Master Map.

To develop individual management plans for the contributing bridges the team explored a range of options for the repair and rehabilitation of each bridge. In 2013 the City of Minneapolis rehabilitated the corridor's 15th and 16th Avenue bridges following the Secretary of the Interior's Rehabilitation Standards. The methods developed during those successful rehabilitations helped inform the technical activities and cost estimates of the current study. The study's goal was to develop options that would allow each bridge to continue serving its current function and provide a service life of 30 years after construction activities had been performed.

The Maintenance, Stabilization, and Preservation activities developed for each bridge were tailored to the deficiencies observed for each bridge and designed to minimize the loss of historic fabric. The suggested work packages (Maintenance, Stabilization, and Preservation) were developed in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties and accompanying guidelines, and the recommendations for the *Preservation of Historic Concrete* (issued by the National Park Service as Preservation Brief 15). Particular attention was paid to preserving the character-defining features of both individual bridges and the overall historic district. Per the Secretary of the Interior's Standards, the emphasis was on repair rather than replacement of bridge elements to conserve as much original fabric as possible.

For the purposes of this study (and following the methods of the Minnesota Historic Local Bridge Study), Stabilization measures were designed to maintain the bridge in its current state until a more substantial repair project is undertaken. These measures might be emergency repairs, or minor repairs intended to prevent emergency repairs in the near future. Preservation measures were designed to preserve the bridge for the next 20 to 30 years. Maintenance activities include items such as annual inspections and cleaning, vegetation removal, minor concrete repairs, and spot painting. For a handful of contributing bridges Additional Preservation measures were identified. These measures include repair or restoration work that would improve the historic integrity of an individual bridge and the historic district; it is suggested that these measures be undertaken if opportunity and funding arises. Additional Preservation work items included activities such as the reconstruction of missing smoke shields.

Other Midtown Corridor Bridge Studies

In 2007 the City of Minneapolis prepared a Midtown Corridor Historic Bridge Study as mitigation for the 2005-2006 replacement of the corridor's historic Park and Chicago Avenue bridges (TKDA and Hess Roise 2007). The study conducted an in-depth analysis of five of the corridor's historic bridges extrapolating the results to other corridor bridges. The study also discussed current repair practices, gave an expected remaining functional life of each bridge, and considered impacts to the historic district should contributing bridges be removed.

In 2008 Hennepin County prepared a detailed analysis of the historic Portland and Cedar Avenue bridges (SRF Dec. 2008). The study examined four alternatives including No Build and recommended that the alternative that met the proposed undertaking's transportation objectives and was most prudent was replacement of the two bridges.

Other Historic Properties

Adjacent to the CM&StP Railroad Grade Separation Historic District are four other historic properties listed on, or eligible for, the National Register of Historic Places (NRHP). Two of the properties – Sears, Roebuck and Company and the Minneapolis Pioneers and Soldiers Memorial Cemetery – have also been designated Minneapolis Landmarks by the Minneapolis City Council on advice of its Heritage Preservation Commission (HPC).

The four historic properties are listed on the following page and marked on this report's Master Map shown in the Bridge Overview section.

Historic Property	Nearest Bridge(s)	NRHP		Mpls Landmark
		listed	eligible	
Grand Rounds Historic District (Mall Subsegment)	**Hennepin Avenue** – The Grand Rounds district is immediately adjacent to the southwest corner of the Hennepin Avenue Bridge.		X	
Zinsmaster Baking Company, 2900 Park Avenue S.	**Oakland and Park Avenues** – The Zinsmaster site is immediately adjacent to the southeast corner of the Oakland Avenue Bridge and the southwest corner of the Park Avenue Bridge.		X	
Sears, Roebuck and Company Mail-Order Warehouse and Retail Store, 2929 Chicago Avenue S.	**Chicago, Elliot, and 10th Avenues** – The Sears, Roebuck site is both adjacent to and overlaps the CM&StP historic district. The Sears site is immediately adjacent to the southeast corner of the Chicago Avenue Bridge, and its boundary entirely encompasses the Elliot and 10th Avenue bridges.	X		X
Mpls Pioneers and Soldiers Memorial Cemetery, 2925 Cedar Avenue S.	**Cedar Avenue** – The cemetery is immediately adjacent to the southeast corner of the Cedar Avenue Bridge; the cemetery wall is attached to the bridge railing.	X		X

Under Section 106 and similar state statues, state or federal work on Midtown Corridor bridges must take potential effects to *adjacent* historic properties into consideration along with potential effects to the CM&StP historic district itself. Under federal law, historic properties are sites or districts listed on, or eligible for, the National Register. At the state level, the Minnesota Historic Sites Act defines historic properties as those *listed* on the State or National Register of Historic Places. Under Minneapolis city code, work that potentially affects a Minneapolis Landmark should be coordinated with the Minneapolis Community Planning and Economic Development (CPED) Department. Early in the process of planning bridge repairs or rehabilitation, bridge owners should contact the State Historic Preservation Office (SHPO) and the Minneapolis HPC to ensure there have been no additions to the above list of adjacent historic properties.

List of Bridges Included in Midtown Corridor Bridge Study

Street Name	MnDOT Bridge No.	SHPO Inventory No.
Hennepin Ave	27599	HE-MPC-7338
Fremont Ave	L8901	HE-MPC-7337
Emerson Ave	27665	HE-MPC-7336
Dupont Ave	27666	HE-MPC-7335
W. 29th St	L5893	HE-MPC-5337
Colfax Ave	L8902	HE-MPC-7334
Bryant Ave	L8903	HE-MPC-7333
Aldrich Ave	L8904	HE-MPC-7332
Lyndale Ave	27243	HE-MPC-7331
Garfield Ave	27675	HE-MPC-7330
Harriet Ave	L8906	HE-MPC-7329
Grand Ave	L8907	HE-MPC-9010
Pleasant Ave	L8908	HE-MPC-7328
Pillsbury Ave	L8909	HE-MPC-7327
Blaisdell Ave	27610	HE-MPC-7326
Nicollet Ave	90590	HE-MPC-7325
1st Ave	92347	HE-MPC-7324
Stevens Ave	L8910	HE-MPC-7323
2nd Ave	27648	HE-MPC-7321
4th Ave	27A32	HE-MPC-7320
Portland Ave	90494	HE-MPC-7319
Oakland Ave	L8911	HE-MPC-7318
Park Ave	27B19	HE-MPC-7317
Columbus Ave	L8913	HE-MPC-7314
Chicago Ave	27A94	HE-MPC-7316
Elliot Ave	L8914	HE-MPC-7315
10th Ave	L8915	HE-MPC-9012
11th Ave	L8916	HE-MPC-7313
12th Ave	L8917	HE-MPC-7312
13th Ave	L8918	HE-MPC-7311
14th Ave	L8919	HE-MPC-7310
15th Ave	L8920	HE-MPC-7309
Bloomington Ave	92350	HE-MPC-7308
16th Ave	L8921	HE-MPC-7307
17th Ave	L8922	HE-MPC-7306
18th Ave	L8923	HE-MPC-7305
Cedar Ave	90437	HE-MPC-7304

2. Historical Overview

Description

The CM&StP Railroad Grade Separation Historic District extends east-west across much of South Minneapolis from Humboldt Avenue on the west to just east of Cedar Avenue on the east. It is about 42 blocks long and is aligned parallel with 29th Street. (See Master Map herein).

When the grade separation project was built in 1912-1917, the surrounding neighborhood was largely residential. There was a narrow strip of about 20 industries located along the railroad, particularly along the western two-thirds of the corridor and especially on the north side of the tracks. A little more than one block south of the corridor was a growing commercial corridor along Lake Street.

Built by the CM&StP railroad in cooperation with the City of Minneapolis, the project consisted of the excavation of a 2.8-mile-long, 22 foot deep grade separation trench; expansion of rail facilities within the trench; construction of 37 concrete bridges (one block apart) to carry city streets across the trench; and reconstruction of the shipping and receiving facilities of numerous trackside industries that required access to the tracks at the new lower level.

Near the west end, the grade separation project incorporated an existing bridge at Hennepin Avenue (built 1897), bringing the number of grade separation bridges to 38. There was no crossing provided at Girard Avenue (one block east of Hennepin). Near the center of the trench was the project's only at-grade crossing at 5th Avenue.

The project included a 39th bridge located on the south side of the trench at 29th Street between Dupont and Colfax Avenues. This structure did not cross the trench but instead provided industry access to the railroad by carrying 29th Street over a private track-level entrance drive.

29th Street Bridge

In about 1960, Interstate 35W was built across the center of the trench east of Stevens Avenue. This added a modern, nonhistoric bridge to the collection and brought the total number of bridges to 40.

Twelve of the 39 original bridges have been removed. The surviving 27 bridges constitute the historic district's contributing bridges. Two of the crossings, at Third and Clinton Avenues, were closed when their bridges were removed. The other 10 crossings received replacement bridges. These ten structures and the I-35W bridge constitute the historic district's 11 noncontributing bridges. The current study includes 37 bridges – all but the I-35W bridge – consisting of 27 contributing and 10 noncontributing bridges.

In addition to the bridges, the historic district includes nearly three miles of additional historic fabric such as the trench itself, concrete retaining walls, sections of original right-of-way fencing, other railroad fencing, and other types of structures. There are also a considerable number of more recent elements. Only the bridges are included in the current study.

Historic Background and Significance

The Railroad. The CM&StP railroad through the present-day Midtown Corridor was built before the surrounding area was densely settled. The tracks were completed in 1881 by the CM&StP, one of Minnesota's most important railroads of the late 19th and early 20th century. The 1881 tracks extended from a major CM&StP

shops facility on the east (at Hiawatha Avenue and 28th Street, a few blocks east of the end of the historic district) to Benton Township near Cologne in Carver County on the west. At the east end, the tracks joined a stub that carried CM&StP trains to the downtown Minneapolis depot, as well as joining tracks leading south out of Minneapolis. At the west end, the tracks joined the CM&StP east-west main line across southern Minnesota. This line had been built west from the Mississippi River town of Hastings by a CM&StP predecessor called the Hastings and Dakota and extended west across southern Minnesota and into the Dakota Territory.

The 1881 tracks were first known as the "Benton Cutoff" because they were built to significantly shorten the distance between Minneapolis and the main line tracks across the state. Before their construction, trains entering and leaving Minneapolis had to loop southward through Shakopee, Farmington, and Mendota.

At the same time that it built the tracks through present-day Midtown, the CM&StP built another bypass east of its Hiawatha Avenue shops. These tracks crossed the Mississippi over a new bridge and continued to downtown St. Paul. This "Short Line" significantly reduced travel between the two downtowns by again bypassing the southern tracks through Mendota (Pearson and Petersen 2009).

Soon after completion in 1881 the tracks through the present-day Midtown Corridor became the CM&StP's main line for all east-west travel. The line played a significant role in the settlement and economic development of a large swath of southern Minnesota and present-day North and South Dakota. The CM&StP founded numerous towns in several states and the line played a major role facilitating the great Dakota Boom of the 1880s during which the Dakota Territory was settled. Through the early 20th century the line was a chief carrier of lumber, people, and manufactured goods westward from the Twin Cities (and Chicago) to these developing regions, and a leading shipper of wheat and other agricultural products from the hinterlands back to the urban centers (Schmidt et al. 2012; Pearson and Petersen 2009).

The line through Minneapolis and across southern Minnesota took on greater significance in 1909 – just as the grade separation project was being negotiated – when the CM&StP became a transcontinental railroad by extending the tracks all the way to Puget Sound. As part of this expansion, the CM&StP increased capacity by upgrading its main line to a double track from Minneapolis west to the Missouri River as well as straightening curves, replacing bridges and culverts, and installing automatic signals (Schmidt et al. 2012). Timing of the double-tracking coincided with construction of the grade separation trench across south Minneapolis. When the trench was built in 1912-1917, the tracks were upgraded from a single main line to a double set of tracks that passed under the center span of the grade separation bridges.

City Growth and Transportation. Much of the area surrounding the CM&StP tracks in South Minneapolis was platted in 1883, with the neighborhoods developing in 1890 through the 1910s. The area became filled with single-family homes for working- and middle-class residents, many of whom were employed by several key industries nearby. Clusters of more expensive homes were built on streets such as Park Avenue (Stark and Vermeer 2009; see also Stark et al. 2002, Roise 2007, and others for development of the area).

Streetcar service on north-south streets and along Lake Street served as a principal means of transportation. Along the present-day Midtown Corridor, streetcar lines crossed the CM&StP tracks at seven locations: Hennepin, Lyndale, Nicollet, Chicago, 4th, Bloomington, and Cedar (Roise 2007). Streetcar ridership in Minneapolis peaked in 1920 with more than 138 million passengers (Stark and Vermeer 2009).

Across the U.S., conflicts between trains and horse-drawn vehicles, bicycles, and pedestrians were a common complaint, with streetcars added to the mix in urban areas. Beginning in the early 20th century, Minneapolis city streets also began to carry a growing number of automobiles. While Minneapolis residents are believed to have owned only 13 cars in 1900, five years later in 1905 the area had more than 1,500 licensed drivers and in 1910 there were more than 15,000 cars registered in Minnesota ("Automotive and Bicycle Milestones").

Railroads such as the CM&StP not only posed a safety hazard for users of other transportation modes, but adjacent rail-based industries created noise, dust, and visual blight. Concerns for transportation, safety, and neighborhood livability led Minneapolis residents and early city planners to press for a separation of railroad and street grades just as their counterparts were in other cities. By 1905 both the depression and elevation of the CM&StP tracks had been discussed. In 1906, for example, the City Engineer lobbied for elevation of the tracks, while in a 1908 civic group proposed relocating the tracks and replacing them with a scenic parkway. Over many years a number of proposals were debated by residents, government, the railroad, and industry, each with a different perspective on safety, transportation priorities, development of the city, visual impact, neighborhood livability, cost sharing, utility concerns, and impact to adjacent industries. In 1909-1910 grade crossings in Minneapolis were the dominant issue facing the City Council, which saw long-ranging implications for the future of the city (Vermeer and Stark 2004).

Efforts toward grade separation in Minneapolis and elsewhere were part of a broad cultural trend called the City Beautiful Movement popularized by the 1893 Chicago World's Fair. The fair helped launch the field of city planning and inspired local governments and residents to plan comprehensively and use formal design ideas to bring order and beauty to areas that had grown up haphazardly or were viewed as blighted. The influential McMillan Plan for the National Mall in Washington, DC (1901), helped spread City Beautiful concepts nationwide.

In early 1910, residents of Minneapolis established an 11-member Civic Commission charged with creating a comprehensive city plan (1917) with the help of a professional planner. In February of 1910 the CM&StP proposed a grade separation project similar to the plan ultimately implemented. In late 1910 the Civic Commission endorsed the proposal and the City Council's grade crossings committee recommended passage of an ordinance compelling the CM&StP to depress their tracks (Vermeer and Stark 2004).

Construction of the Project. The City ordinance requiring the grade separation project passed in December of 1910. Four months later in April of 1911, the CM&StP began installing side tracks in preparation for construction, and on June 19, 1911, excavation of the trench began (Vermeer and Stark 2004). Design work for the bridges proceeded over the next several months. In the meantime, however, trackside industries continued to oppose the depression on fears it would harm their operations. In 1911 a large group of businesses obtained a court injunction to stop construction. The legal battle did not end until July of 1912 when the Minnesota Supreme Court upheld the City ordinance and construction resumed (Stark et al. 2002).

The grade separation project was a monumental 42-block undertaking largely built over six construction seasons from 1912-1917. It was the result of more than a decade of planning and controversy during which civic interests prevailed over those of the railroad and industry. The tracks were not only depressed, but the set of bridges that crossed them was designed with an emphasis on aesthetics. The project played a significant role in the development of Minneapolis by advancing civic planning, facilitating transportation, increasing safety, protecting the quality of adjacent residential neighborhoods, and enhancing community aesthetics, all while maintaining important rail service and the viability of trackside industries.

The trench was excavated by a steam shovel supported by work trains in multiple longitudinal cuts that moved the grade incrementally downward. Most fill was hauled to a new freight yard the CM&StP was building at Bass Lake west of the city. Train service was maintained throughout construction by continually shifting and reinstalling the tracks (see 1915 articles in Appendix B as well as Stark et al. 2002 and Roise 2007).

The railroad trench and bridges were designed by J. H. Prior and H. C. Lothholz, men who successively served as Engineer of Design for the CM&StP. (Prior's signature appears on plans for bridges west of about Stevens Avenue, and Lothholz signed plans for bridges from approximately Stevens Avenue eastward.) The railroad's Chief Engineer for the process was Charles F. Loweth. Minneapolis City Engineer Frederick W. Cappelen signed off on each plan.

The grade separation project, including the bridges, was constructed by crews of CM&StP workers supervised by W. R. Powrie, the railroad's District Engineer based in Minneapolis. General Foreman for much of the project was F. M. Sloane. In July of 1915 there were 500 men at work on the corridor project, more than half of whom were working on the bridges (Bainbridge 1915; "Track Depression" 1915).

Among the components of the massive engineering project were:

- construction of a nearly 3-mile-long trench that was 22 feet deep and 110 to 120 feet wide at the top
- construction of temporary bridges and other provisions to allow traffic to cross the trench during six years of construction
- expansion of the CM&StP from a single to double-track main line
- construction of numerous industry side tracks
- construction of 37 bridges to carry city streets across the tracks and one more bridge (on 29th Street east of Dupont) to provide access to the trench for a private industry

- construction of concrete retaining walls immediately behind bridge abutments to support the ends of city streets as they met the top of the trench
- realignment of portions of 29th Street and some east-west alleys adjacent to the top of the trench
- relocation of city utilities including gas and sewer lines buried below the trench floor and water mains and some telephone lines carried beneath the bridge decks
- construction of permanent right-of-way fencing in many locations at the top of the trench
- alteration and reconstruction of adjacent industries whose shipping and receiving facilities were relocated to the new track level (for information on these efforts see the 1915 articles in the appendices; "Views of the 29th Street Track Depression" ca. 1917; and Roise 2007).

The completed grade separation bridges crossed a busy railroad line, with at least 20 through trains per day (both passenger and freight) using the central tracks. In addition, there were freight cars being delivered, loaded or unloaded, and hauled away on numerous industry sidings.

The Grade Separation Bridges. The corridor's impressive collection of concrete bridges was built in sequence from west to east in 1912-1917. Several bridges were built over several construction seasons. According to notations on the original plans for the 14th Avenue Bridge, for example, work began on June 15, 1915. The north abutment was built in 1915; the south abutment was built in 1915-1916; the piers, deck, railing, and an adjacent 90' trackside retaining wall were built in 1916; and the smoke shields were built in 1917.

The grade separation bridges are continuous reinforced concrete girder bridges designed in the Neoclassical Revival style and cast in place. A goal of the project was "to have the finished work give as pleasing effect as possible" and the bridges were an important element in this effort (Bainbridge 1915: 1059).

The railroad explored various means to make the project cost-effective including making the bridges essentially identical and precasting portions of the bridges, the latter idea being rejected. The bridges were designed using the classically-influenced vocabulary favored by the City Beautiful Movement, but have a simplicity or austerity that reflects the project's budgetary realities.

The grade separation bridges vary in length, but each was designed to span a trench approximately 120 feet wide at the top. All but two of the bridges had three spans of approximately equal length – about 30 feet. The exceptions, which were adjacent bridges at Clinton and 4th Avenues near the midpoint of the trench, were six and ten spans, respectively, so they could cross a CM&StP rail yard.

Most bridge decks are about 50 feet wide and carried two lanes of traffic and two 8 foot wide raised concrete sidewalks, as most do today. Six of the bridges required extra width to carry a streetcar line between vehicle lanes. The decks were paved with 4 inch thick creosoted wood blocks, now replaced by bituminous and concrete overlays.

Each bridge substructure is comprised of concrete abutments and two piers or bents. The bridges have about 18 feet vertical clearance in the center span. The abutments vary in height depending on whether the outer span needed to accommodate spur tracks. The abutments have Neoclassical detailing and date blocks cast into the inner (trackside) surface. Each pier has four square columns with a rounded-arched cross beam system that extends to the fascia to support cantilevered raised sidewalks. On many bridges the beams are roughly 13 inches wide, 4 feet deep, and 5 feet apart. Beams designed for a streetcar load are somewhat larger. The lower edge of the beams is angled to mirror the lower curve of the fascia beams.

On the sides of the bridge, the fascias are haunched and ornamented with recessed panels that align with the pier columns. Each bridge was designed with a 19 foot long concrete smoke shield above the center span designed to deflect locomotive exhaust from the deck above.

The bridges have approximately 36 inch tall solid concrete, Neoclassical style railings. Near the ends of the bridge the railings move apart laterally, tracing the edge of the abutments, with the sidewalks widening correspondingly.

The bridges were originally unpainted. The surface of the abutments, piers, beams, underside of deck, and, to some extent, fascia, generally retain original board form lines. The fascia and railings have a fairly smooth finish. The underside of the bridge decks is blackened by locomotive smoke.

Integrity of the Historic Bridges. Many of the surviving 27 historic bridges retain very good integrity of location, design, materials, workmanship, feeling, and association – the seven aspects of historic integrity identified in National Register of Historic Places eligibility criteria.

Typical alterations include removal of deteriorated smoke shields, shotcrete repairs, partial painting of the concrete, deck and sidewalk overlays, and the addition of a metal handrail.

Since 2000, about 15 bridges have been altered with the addition of concrete block retaining walls and/or trail ramps built adjacent to the abutments.


14th Avenue Bridge

There are eight bridges in the historic district that are particularly intact: the bridges at Bloomington, Cedar, Grand, Harriet, Portland, 1st, and 17th Avenues, and the 29th Street Bridge. The five bridges with the next highest level of historic integrity are the Colfax, Columbus, 12th, 15th, and 16th Avenue bridges.

Recent History and National Register Listing. After World War II, railroad profitability continued to decline as passenger service was nearly superseded by personal automobiles, and freight service faced competition from long-haul trucking. Industries along the CM&StP tracks in south Minneapolis gradually closed, many to be replaced by businesses that did not require rail access. By the mid-1990s the tracks were still in use but seeing only a fraction of the traffic they saw in 1940.


14th Avenue Bridge
(1995 copyrighted photo by Greg Smith)

In 1997 the grade separation historic district was determined eligible for the National Register by the State Historic Preservation Office in association with a statewide study of historic bridges in Minnesota. The study found the CM&StP corridor bridges to be significant within the statewide historic context "Reinforced Concrete Highway Bridges in Minnesota, 1900-1945." The bridges are the work of designers identified in the historic context as significant engineers (J. H. Prior, H. C. Lothholz, and C. F. Loweth) and, as a collection, display unusual aesthetic qualities. According to the study's inventory forms on the bridges, "From an engineering perspective, the new crossings also were notable as early Minnesota examples of continuous, concrete, girder construction – a bridge type rarely used in the state for highway crossings" (Hess ca. 1997). Details of the historic district's National Register eligibility, including a physical description, suggested boundaries, historic background, and information on significance, were developed in a 2002 cultural resources report prepared by 106 Group in association with construction of the Midtown Greenway recreational trail (Stark et al. 2002).

In 2000 the Midtown Greenway recreational trail was added to the north side of the west half of the corridor (west of 5th Avenue) with trains continuing to occasionally use the south side of the trench. To accommodate the trail and its access ramps, the grade of the northern part of the trench floor was elevated. A chainlink fence, in many areas mounted on a modular block retaining wall, was installed down the center of the west half of the trench. Trains stopped running in the summer of 2001 and the last tracks were removed circa 2002. In 2004 the recreational trail was extended through the east half of the historic district (east of 5th Avenue).

The CM&StP Railroad Grade Separation Historic District was officially listed on the National Register in 2005 based on a National Register nomination that was prepared in 2004 (Vermeer and Stark 2004). It was listed under Criterion A (broad patterns of history) in the area of Community Planning and Development. The level of significance is Local. The period of significance was listed as 1912-1916. In 2006 a set of cultural landscape treatment guidelines for the district was completed as mitigation for the construction of the recreational trail (HCRRA 2006). Information in the 2015 Midtown Corridor General Bridge Management Plan and individual bridge reports should be considered an update to the 2006 guidelines' bridge information.

Character-Defining Features of the CM&StP Railroad Grade Separation Historic District

Character-defining features are prominent or distinctive qualities or elements of an historic property that contribute significantly to its physical character, historic integrity, and significance. A list of character-defining features does not identify all important aspects of an historic property, however. Each historic property contains additional elements of location, design, setting, materials, workmanship, feeling, and association that together comprise its historic integrity or authenticity. Character-defining features of the CM&StP Railroad Grade Separation Historic District are summarized below. Since the current study is focused on the bridges and is not a corridor analysis, the list is not all-inclusive.

A 2.8-mile continuous corridor representing the separation of two overlapping transportation facilities, the urban grid of streets and sidewalks used by horse- and gas-powered vehicles, streetcars, and pedestrians, and the CM&StP railroad. The corridor passes through a largely residential neighborhood with industries (originally about 20) scattered along the tracks. City streets cross the depression on bridges spaced one block apart. One crossing near the center of the corridor is at track level. Segments of 29th Street are adjacent to (parallel with) the top of the trench for all but seven blocks. There are alleys along the trench in several locations. (Segments of both 29th Street and the alleys were realigned and rebuilt as part of the project.)


Pleasant Avenue Bridge

The trench is about 110 to 120 feet wide at the top and about 22 feet deep. Its uniform size contributes to the corridor's visual continuity. The floor, which served as the rail bed, was originally flat. From many locations outside of the corridor, the lower portions of the trench are hidden from view. The trench's earthen sides are moderately sloped at most locations. In some parts of the trench, the walls are vertical and supported by either tall retaining walls or the basement level of adjacent buildings. These vertical walls, along with several shorter track-level retaining walls and the bridge abutments, allowed the trench floor to accommodate spur tracks and are associated with the corridor's role as an industrial rail shipping facility. The trench is characterized by volunteer vegetation.


16th Avenue Bridge

Colfax Avenue Bridge

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11th Avenue Bridge

The 26 historic bridges that cross the corridor (originally 37) are nearly identical, three-span, reinforced concrete, continuous tee beam structures. The bridges' Neoclassical Revival form and detailing reflect the aesthetic function of the project and its City Beautiful associations, while their somewhat austere design reflects the project's budgetary constraints. The bridges' identical appearance and close spacing contribute to the corridor's visual continuity. The three spans of approximately equal length create a tunnel-like effect.


17th Avenue Bridge

Most bridge decks are about 50 feet wide; six bridges required extra width to carry a streetcar line between vehicle lanes. All bridges have two raised sidewalks. The bridges have concrete abutments with classical coping on the bridge seats and date block imprints. The piers are comprised of four square columns joined by rounded arches that extend to the fascia beam to support cantilevered sidewalks. The multiple tee beams are integrated with the deck and angled to follow the curve of the fascia beams. The fascias are haunched with recessed pilaster-like detailing over the piers and 19 foot long smoke shields above the center span.

18th Avenue Bridge

The bridges have 36 inch tall concrete railings. Both posts and panels are divided into a classical base, shaft, and capital and have simple recessed panels. The railings move apart laterally, tracing the edge of the abutments, while the sidewalks widen correspondingly. The bridges were designed with unpainted concrete surfaces. There are board form lines on abutments, piers, beams, and the underside of the deck, while the fascia and railings have a smoother finish.

Bryant Avenue Bridge

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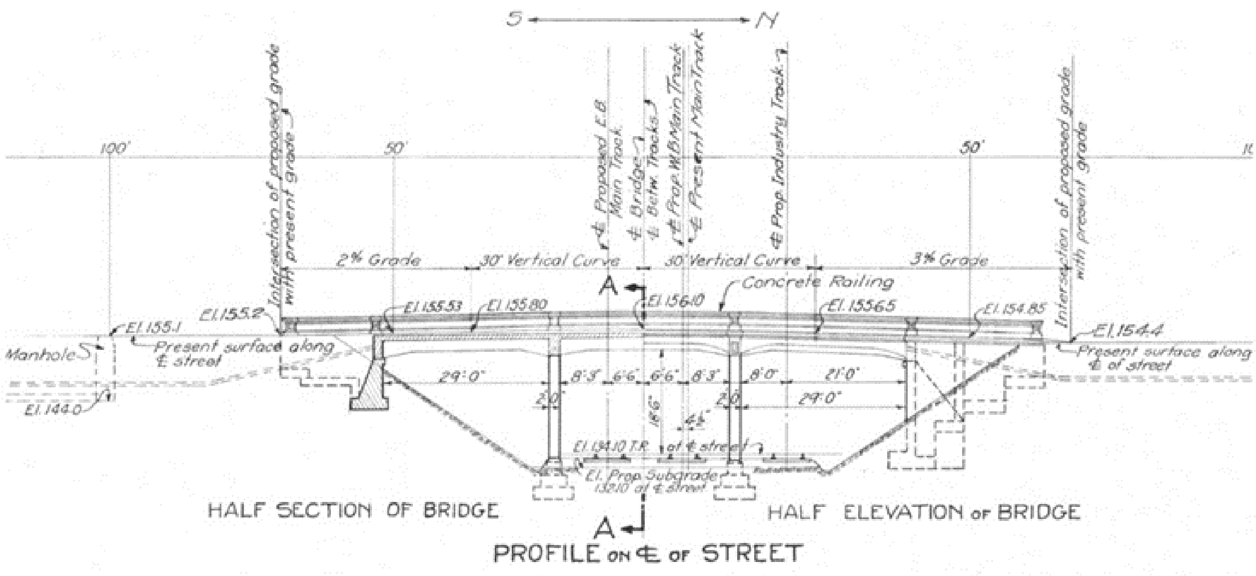
Colfax Avenue Bridge

Additional Historic Fabric in the Historic District. The grade separation district's historic fabric also includes a number of other original and early structures. Some are immediately adjacent to the bridges including concrete retaining walls aligned north-south behind some bridge abutments to help support city streets. There are surviving segments of original iron right-of-way fencing along the upper edge of the trench on the south side, and remnants of fencing on the trench floor that separated main line tracks from sidings. One abutment each from the removed 3rd and Clinton Avenue bridges remains. Storm sewer entrances, wood power poles, and other structures represent the project's provision for utilities. Near the upper edge of the slope in many locations are segments of stone and concrete retaining walls and slope paving – many of them privately built – that helped support buildings, lots, and the slope within and adjacent to the trench.

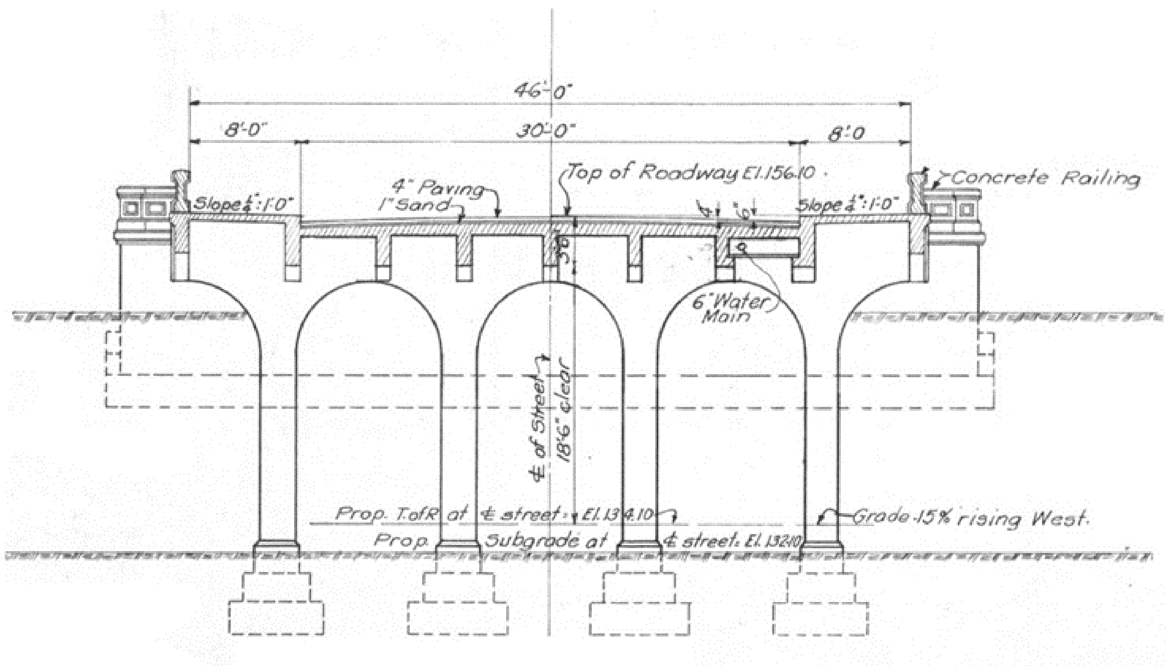
3. Bridge Overview

Contributing Bridges

There are 37 bridges within the CM&StP Grade Separation Historic District (see this report's Master Map and table of suggested work). Twenty-seven of these bridges are original bridges and were built between 1912 and 1917. They are very similar in appearance. These Neoclassical Revival style, three-span bridges consist of continuous concrete tee beams. The fascia beams are typically curved to provide a slight arch appearance. Most of the historic bridges are about 50 feet wide and span a trench about 22 feet deep and about 120 feet wide at the top. Each deck is concrete and most bridges have a thick bituminous overlay. The bituminous was added after the original wood block pavers and sand bed were removed. Bridges that do not have a bituminous overlay have a concrete overlay. The superstructure is supported by pier columns with an arched shaped cap connecting the columns. The south abutments are typically stub abutments, while the north abutments are either tall abutments or stub abutments depending on the original location of spur railroad tracks. The bridges have approximately 36 inch tall solid concrete railings. Below is a typical elevation view from one of the original bridge plan sets. It shows a stub abutment on the left and a tall abutment on the right.



Two more details from the original plans are shown below. They show standard cross sections of the bridges. The configuration of a typical pier is illustrated. It has four columns and a pier cap with rounded openings between the columns. Sidewalks are provided on both sides of the bridge deck and the configuration of the "T" beams is also illustrated. Line work for the stub abutment is also presented. Two items should be noted. First, the width of the deck varies throughout the corridor. Most bridges are similar to the typical section immediately below. Other bridges, such as Nicollet Avenue shown in the second typical section, are substantially wider because they accommodated streetcar lines. Second, it should be noted that utilities are carried by or below many of these bridges. A 6 inch diameter water main is called out in both typical sections and a sewer is shown below the bridge in one typical section.



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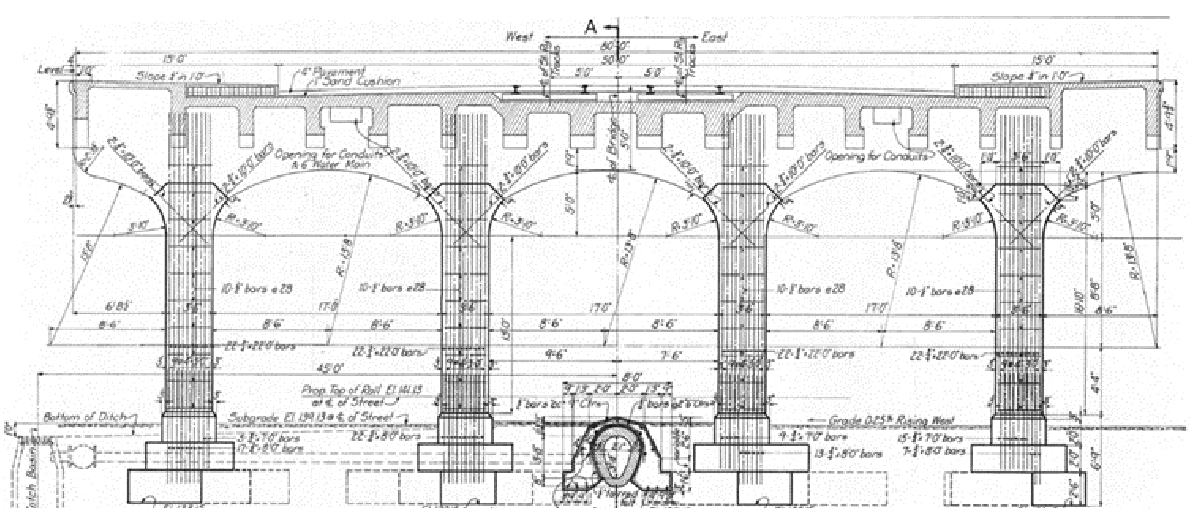


ELEVATION

Noncontributing Bridges

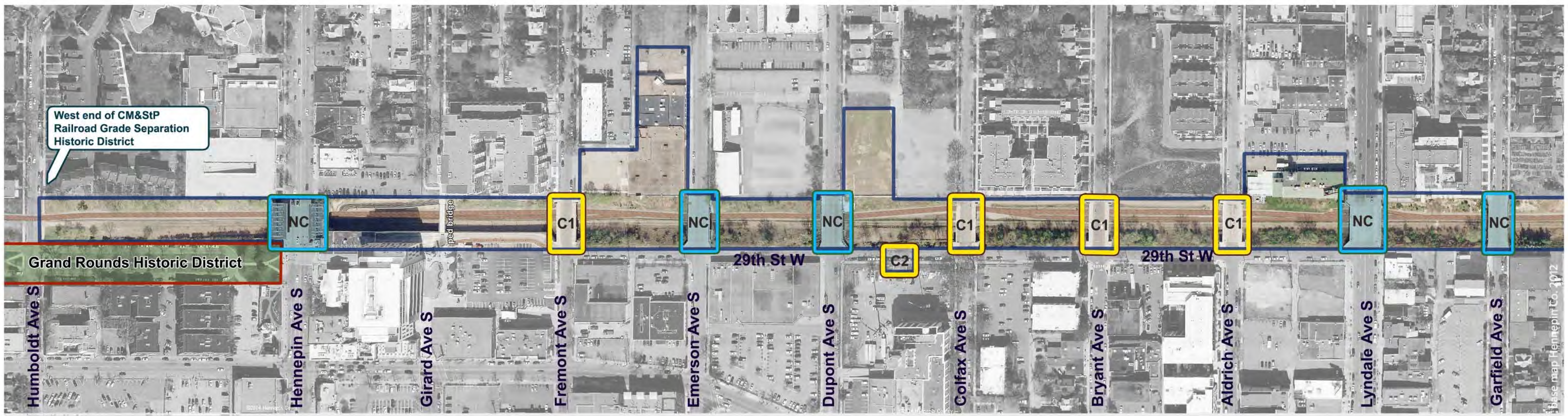
The other ten bridges were replaced between 1980 and 2006. They consist of three concrete rigid frames, five continuous concrete slab bridges, one post-tensioned concrete slab bridge, and one steel girder bridge. Seven of these bridges are 3 spans supported by pier columns with a straight concrete cap, and two stub abutments. Five of the seven (the continuous concrete slab spans at Blaisdell, Dupont, Emerson, Garfield, and Lyndale Avenues) are similar in appearance (see photo of the Garfield Avenue Bridge below). The three rigid frames (Chicago, Hennepin, and Park Avenues) have only one span (Park Avenue is pictured below).

Garfield Avenue - Continuous Slab Bridge

Park Avenue - Rigid Frame Bridge

This report's Master Map shows the location of the contributing and noncontributing bridges in the district. The historic properties immediately adjacent to the district mentioned in the Project Introduction Section are also identified.

Master Map
Midtown Corridor Historic Bridge Management Plan



MnDOT Bridge No.	27599	L8901	27665	27666	L5893	L8902	L8903	L8904	27243	27675

Key to Suggested Work

C1 Contributing - Major Work Suggested
C2 Contributing - Minor Work Suggested
C3 Contributing - Rehabilitated 2013
NC Noncontributing - Minimal Work Suggested

Hennepin Ave	NC
Fremont Ave	C1
Emerson Ave	NC
Dupont Ave	NC
29th St	C2
Colfax Ave	C1
Bryant Ave	C1
Aldrich Ave	C1
Lyndale Ave	NC
Garfield Ave	NC

- CM&StP Grade Separation Historic District
- Contributing bridge
- Noncontributing bridge
- Other National Register listed or eligible
- Bituminous trail

Abutment Height

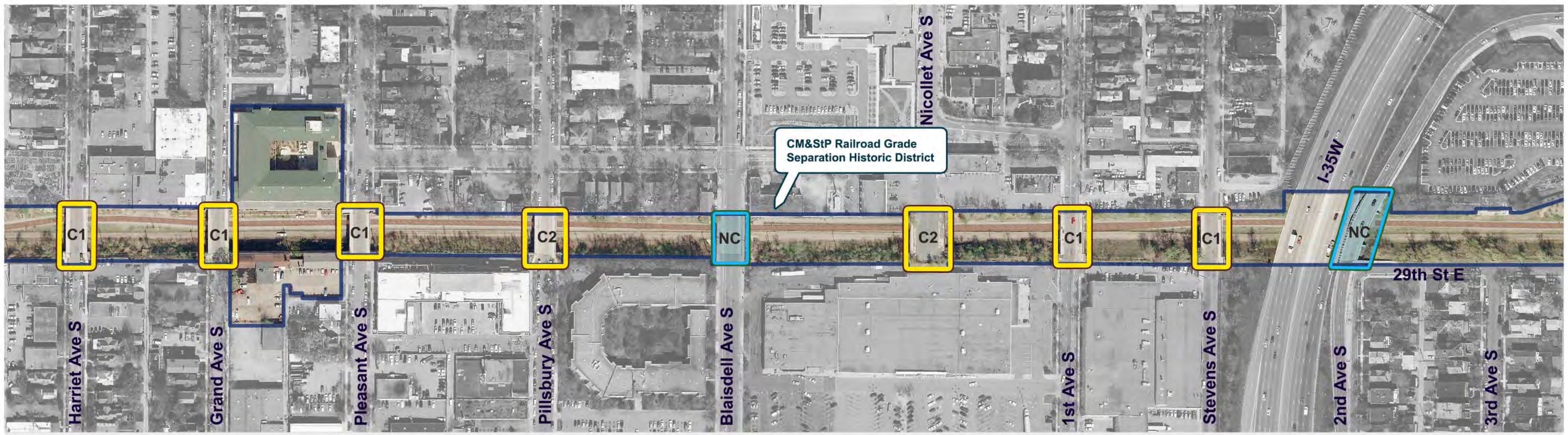
N = North
S = South

H = High
M = Medium
L = Low

Hennepin Ave	NHSH
Fremont Ave	NMSM
Emerson Ave	NLSL
Dupont Ave	NLSL
29th St	
Colfax Ave	NHSM
Bryant Ave	NHSL
Aldrich Ave	NHSL
Lyndale Ave	NLSL
Garfield Ave	NMSM

Sheet 1 of 4

prepared 2014



MnDOT Bridge No.	L8906	L8907	L8908	L8909	27610	90590	92347	L8910	27648

Key to Suggested Work

C1 Contributing - Major Work Suggested
C2 Contributing - Minor Work Suggested
C3 Contributing - Rehabilitated 2013
NC Noncontributing - Minimal Work Suggested

Harriet Ave	C1
Grand Ave	C1
Pleasant Ave	C1
Pillsbury Ave	C2
Blaisdell Ave	NC
Nicollet Ave	C2
1st Ave	C1
Stevens Ave	C1
2nd Ave	NC

- CM&StP Grade Separation Historic District
- Contributing bridge
- Noncontributing bridge
- Other National Register listed or eligible
- Bituminous trail

Abutment Height

N = North
S = South

H = High
M = Medium
L = Low

Harriet Ave	NHSH
Grand Ave	NHSH
Pleasant Ave	NHSM
Pillsbury Ave	NHSM
Blaisdell Ave	NLSL
Nicollet Ave	NHSH
1st Ave	NHSL
Stevens Ave	NHSL
2nd Ave	NLSL

Sheet 2 of 4

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Key to Suggested Work

C1 Contributing - Major Work Suggested
C2 Contributing - Minor Work Suggested
C3 Contributing - Rehabilitated 2013
NC Noncontributing - Minimal Work Suggested

4th Ave	NC
Portland Ave	C1
Oakland Ave	C2
Park Ave	NC
Columbus Ave	C1
Chicago Ave	NC
Elliot Ave	C2
10th Ave	C1
11th Ave	C1

- CM&StP Grade Separation Historic District
- Contributing bridge
- Noncontributing bridge
- Other National Register listed or eligible
- Bituminous trail

Abutment Height

N = North
S = South

H = High
M = Medium
L = Low

4th Ave	NHSH
Portland Ave	NHSH
Oakland Ave	NHSL
Park Ave	NHSH
Columbus Ave	NMSL
Chicago Ave	NHSH
Elliot Ave	NHSH
10th Ave	NHSH
11th Ave	NHSL

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Sheet 3 of 4

Key to Suggested Work

C1 Contributing - Major Work Suggested
C2 Contributing - Minor Work Suggested
C3 Contributing - Rehabilitated 2013
NC Noncontributing - Minimal Work Suggested

12th Ave	C1
13th Ave	C1
14th Ave	C1
15th Ave	C3
Bloomington Ave	C1
16th Ave	C3
17th Ave	C2
18th Ave	C1
Cedar Ave	C1

- CM&StP Grade Separation Historic District
- Contributing bridge
- Noncontributing bridge
- Other National Register listed or eligible
- Bituminous trail

Abutment Height

N = North
S = South

H = High
M = Medium
L = Low

12th Ave	NHSL
13th Ave	NHSL
14th Ave	NHSL
15th Ave	NLSL
Bloomington Ave	NLSL
16th Ave	NLSL
17th Ave	NLSL
18th Ave	NLSL
Cedar Ave	NLSL

Sheet 4 of 4

prepared 2014

Overall Condition of the Bridges

The condition of the original, contributing bridges varies significantly along the corridor. The conditions range from good and requiring only minimal preservation activities, to serious where the condition likely precludes repair. In addition, bridges at 15th and 16th Avenues were rehabilitated in 2013. Reconstruction of smoke shields is the only suggested work item for these two bridges.

The overall condition of the noncontributing bridges ranges from good to very good. They were constructed between 1980 and 2006 with sufficiency ratings between 94.3% and 99.9%, except for 2nd Avenue which has a sufficiency rating of 80.6%. All the noncontributing bridges require minimal repair activities.

The table below summarizes the level of preservation activities that are suggested for each of the bridges in the study. The bridges are listed from west to east.

Extent of Suggested Work					
		Contributing Bridges			*Noncontributing*
Street	**MnDOT Bridge No.**	***Major Work***	***Minor Work***	***Rehabilitated 2013***	***Minimal Work***
Hennepin	27599				X
Fremont	L8901	X			
Emerson	27665				X
Dupont	27666				X
29th	L5893		X		
Colfax	L8902	X			
Bryant	L8903	X			
Aldrich	L8904	X			
Lyndale	27243				X
Garfield	27675				X
Harriet	L8906	X			
Grand	L8907	X			
Pleasant	L8908	X			
Pillsbury	L8909		X		
Blaisdell	27610				X
Nicollet	90590		X		
1st	92347	X			
Stevens	L8910	X			
2nd	27648				X
4th	27A32				X
Portland	90494	X			
Oakland	L8911		X		
Park	27B19				X
Columbus	L8913	X			
Chicago	27A94				X
Elliot	L8914		X		
10th	L8915	X			
11th	L8916	X			
12th	L8917	X			
13th	L8918	X			
14th	L8919	X			
15th	L8920			X	
Bloomington	92350	X			
16th	L8921			X	
17th	L8922		X		
18th	L8923	X			
Cedar	90437	X			

4. Activities for Contributing Bridges

As mentioned in the Bridge Overview, the condition of the contributing bridges varies significantly along the corridor. There are bridges in good structural condition and bridges in extremely poor structural condition. The condition of the bridges is expected to deteriorate as water and salt continue to reach bridge components below the deck. The two bridges in the most serious condition, at Bryant and Fremont Avenues, are discussed separately below. A few common threads were found when observing the entire collection of bridges as described below.

First, the date of construction (1912-1917) would indicate the concrete is not air entrained. Air entrainment was not prevalent in concrete construction until the 1950s. For air entrained concrete, if the concrete is saturated with water and is subjected to freezing temperatures, the air voids provide relief for the expanding water. The lack of air entraining indicates the concrete may not be resistant to the expansive forces of water when freezing. Freeze/thaw resistances does not only depend on the presence of air entraining but also on the water/cement ratio and the exposure. If the water/cement ratio is sufficiently low, the concrete will not become saturated. If water is kept from saturating the concrete (by eliminating the exposure to water), the concrete will not be affected by freezing water. Freeze/thaw damage is present on over half of the bridges in the historic district. Extensively damaged concrete cannot be repaired, but will need to be replaced in select locations. Testing (see discussion in Projected Programming Costs for Contributing Bridges section) should be done to determine the depth of the damage.

The bridge decks and sidewalks are treated during the winter to clear and melt snow. These treatments introduce chlorides to the structure which is known to permeate through the overlay. Once the chlorides reach the reinforcement, they begin to corrode the steel. The exact severity and extent of the chloride contamination is unknown. In addition to chloride contamination, carbonation could also be causing the reinforcement to corrode, but the extent of this is also unknown. Testing should be done to determine the extents of the damage.

A few of the contributing bridges (for example, Pillsbury, Oakland, and 17th) have concrete deck overlays which are in good condition. The team found these bridges to be in better overall condition than bridges with bituminous overlays. Water and chlorides are seeping through the bituminous overlays and damaging the concrete below. The water infiltration needs to be stopped to preserve the remaining historic fabric.

Some of the abutments are settling vertically and/or shifting horizontally. This movement causes cracks in the substructure and undue strain on the superstructure. Future movement should be eliminated.

Most of the railings on the contributing bridges are exhibiting deterioration from freeze/thaw damage and from corrosion of reinforcing steel. For some bridges only minor concrete repairs are suggested for the railings. For others the repairs will be more extensive with larger amounts of historic concrete removed and replaced. This study has taken a careful approach, as per the Secretary of the Interior’s Standards, in that repair has been fully explored prior to suggesting the replacement of railing elements.

Listed below are most of the standard Maintenance, Stabilization, and Preservation activities suggested in the individual bridge management plans. Any work on bridges in the historic district should proceed according to the Secretary of the Interior’s Standards for the Treatment of Historic Properties and the “Guidelines for Bridge Maintenance and Rehabilitation Based on the Secretary of the Interior's Standards” as adapted by the Virginia Transportation Research Council (included herein). Also per Stipulation 4 of the 2008 Programmatic Agreement on Historic Bridges, designers should consider the use of design exceptions and the use of non-typical details during project development. It may be possible for the current rehabilitation engineering standards (at the time of project development) to be relaxed and accepted by all parties. Creative solutions are encouraged to provide safe, durable, and functional designs that minimize the impact to the historic integrity of the bridge. For example, the existing railings do not meet current (today’s) crash test level requirements. A non-typical detail might include the introduction of an inner traffic railing to meet traffic railing criteria, or, as was done on 15th and 16th Avenues, the existing railing could be strengthened to meet a reduced crash load.

Standard Maintenance Activities: Standard maintenance activities include items such as annual safety inspections and the power washing of decks.

Standard Stabilization Activities: Standard stabilization activities include restoring embankment slopes below stub abutments, removing vegetation growing between substructure components, and fixing drainage issues around abutments. It also includes addressing the drainage issues through the sidewalk on the Elliot Avenue Bridge.

It should be noted that two contributing bridges had stabilization activities performed during 2014. The severely cracked northwest wingwall of the Pleasant Avenue Bridge was repaired as part of an emergency contract administered by Hennepin County. In addition, City of Minneapolis Bridge Maintenance personnel repaired the northeast sidewalk on the 11th Avenue Bridge.

Standard Preservation Activities: The individual bridge management plans identify several preservation activities in suggested work packages to achieve a 30 year service life. In general, the preservation activities suggest removing the modern bituminous overlay and replacing it with a structural concrete deck to prevent further water infiltration to the structure below, reconstructing select severely deteriorated beams but repairing where possible, halting settlement, and repairing spalls and cracks. The primary activities are described below:

Spall repairs are the most common repair and occur on a variety of bridge components including beams, piers, abutments, railings, etc. Spall repairs could be minor where less than 2 inches of concrete thickness requires replacement, or major where approximately 4 inches of concrete would be replaced. With the major repairs, the existing reinforcement should be cleaned and assessed for deterioration. Additional reinforcement may need to be added depending on the extent of the deterioration. All new concrete should be finished with a board form treatment to line up with the original board form lines and should match the texture and color of the adjacent historic concrete following best historic preservation practices including those discussed in *Preservation of Historic Concrete* (Preservation Brief 15).

Helical anchors would be installed by drilling through the abutment and wing wall footings and vertical faces. The helical anchors should be designed to stop further settlement of the abutment and wing walls. The new concrete which will replace the concrete removed to install the anchors would be finished similar to the spall repairs.

Concrete approach panels would be added to the end of some bridges to prevent water from collecting behind the abutments. Structure excavation is required so that a concrete ledge can be built on the back side of the abutment wall to support the concrete approach panel. This ledge will not be visible as it will be buried beneath the new approach panel.

Reconstruct beam would involve an in-kind replacement of severely cracked, spalled, and corroded portions of the beam that are deteriorated beyond repair. This is necessary because of significant freeze/thaw damage, large spalls, and corroded reinforcement caused by water and salt infiltration. The concrete should match the texture and color of the adjacent historic concrete. The suggested length of in-kind replacement was determined on visual inspection and engineering judgment. Testing (see discussion in Projected Programming Costs for Contributing Bridges section) should be done when the project arises to determine better limits of the damage.

Mill and overlay of the deck would involve removal of the existing non-historic overlay (usually about 5 inches) and approximately 1 inch of the original concrete deck, which was not historically visible. A new 2 inch concrete overlay would be added above the new 4 inch structural concrete deck (mentioned below) to provide significant protection against water infiltration. The alteration of the historic curb profile would be minimal.

Add structural deck would involve placing a new 4 inch reinforced concrete deck on top of the existing concrete deck. The deck will strengthen the bridge and preserve historic fabric by preventing water from infiltrating the beams and substructure below.

Full depth deck repairs would consist of full depth removal of deteriorated deck concrete beneath the existing overlay. These repairs are anticipated at the longitudinal joint and at curb lines where water infiltration is the worst. Currently the underside of the deck is spalled at these locations. New concrete would be poured with the structural deck. The underside would be treated to match the surrounding historic fabric as described above under spall repairs. The upper side of the deck was not historically visible and will not be visible after the repair.

Reconstruct sidewalk refers to a complete reconstruction of the sidewalk (which in most cases has a modern concrete overlay) because extensive deterioration precludes feasibly retaining any historic fabric. The sidewalk should be reconstructed at the current width. The toe of the railing should not be obscured. The lower surface of the sidewalk should be cast against a board form formliner to retain the appearance of the existing board form lines on the visible lower surface of the sidewalk.

Reconstruct railing would involve an in-kind replacement of severely cracked and spalled portions of the railing that are deteriorated beyond repair. This is necessary because of significant freeze/thaw damage, large cracks and spalls, or complete coverage with shotcrete. In most cases only a small portion of the railing is unrepairable, but on a few bridges the entire railing unrepairable. The concrete should match the texture and color of the adjacent historic concrete.

The roadway face of the original railing should be coated with an acrylic coating to protect it as much as possible from chlorides. The choice of coating should be based on MnDOT's most recent research on appropriate coatings for historic bridges. (Currently the roadway face of most railings has a coating which covers graffiti).

Bryant and Fremont Avenues: Fremont and Bryant Avenues were found to be so deteriorated that repair may be precluded. The original fabric of Fremont Avenue is extremely deteriorated. (A typical picture is shown below.) All of the beams are in poor condition with spalls and most with exposed, corroded reinforcement. There are also spalls on the underside of the deck. The substructure is cracked and spalled; the abutments are also settling. Repair of the historic fabric (including through the use of chloride extraction and deep spall repairs) is not believed to be feasible. Consultation among interested parties will be needed to arrive at a course of action that takes into account the future project's Purpose and Need, preservation of the historic district's overall integrity, additional environmental impacts, and other factors. One possibility is in-kind replacement of the bridge to original dimensions per the Secretary of the Interior's Standards for Reconstruction. While generally done only in special circumstances, it may be justified because interpreting or understanding the significance of the historic district relies on experiencing it as a designed collection of essentially identical bridges spaced one block apart. A second option is a new bridge closely modeled on the historic bridges to protect the district's important design integrity. The goal would be a bridge subtly or mildly differentiated from the historic bridge it replaces. (See the Fremont Avenue Bridge's individual bridge management plan for more information.)

The original fabric of Bryant Avenue is covered with shotcrete and inspection photographs, taken prior to the application of shotcrete, show extremely deteriorated concrete and reinforcement. On the beams, water is leaching through the shotcrete in many locations and a few cracks are showing through. Cracks are also protruding through the shotcrete on the substructure. The condition of this bridge is believed to be serious; only about 5% of existing fabric is currently visible due to shotcrete applications. Again, consultation among interested parties will help determine the course of action. Preservation recommendations are the same as those described for the Fremont Avenue Bridge.

Bryant Avenue Bridge

5. Projected Programming Costs for Contributing Bridges

The cost estimates provided below are presented in 2014 dollars. These costs were developed without benefit of a detailed, thorough bridge inspection, bridge survey or completion of preliminary design for the estimated improvements. The estimated costs represent an opinion based on background knowledge of historic unit prices utilizing the bid data submitted by several contractors for the recent rehabilitation of the 15th and 16th Avenue Bridges (completed in 2013) and additional construction cost data for other construction projects. The opinions of cost are intended to provide a programming level of estimated cost. These costs will require refinement and may require adjustments as further analysis is completed to determine the course of action for future structure improvements. A 25% contingency and 10% mobilization allowance have been included in the construction cost estimates. These assume additional mobilization and construction requirements for working over an active pedestrian and bicycle trail and are informed by the 2013 rehabilitation of the bridges at 15th and 16th Avenues. (It should be noted that the other reports for the Minnesota Local Historic Bridge Study assume a 20% contingency and 7% mobilization costs).The programming costs presented in the table below include construction, or hard costs, and soft costs such as preliminary and final design services and support during construction.

Total Programming Preservation Cost Estimate for Contributing Bridges in CM&StP Grade Separation Historic District (Includes "Additional Preservation Measures")

Street Name	MnDOT Bridge No.	Construction Cost Estimate	Soft Cost Estimate
Cedar Avenue	90437	$3,891,000	$780,000
18th Avenue	L8923	$2,123,000	$440,000
17th Avenue	L8922	$639,000	$130,000
16th Avenue	L8921	$11,000	$2,000
Bloomington Avenue	92350	$1,663,000	$340,000
15th Avenue	L8920	$14,000	$3,000
14th Avenue	L8919	$1,375,000	$280,000
13th Avenue	L8918	$1,600,000	$320,000
12th Avenue	L8917	$1,473,000	$300,000
11th Avenue	L8916	$1,677,000	$340,000
10th Avenue	L8915	$1,561,000	$320,000
Elliot Avenue	L8914	$232,000	$48,000
Columbus Avenue	L8913	$1,269,000	$260,000
Oakland Avenue	L8911	$168,000	$34,000
Portland Avenue	90494	$3,426,000	$700,000
Stevens Avenue	L8910	$1,297,000	$260,000
1st Avenue	92347	$1,401,000	$280,000
Nicollet Avenue	L8909	$213,000	$44,000
Pillsbury Avenue	L8908	$309,000	$62,000
Pleasant Avenue	L8907	$1,554,000	$320,000
Grand Avenue	L8906	$1,420,000	$300,000
Harriet Avenue	L8905	$1,442,000	$300,000
Aldrich Avenue	L8904	$2,709,000	$560,000
Bryant Avenue	L8903	$2,909,000	$600,000
Colfax Avenue	L8902	$2,468,000	$500,000
Fremont Avenue	L8901	$2,893,000	$580,000
29th Street	L5893	$1,233,000	$240,000
Grand Total =		$40,970,000	$8,343,000

As part of the overall cost programming for the corridor, provision should be made for soft costs such as preliminary design, material sampling and testing, final design, and construction support. For programming purposes, these costs are estimated to be on the order of 20% of the hard or construction costs. $41M of hard costs would therefore require $8.3M of soft costs leading to an overall programming cost of $50M for the corridor for the immediate needs.

It is important to recognize that the individual bridge reports accompanying this general bridge management plan present work packages and estimated costs based on a limited level assessment of the existing structure. No testing or sampling was conducted during this study to quantify the deterioration of different elements. Quantities were obtained by visually assessing the bridges in the field and reviewing photographs and other documents. Prior to designing the repairs on each individual bridge a series of testing and sampling procedures should be carried out. This would allow the designers to quantify the extent of damage at the time of design. This will limit the project risk for the HCRRA and will allow the designers to communicate the extent of deterioration in the contract bid documents. The extent of and locations where these tests and samplings would be conducted will depend on the conceptual repair for each bridge.

Visual Inspection
All the bridges were observed from grade during this project; detailed up-close visual inspection and sounding of each bridge will be required for final repair details. This observation will highlight areas of concern, areas needing additional investigation, and areas where concrete are sound and durable.

Non-Destructive Testing
Non-destructive testing could consist of various techniques although the focus would be on Ground Penetrating Radar (GPR), Corrosion Potential and Extracting Cores for laboratory analysis.

GPR utilizes radar waves to determine the location of embedded objects in the concrete. This technique does not provide the current condition of the reinforcing steel although it allows its location to be determined. Knowing the location, cores can be taken to expose the reinforcing steel for inspection and/or to avoid the reinforcing steel when extracting cores.

Corrosion potential utilizes a copper-copper sulfate half-cell as half a battery and the reinforcing steel in concrete as the other half of the battery. As they are connected the potential in volts can be measured. Depending on the potential voltage, areas of active corrosion may be determined. This test could be conducted on bridges where limited corrosion activity is visible to determine the corrosion potential in unexposed reinforcing steel.

Cores may be extracted for various reasons. The most common reason to extract cores will be to determine the depth of freeze-thaw damage, carbonation, and chloride contamination. Distressed concrete may be visible on the surface although it is difficult to determine the amount of concrete required to be removed to expose sound concrete. Additionally cores could be extracted to expose reinforcing steel for visual inspection.

Laboratory Testing
Laboratory testing will depend of the condition of the bridge and members. Samples should be taken to represent the range of conditions present, from visually intact to obviously deteriorated. Compressive strength of cores and strength testing of reinforcing steel samples may be conducted to help in determining the structural capacities of the members. Petrographic observation may be conducted to confirm the mechanism of deterioration and depth of carbonation and freeze-thaw damage. Additionally chloride ion contents may be measured at incremental depths in the cores in order to evaluate the degree of contamination in the different structural elements and appropriate concrete repair details.

In moving forward with future project planning, it will be essential to undertake a detailed structure assessment addressing the proposed work for the structure. It is also important that any future preservation work follow applicable preservation standards with emphasis to rehabilitate and repair in-place structure elements in lieu of replacement. This includes elements which are preliminarily estimated for replacement within the work scope of this report. Only through a thorough review of rehabilitation and repair options and comprehensive structural and historic assessment can a definitive conclusion for replacement of historic fabric be formed.

6. Evaluation of Noncontributing Bridges

The condition of the noncontributing bridges ranges from good to very good. All the bridges have varying degrees of map cracking on the top side of the decks, with only a handful having a few small cracks in the underside of the decks. The repairs for these bridges will consist of sealing the cracks on the top side of the deck every 5 to 7 years and milling and placing a concrete overlay on the decks in 15 years for the older bridges and 25 years for the newer bridges. The pedestrian metal railings are showing signs of wear and will need to be repainted in the next 10 to 20 years depending on the age of the bridge.

Generally non-historic bridges have a useful life of approximately 70 years, so the County and City can expect to replace these bridges in 40 to 60 years depending on the age of each bridge. When the noncontributing bridges reach the end of their service life, a consultative process among interested parties will be needed to arrive at a course of action that takes into account a future project’s Purpose and Need, the Secretary of the Interior’s Standards including preservation of the historic district’s overall integrity, additional other environmental impacts, and other factors. (One possibility for some bridges may be reconstruction of the original historic bridge to original dimensions. Another possibility may be construction of a bridge that is closely modeled on, and subtly differentiated from, the historic bridges.)

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APPENDIX A – Historic Photographs

The CM&StP corridor was built over six construction seasons, 1912-1917. This ca. 1915 photo, which faces west, was taken near the middle of the 40-block-long project. In the foreground is the Clinton Avenue Bridge nearing completion. Unlike most of the historic bridges, Clinton had six spans to accommodate the west end of a rail yard on the north side of the trench. The 3rd, 2nd, and Stevens Avenue bridges are visible to the west. The Clinton, 3rd, and 2nd Avenue bridges are no longer extant. I-35W now crosses the corridor just west of 2nd Avenue (photo by C. J. Hibbard, ca. 1915, Minnesota Historical Society).

In the center of this ca. 1915 view is the Portland Avenue Bridge under construction. The Oakland and Park Avenue bridges are being built adjacent to the east. Farther east is Bagley Grain Company's Elevator X and a temporary foot bridge erected so the public could cross the corridor during construction. In the foreground is the corridor's only at-grade crossing at 5th Avenue (photo by C. J. Hibbard, ca. 1915, Minnesota Historical Society).

A long view, facing west, of the corridor's nearly identical Neoclassical Revival style concrete bridges spaced one block apart. The Park Avenue Bridge is under construction near the bottom of the photo, with the Oakland and Portland Avenue bridges adjacent to the west. The next two bridges, at 4th and Clinton Avenues, had extra spans to accommodate the rail yard (ca. 1915 photo from "Views of the 29th Street Track Depression Construction Project in Minneapolis," annotated photo album, Minnesota Historical Society).

Aerial view of the corridor facing east. Hennepin Avenue is at lower right. Visible between the Hennepin and Fremont Avenue bridges is Girard Avenue, the only street in the corridor that had neither a bridge nor an at-grade crossing (ca. 1940 photo, Minnesota Historical Society).

APPENDIX B – Historic Articles

When navigation became obstructed in this way it was formerly the custom to send natives into it with tools to cut the roots by hand and endeavor to pull out the mass bit by bit with wire ropes, a slow and sometimes impossible operation. In order not only to keep navigation open but also to conserve the river and reduce loss by wastage into the swamp area and by evaporation, the Egyptian Government has been doing some experimental dredging on a large scale, and for this purpose has had built the specially designed dredge shown in the accompanying views.

This dredge is built on the lines of a light-draft river steamer of the stern-wheel type, having a steel boom 60 ft. long at the forward end for working a grab bucket of about 8 cu.yd. capacity. The grab is specially designed with long tapering steel tines to penetrate and close upon the roots, and sufficient power is applied to pull out the mass bodily. The illustration Fig. 3 shows the grab embedded in the swamp, and Fig. 4 shows a mass of vegetation being lifted out, the pictures being taken from the bow of the dredge.

The hull of the dredge is of steel, 160 ft. long by 32 ft. beam and with 3 ft. draft of water. Two steel spuds are fitted with special feet of large area to bear upon the soft bottom. The spuds are so designed that they can be lifted clear of everything and present no obstruction to navigating the vessel. This dredge is fitted with large fuel storage and also moderate accommodation for passengers and freight, so that she can navigate long stretches of the river, and can also be used as a towboat. The distance from the base of supplies at Khartoum to the swamp district is about 800 miles. Since this vessel has been placed in commission the stoppage of navigation in the sudd region has become a thing of the past, and being fitted also with other buckets for mud and clay, she has been employed more or less in other work.

This vessel was built in 1909 from designs by A. W. Robinson of Montreal, Consulting Engineer to the Egyptian Government for this work. The dredging machinery was by Stothert and Pitt of Bath, Eng., the propelling machinery by a Clyde firm, and the hull and general machinery were also built in the Clyde, and shipped in pieces to Khartoum.

Track Depression at Minneapolis

SYNOPSIS—To eliminate street crossings a stretch of track nearly three miles long has been depressed, and is crossed by nearly 40 street bridges. A special problem was the maintenance of spur connections to numerous industries along the line. At several streets also the grade line is close to the crown of the sewer, and the sewers have had to be covered with concrete saddles. An unusual feature in the bridges is a curved shelf on the outer face of the girder, this being intended to act as a smoke shield by diverting the smoke from the parapet as engines pass under the bridge. The work is being done by company force.

The elimination of grade crossings in cities is accomplished in most cases by the elevation of the tracks above the streets, while the depression of tracks below the street level is of much less frequent occurrence. The latter method usually involves special difficulties due to intersection of or interference with sewers, water and gas mains, etc., and the work is usually attended with greater difficulty than track elevation.

An interesting piece of track-depression work now in progress is that on the Hastings & Dakota Division of the Chicago, Milwaukee & St. Paul Ry., at Minneapolis, Minn. This division commences by junction curves from the main line at the South Minneapolis shops and extends westward in a straight line just north of and parallel with 29th St., from Cedar Ave. nearly to the city limits. It was built originally at the street level, and passes largely through a residence district, although for a considerable part of its length it is bordered by elevators, coal yards, lumber yards and other industries.

In 1910 the city passed an ordinance requiring the railway company to lower its main tracks, and (with only one exception) to separate the grades at every existing street crossing from Cedar Ave. to Hennepin Ave. On account of the favorable conditions for depressing the tracks between these points, the railway company accepted the ordinance. But as there was no provision for taking care of the industry tracks a number of the industries joined forces and by legal proceedings delayed the beginning of the work until late in 1912. This controversy is noted below. The cost of lowering the main tracks was estimated at $1,000,000, but the compromise increased the estimate to something over $1,500,000.

As the ground falls away from the general level east from Cedar Ave., and west from Hennepin Ave., it was decided to lower the line between these points, a distance

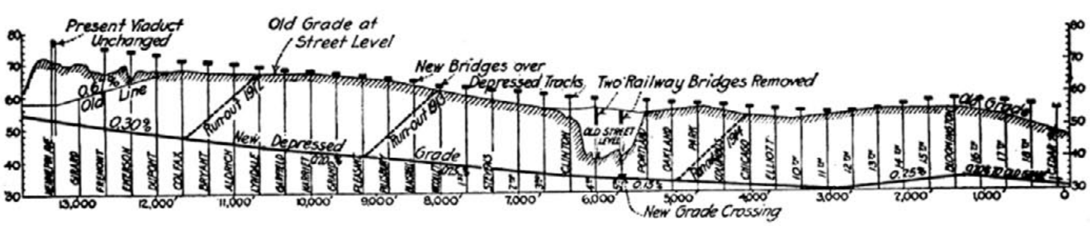


FIG. 1. PROFILE OF TRACK DEPRESSION OF THE CHICAGO, MILWAUKEE & ST. PAUL RY. AT MINNEAPOLIS, MINN.

of 3 mi., involving nearly 40 street crossings. This improves the grades of the connections at either end. The depression is about 20 ft., and the streets are raised about 3 ft. over the cut by inclined approaches of 3% grade, so that all street bridges have a minimum clearance of 18½ ft. The grade of the revised line is flat, ranging from 0.15 to 0.3%. The old and new profiles, with the position of the various bridges, etc., are shown in Fig. 1.

The work was commenced in 1912 at Hennepin Ave., which street has for several years been carried over the tracks by a viaduct. At this point the old line ascended to the ground level (and street level) by a grade of 0.67%, while the new line has a descending grade of 0.3%. At the end of that season a run-off or incline of 2% grade was built, running out on the old level at Lyndale Ave.; in 1913, the run-off was at Nicollet Ave., and that for 1914 will be at Chicago Ave., while it is expected to complete the work to Cedar Ave. in 1916.

Although the ground is practically level, there is a ravine between Portland and Clinton Aves., where 4th and 5th Aves. were formerly crossed by railway bridges. A grade crossing will be maintained at 5th Ave., but at 4th Ave. the old subway will be replaced by a viaduct with long approaches, as this street is an important thoroughfare with a double-track car line.

Water mains, gas mains and sewers are encountered at most of the cross streets. The water mains were cut temporarily and are being relaid permanently between a pair of the girders of the concrete bridges. For this purpose each of these girders has a ledge on the bottom of the inner side, forming shelves to support concrete slabs, as shown in Fig. 2. The pipes are inclosed in frost-proof boxing and are laid upon these slabs. Electric and telephone conduits are carried in the same way, while the gas mains are carried under the bridge abutments and beneath the tracks.

The sewers are mainly below the grade line, but in many cases with only a few inches of cover. These sewers are protected by reinforced-concrete saddles as shown, new manholes being provided outside of the right-of-way. Several of these old sewers while uncovered gave trouble by bursting during heavy rains (when they flowed to full capacity), thus discharging water into the cut. Where the sewers were not deep enough to permit the track depression, they were diverted to the nearest sewer of adequate capacity.

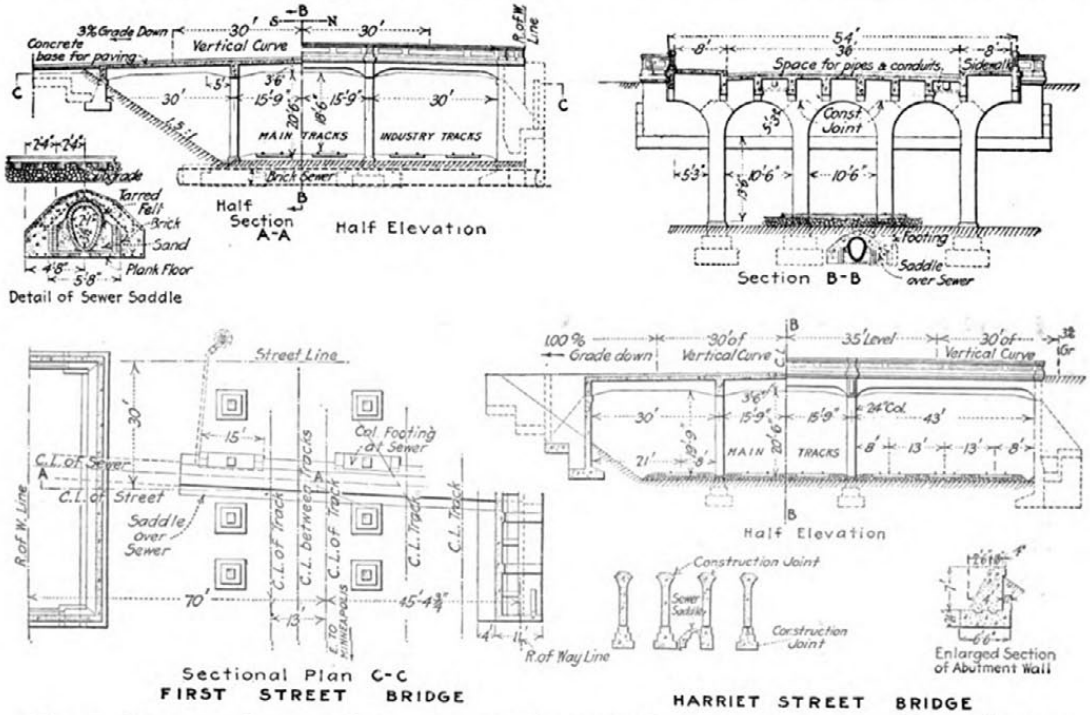


FIG. 2. REINFORCED-CONCRETE BRIDGES OVER THE DEPRESSED TRACKS AT MINNEAPOLIS, MINN.; CHICAGO, MILWAUKEE & ST. PAUL RY.

(The tracks under the side spans are for industry connections)

For a part of the distance, 29th St. is parallel with the railway, and its north line coincides with the south right-of-way line, so that in some instances a retaining wall was required to support the street. This is surmounted by an iron railing instead of a parapet wall.

The roadbed is of ample width for drainage, and at intervals of about 300 ft. there are special catchbasins with connections to the sewers. These are of concrete, 2½x5 ft., with an iron grating on top to retain large pebbles, etc. At the side of the catchbasin is a low toe wall to prevent material from the slope of the cut being washed down upon the grating.

INDUSTRY TRACKS AND FACILITIES

The industries noted above introduced special problems in regard to their track connections, and these were a source of controversy. The right-of-way was generally

100 ft. wide, with one main track and from one to five additional tracks to provide service to industries on either side. The width was sufficient generally for two main tracks and the slopes of the new depression.

The question raised by the industries was as to the railway company's liability for the changes necessary to be made in industry tracks, since the lowering of these tracks and adjusting the industries to be served from the lowered tracks represented a very considerable expense. The industries claimed that the railway company should bear this expense. The company contended that the tracks were to be lowered, not of its initiative and for its benefit, but by order of the city authorities and as a measure of public safety; and therefore the industries should make the necessary adjustments themselves and entirely at their own expense, including the cost of the changes in the tracks serving them.

The litigation was compromised by the railway company agreeing to put in one track (to be called a service track) in addition to the two main tracks, leaving the industries to stand the cost of providing the additional trackage necessary to serve them, these latter tracks to be laid next to the right-of-way lines, and the industries at their own expense to adjust themselves to these tracks. All such tracks were laid at the grade of the main tracks (instead of rising on an incline to the old elevation) and this required a considerable depression of the industries.

Where the right-of-way was not wide enough for the two main tracks and one service track, the railway company contributed to the cost of the industry track an amount which was approximately what would have been required if a retaining wall had been built to hold the slopes for the three tracks within the right-of-way limits. The result has been a great burden of expense to the industries, and a large additional burden on the railway company.

It has been pointed out in this connection that in many cases the elimination of grade crossings by track elevation or depression cannot be brought about without hardship to the abutting interests, especially where these are industries in which the railway is giving service. Further, the railways are not under obligation to assume the expense of restoring these facilities, and much less to assume the cost of adjustments necessary to be made in the industries to permit of the continuation of track service from the railway.

The industries required special treatment to suit the conditions and requirements of each case. In some cases a retaining wall had to be built at the right-of-way line, surmounted by a reinforced-concrete fence. In other cases, the owners permitted the slope of the cut to extend over their property, a toe wall being built at the right-of-way line. This occurred usually where a trestle or other structure at the upper level could be built over the slope. In one case, where 29th St. is parallel with and adjacent to the top of the retaining wall of the cut, an industry had a warehouse on the opposite side of this street. Here a track and team driveway have been provided on the railway side, and a lateral subway built under 29th St. to enable the industry's wagons to drive down a private road from 30th St. and pass under 29th St. to the team driveway.

It is interesting to note the different methods adopted for handling coal in three of the coal yards on this line. In one case, the coal yard is at the track level, with an inclined driveway to the street; coal is delivered from cars into a track hopper and carried by an elevating conveyor to large elevated storage bins of timber construction, beneath which the carts drive to take their supply from various chutes. In another case, the yard is at the street level with a steel storage bin built close to the edge of the cut, and provided with a traveling hoist upon the roof with a horizontal carrier to distribute the coal to the various bins. In the third case, the yard is at the street level, but the concrete elevated dock is set back from the tracks. Here the cars deliver coal to a track hopper beside an elevator tower, from which an inclined conveyor bridge extends over intervening tracks to the bins.

Street Bridges

There will be 37 bridges. These are of reinforced concrete of the slab-and-girder type, with three spans, the girders and slabs forming a continuous structure from end to end. The center span, 31 ft. 6 in. c. to c. of columns, covers the double-track main line. The side spans are usually 29 ft. in the clear (sometimes 42 ft. where three tracks are spanned) and cover a bank slope, team driveway, industry tracks, etc., according to the local conditions. Two typical designs are shown in Fig. 2. The bridges are about 350 ft. apart, and a view along the track gives the general appearance of a tunnel. The width of the bridges varies, and is such as to conform to the width of the roadway with an 8-ft. sidewalk upon each side.

The soil is sand and gravel; with a few clay seams, and no piling is required, but it is provided that the bearing of foundations on the natural soil shall not exceed 2½ tons per sq.ft. The pier footings have to be modified in shape in some cases, where they are adjacent to a sewer (Fig. 2). These footings are made long and narrow (at the side of the sewer) instead of the usual square shape. The street-approach grades are in general 3%, with 60 ft. of vertical curve at the middle of the bridge.

The concrete is of stone with proportions as follows: 1:3:6 for footings of the bents and for all concrete work of gravity section; 1:2½:5 for all reinforced abutments, and 1:2:4 for the columns, girders, floors and handrails. The aggregate consists of torpedo sand and granite screenings of ½- to ¼-in. size. The reinforcement is of deformed bars, which are cut and bent at a neighboring yard and assembled on the work. Some of the stirrups have the upper ends of the legs bent over, horizontally so as to hook upon the sides of the form. This eliminates the use of blocks to keep the stirrups above the bottom of the form.

In construction, the footings are built first, and then the columns, the latter being finished with enlarged heads, as shown, to carry the cross-girder built later. The beams and deck slab are then poured at one time. The falsework and floor forms are left in place from two to three weeks before removal. The handrail forms have usually been allowed at least 48 hours before removal. Previous to this season, the handrail forms were removed after 24 hours and the face of the concrete was brushed with a stiff wire brush to expose the red granite screenings in the aggregate.

It was decided to discontinue this practice, as a smooth concrete face seems to give a more pleasing effect and to bring out more clearly the angles and planes of the design. As a consequence, the hand rails as they are now built, show a smooth concrete face. They are rubbed with emery stone just enough to take out surface irregularities or brushed with cement grout to remove surface discolorations.

A rather novel deck construction on the Nicollet Ave. bridge provides for a future widening of the present 50-ft. roadway to 60 ft. The concrete roadway deck is made 60 ft. wide, with 10-ft. sidewalks, but the latter are widened to 15 ft. by hollow tile blocks laid upon the roadway and covered with a thin layer of concrete. Whenever the city desires to widen the roadway, the 5 ft. of tiles can be removed readily, without affecting the structural design of the bridge.

The bridge parapet walls are 3 ft. high, paneled as shown in Fig. 3. In removing the forms from these, the cleats *A* are removed and the lagging loosened. Then the cleats *B* and bolts *C* are removed (the latter having been greased before placing). Next, the 2x6-in. studding is

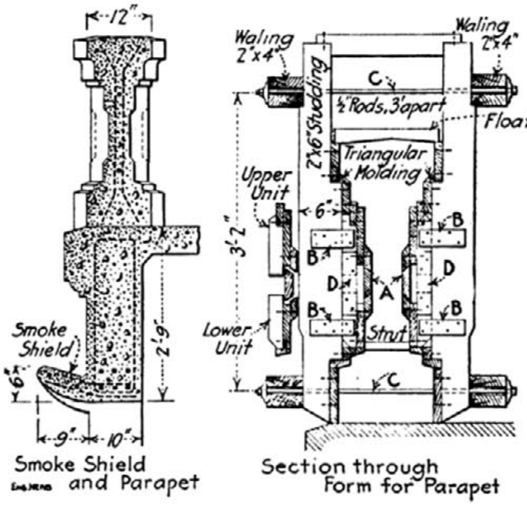


FIG. 3. SMOKE SHIELD, PARAPET AND PARAPET FORMS FOR BRIDGES OVER DEPRESSED TRACKS AT MINNEAPOLIS, MINN.; C., M. & ST. P. RY.

removed, with the lagging attached. Finally the strips *D* are removed and the remaining lagging is taken off by dropping the upper unit and raising the lower one, as shown. An unusual feature of the bridges is a smoke shield, intended to throw the smoke away from the parapet wall. This is a ledge 9 in. wide formed along the bottom of each fascia girder, as shown in Fig. 3.

Temporary bridges with framed timber bents and joists are constructed wherever it seems necessary and street-car traffic is carried on a temporary bridge at one side of the bridge site. At one street, where a regular temporary bridge was not required, but where school children crossed the work, a narrow timber footbridge was built. This had high close-boarded sides, sloping outward at the top, to prevent the inquisitive children from hanging over the edge.

Behind the abutments and retaining walls are 4-in. tile drains which lead either to a catchbasin or to weep holes through the walls.

Construction Methods

The excavation is done by steam shovels, the gravel soil standing well. The material is removed by standard-gage equipment and used largely as filling for enlarging the site of a freight yard. It was found possible in many instances to make the excavation for bridge abutments just previous to steam-shovel cuts, the excavated material being thrown out in front of the abutment site and loaded by the steam shovel on its next cut. When it was impossible to do this it was necessary to load the excavated material on cars by hand.

There are 16 to 20 trains daily over the line, besides a heavy switching service to accommodate the numerous industries. On part of the work, a temporary running track was laid on the surface, outside of the line of the cut and being partly on private land and partly in 29th St. At some points this was used until the completion of the depressed work, but at others it was abandoned as soon as one track could be laid through the cut, and the traffic was operated on this latter track. The grades of the run-outs at the end of the depressed section are about 2.8%, but trains have been operated temporarily over grades of 5%, using a pusher engine for the assistance of passenger trains.

The portable concreting plant travels on the construction track at the lower level, and has a ½-yd. mixer of the drum type mounted at the rear of a flat-car. Behind this is a pile-driver car, converted into a concrete elevator, using the leads as guides for a ½-yd. dump bucket having the discharge door at the bottom of the forward side. The empty bucket drops into a pit beneath the ties, and a short hinged chute is swung out to receive the concrete dumped from the mixer and deliver it to the bucket. The chute is then raised and the bucket hoisted. At the top, an attendant trips the side door, which falls outward to form an apron connecting with the chute through which the concrete flows to the forms. This bucket was designed by the engineering department, and it is planned to make the side door operate automatically.

On the first part of the work, stationary stiff-leg derricks at the ground level were used to handle the forms and concrete buckets, but the present arrangement for concreting is more convenient. The stiff-leg derricks were used this season at places where they were already set up, but at other bridges A-frame derricks fitted with hand crabs or hoists were used to erect the falsework for the bents and the bent forms. The falsework timbers and floor forms were erected from the street level, the timbers being run out on dollies and the floor forms assembled and carried to place. Although the bridges vary in dimensions, it has been found possible to use sectional floor forms by making slight changes. These have been used as many as three times, while handrail forms have been used on five bridges before being discarded. The forms for the bent columns have also been made sectional.

Engineers

The work is being done by the railway company's engineering department, most of the construction work on this road being built by company force. From 200 to 300 men are employed. W. R. Powrie is District Engineer, and F. M. Sloane is foreman in charge (for the Engineering Department). The design and execution of all the work are under the general direction of C. F. Loweth, Chief Engineer of the Chicago, Milwaukee & St. Paul Ry.

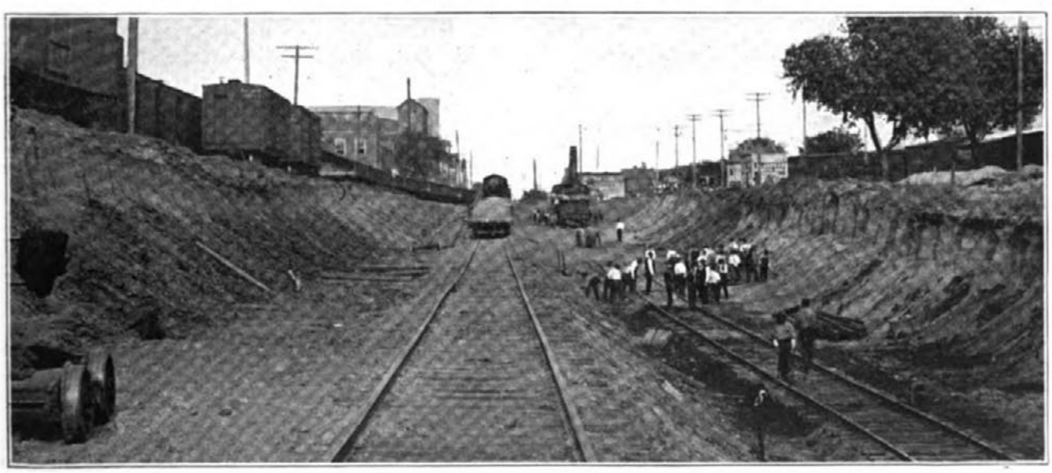
gation and suspension docket No. 414. The formal complaints filed in these proceedings raise no issue with respect to any particular rate or rates. They attack, in effect, the principles applied by the carriers in the cancellation of their arrangements with industrial lines. Carriers against which these complaints were filed will be expected to follow the same lines of action herein suggested for the carriers whose tariffs were suspended in this proceeding. We shall, therefore, enter an order dismissing the proceedings in docket No. 4181 without prejudice."

Track Depression Work of the C. M. & St. P. Ry. at Minneapolis

Extensive work of depressing main tracks in the city of Minneapolis. Some of the items are 37 street bridges over tracks and the underpinning of numerous manufacturing plants with permanent masonry. One of the complications is the handling of street car travel across the excavation in advance of the erection of the permanent bridges.

The Chicago Milwaukee & St. Paul Ry. has under way, in the city of Minneapolis, Minn., an extensive piece of track depression work which has been in progress for the past three years. The work consists in lowering the main tracks of the Hastings & Dakota division of the road over a distance of about three miles, through a built-up section of the city. These tracks lie parallel with and just north of 29th street, which thoroughfare is adjacent to the work throughout the whole distance except for a break of about seven blocks, where the street is not continuous. The western limit of the work is at Hennepin avenue, which is bridged over the tracks and is not disturbed. The work was started at this point in 1912, at moderate pace, but it was not until the next year that it was carried on with full organization.

C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 1—First Cut of Shovel, Looking East from Emerson Ave.



C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 2— Looking East on Temporary Main Track; Shovel in Third Cutting.

The object of the undertaking, which is in compliance with a city ordinance, is to eliminate numerous street crossings at grade. The ordinance requires that all of 39 streets except two be carried over the tracks at approximately the original street level, so that the plan of construction involves the erection of 37 bridges over the tracks, and of these six will carry street car traffic. Of the two exceptions above noted, one of the streets will be closed and the other street, which originally crossed in a subway under the tracks, will, after the tracks have been depressed, cross at grade.

The tracks are being lowered to permit clear head room of 18½ ft. under the bridges, and, the grade of the street being only slightly changed at the bridges, for drainage purposes, the cut required to permit this clearance has averaged about 22 ft. in depth. The excavation is in sand and gravel, and will amount, all told, to about 900,000 cubic yards. The excavation is being done with a steam shovel, and most of the material taken out has been hauled to Bass Lake yard, where it is being utilized for filling and enlarging the yard.

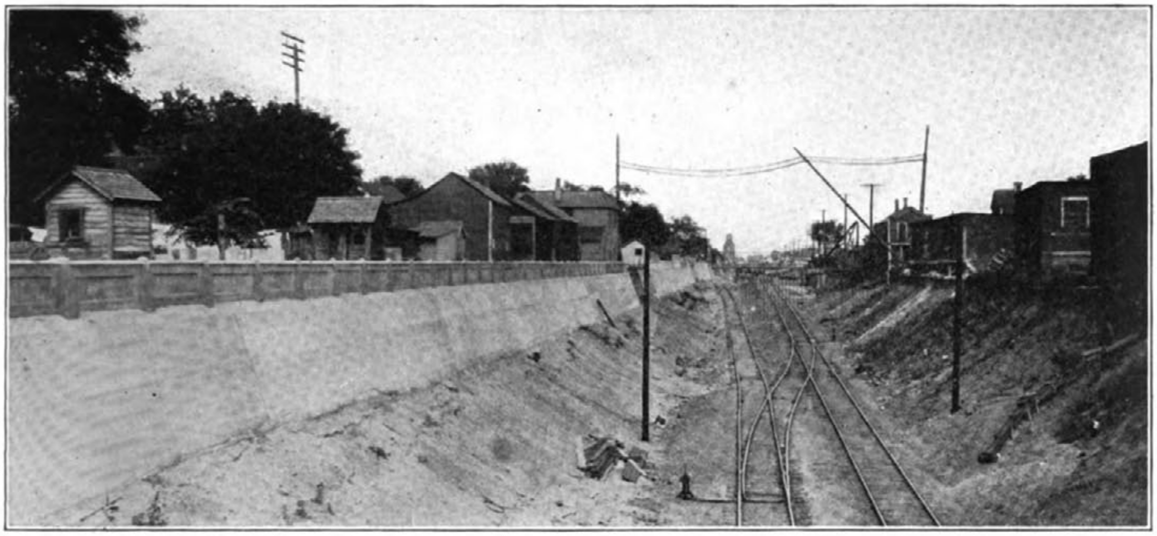
C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 3—Looking East from Center of Block Between Dupont and Emerson; Shovel in Final Cutting.

This work of depression is through a residence district, with numerous industries scattered along. The matter of taking care of the industry tracks while the work was in progress and the special problems of connecting them with the lowered tracks has been, throughout, an interesting feature of the undertaking. The accompanying illustrations show several views of the plants that have had to be remodeled in order to utilize lowered tracks. At first it was the intention of the railroad company to depress only two of its tracks, and for this the width of right of way was sufficient for slopes without retaining walls. The problem involved by the industry tracks, however, soon made it apparent that a third track would be desirable in the depression, to connect with the industry tracks and permit of necessary switching without occupying either of the two main tracks, and the work has been so planned, although the additional room for the third track has made necessary, in some cases, the acquirement of additional right of way.

The bridges are all of reinforced concrete, and, for the most part, similar in design. Examples of the structures are shown in several of the illustrations. In general the bridges are in three spans, the center span covering the two main tracks and the end spans the slopes of the cut or industry tracks, as occasion requires. Where the end span covers a slope there is a small bank abutment at the top, but where it covers a third track or an industry track the abutment is made full height, from the bottom of the excavation. Two exceptions to the three-span arrangement may be noted, one at Fourth avenue, where there are ten spans, and the other at Clinton avenue, where there are six spans, to carry the streets named across a series of depressed team tracks located about midway of the depression. The street bridges generally provide full width of roadway, to conform to the original street widths, and are paved with wood blocks. On each side of the bridge there are sidewalks 8 ft. in width and hand rails of reinforced concrete are built along the outer edge of the walks.

The manner of excavation is that of cut and shift. The steam shovel makes a cut as deep as is permissible with loading of cars on main track, in some place to a depth of 8 ft. A new track is laid in the cut so made (see Fig. 1), to which traffic is then diverted, and the steam shovel is shifted to the other side and is put to cutting down under the old track. In this manner the work progresses, cutting and shifting from side to side until the desired level is reached, the entire excavation in different places being made in from five to seven cuts and shifts. For a usual thing the tracks have been depressed to full depth covering a stretch of about eight blocks at a time.

An interesting part of the work has been the method of handling street traffic across the tracks during construction. For the first cut of the steam shovel the usual arrangement has been

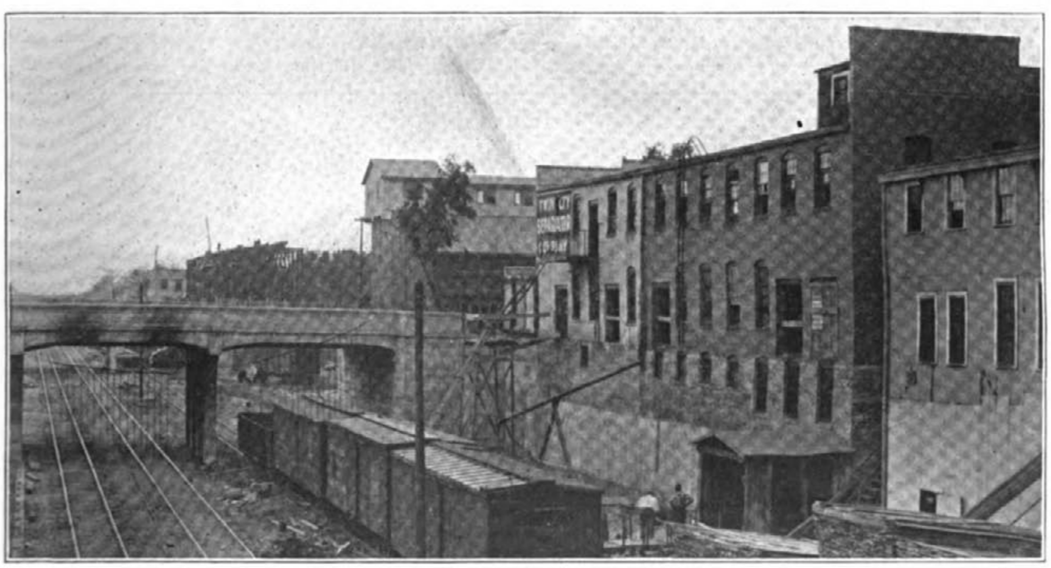


C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 4—Retaining Wall on North Right of Way Line Between Pleasant and Nicollet.

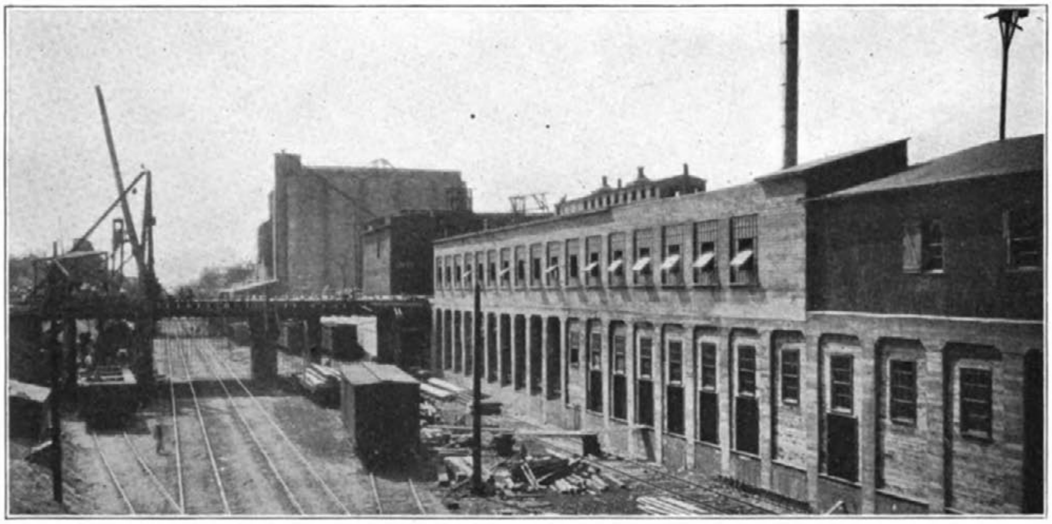
to lay stringers across the cut and plank them over for a temporary bridge after the shovel has passed. As successive cuts were made all of the streets would be temporarily closed except one, at about the center of the work in progress, and at this street a temporary bridge was used to carry the usual street traffic or to transfer passengers from street cars on stub-ended tracks at either side. As soon as the depression reached full depth, a temporary wooden bridge was erected over the depression, across one of the streets, to carry the traffic, and this bridge would serve until the permanent structures were erected. An engineer connected with the work has described the manner of handling street car passengers across the work as follows:

"People using the street car lines intersecting 29th street have not been sure from day to day just how they were to cross the cut or what route they would have to travel to do so. One day they have been required to transfer, then they have been shunted through a subway that carried them under the tracks on which the dirt trains load. This, for a day or two only, then they would find they must use the other side of the street and go down and across the first cut of the shovel, by means of a temporary stairway. This sufficed until the shovel came back on its second cut, when the public would have to climb stairs to a level 14 ft. above the street, and cross on a wooden truss span to the opposite side of the cut. The third cut of the steam shovel finds this same truss in a slightly different and lowered position and the weary strap-hangers have reached the last stage in the transferring process. Shortly after this last move the cut is completed and street cars can go on without further interruption."

About 500 men are employed on the work. The excavation is being made with one steam shovel. Three work trains of twenty-five 12-yard air dump cars each are employed. Of the number of men stated, 250 to 300 are employed on the work of bridge construction. At the beginning of the present season it



C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 5— Work at the Twin City Separator Co.



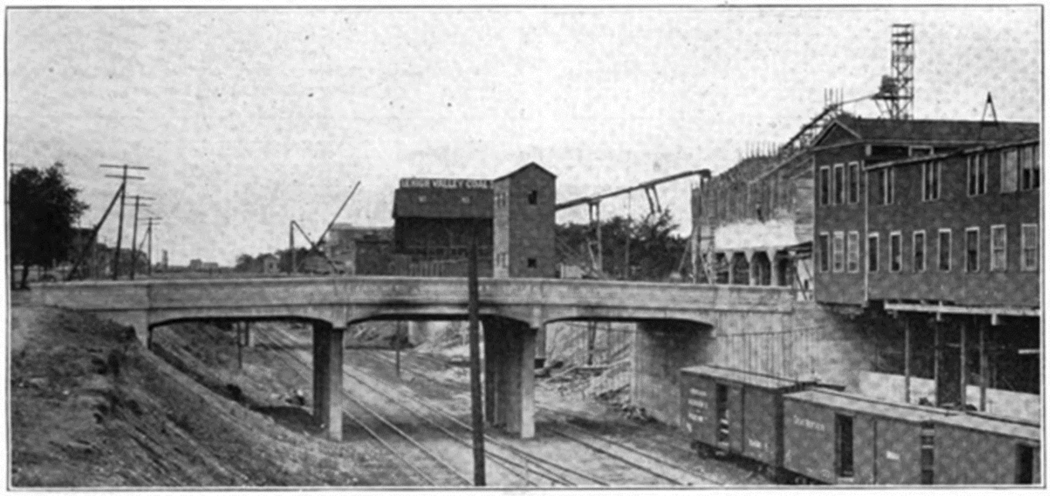
C. M. & St. P. Ry. Track Depression in Minneapolis. Fig. 6—Grand Ave. Bridge Under Construction; Concrete Underpinning of Plant of Western Crucible Steel Castings Co.

was estimated that about 50 per cent of the work was completed, including 17 of the bridges, on which traffic has been restored It is planned to complete all of the excavation this year and all but four of the bridges. The work is being done by company forces under the general direction of Chief Engineer Mr. C. F. Loweth, Mr. W. R. Powrie being the engineer in direct charge.

Commission Equalizes St. Louis Grain Rates.

The Interstate Commerce Commission has returned a decision in two cases in which the Merchants Exchange of St. Louis, Mo., and the Southwestern Missouri Millers' Club were complainants against the Baltimore & Ohio, the Chicago & Alton and other railroads. The situation complained of is that intrastate rates from interior Missouri points to St. Louis, Mo., are lower than the interstate rates for the same movement applicable on through shipments. A requirement enforced by Central Freight Association and trunk line carriers that expense bills showing the payment of interstate rates inbound be surrendered in order to secure the reshipping rates outbound, was complained of in the first case is unreasonable. The complainant in the second case alleged unjust discrimination, because the combination of intrastate rates to St. Louis and outbound rates to Central Freight Association, trunk line, southeastern, Mississippi Valley, and southwestern territories of which St. Louis shippers are able to avail themselves is lower than the rate for the through movement from interior Missouri points. The commission held on the several points as follows: "1. In the absence of local or flat rates from St. Louis proper, shipments of grain and grain products are entitled to move out on reshipping rates, 'regardless of the point of origin of the grain, and regardless of the rate paid on the inbound shipment,' because 'we must so construe the tariffs as to permit the traffic to move, if that be possible.' 2. By maintaining interstate rates higher than the intrastate rates from interior Missouri points to St. Louis an unlawful and undue prejudice and advantage is given to St. Louis, and an unjust and unlawful discrimination is effected against the interior Missouri and southern Illinois points and East St. Louis, from which carriers serving St. Louis from the west are ordered to cease and desist. 3. The record is not sufficient to justify a determination as to the reasonableness of the

C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 7—Colfax Avenue Bridge.



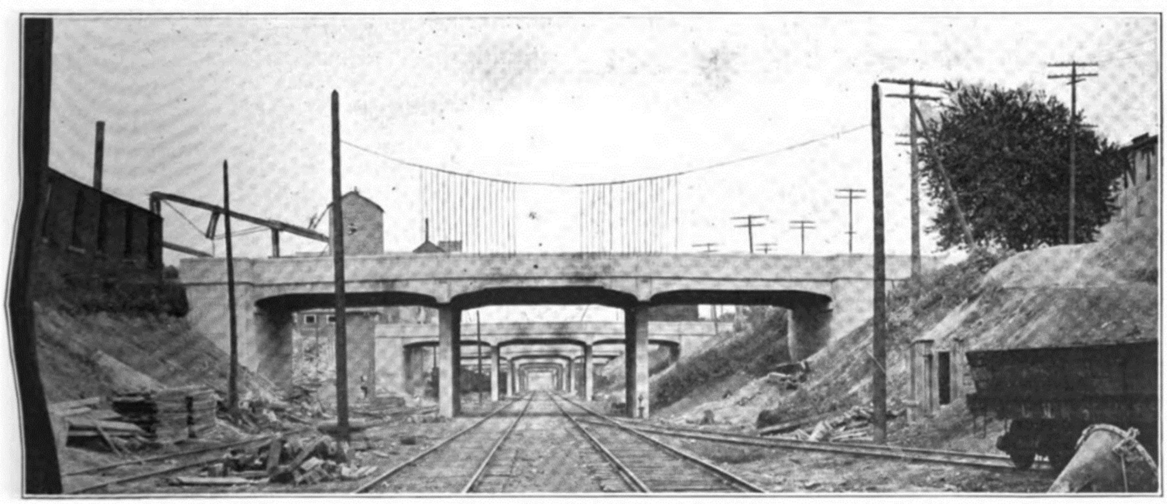
C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 8—Aldrich Avenue Bridge and Bruer Bros. Woodworking Plant.

present interstate rates from interior Missouri points to St. Louis. No change should be made without due consideration of the relation of the rates to and from St. Louis with the rates to and from Memphis. 4. While reshipping or proportional rates are applicable to part of a through but suspended movement from point of origin to ultimate destination, outbound local rates, although they may likewise apply to part of a through movement, cannot be limited according to the point of origin of the shipment or the rates which were paid inbound. So long as there are intrastate rates published to St. Louis, shippers cannot be denied the right to avail themselves of these rates for movements which are clearly intrastate, and so long as there are flat rates published out of St. Louis shippers must be permitted, in proper cases, to ship outbound under these rates, irrespective of the rates paid inbound. It is plain that the intrastate movement to St. Louis must be considered as a separate movement which cannot be tied up to the outbound movement in such a manner as to constitute the two one through movement, provided the consignee has in good faith taken possession. 5. Absorption of elevation charges is made upon the theory that the inbound and outbound movements comprise a through movement and that the grain has been elevated in transit. Whenever the absorption is made the grain cannot lawfully move forward except at the balance of the through rate."

Rapid Growth of Hawaiian Railway.

The railroad system on the island of Oahu, Hawaiian Islands, provides a romantic story of a financial undertaking that at first almost ruined its backers, but is now one of the best-paying investments in the Hawaiian Archipelago. A. P. Taylor, a correspondent of the United States Department of Commerce, has sent in a report which describes the growth of the road. "Twenty years ago," Mr. Taylor writes, "the system boasted 23½ miles of track; today the company maintains 127 miles of road (a portion of which is plantation trackage); owns 22 locomotives, 44 passenger cars, and 520 freight cars; has 36,000 feet of wharfage, and can store 20,000 tons of sugar.

"Taxes on property from Ewa to Kahuku plantation, which are tapped by this railway, amounted at the time the road started to $28,853; in 1914 the taxes on the same property totaled $310,000. This is one example how the land along the line has increased in value in the last 20 years.



C. M. & St. P. Ry. Track Depression in Minneapolis, Fig. 9—View Looking Under a Series of Bridges from Colfax Ave.

A Large Track Depression Project at Minneapolis

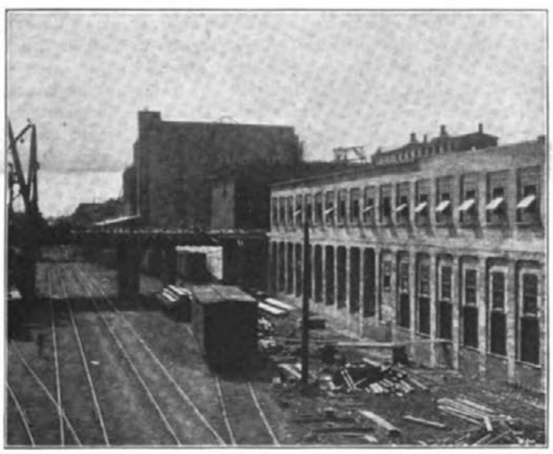
The Chicago, Milwaukee & St. Paul is Building Concrete Street Viaducts to Eliminate 37 Grade Crossings

By C. N. Bainbridge
Office Engineer, Chicago, Milwaukee & St. Paul, Chicago

One of the largest projects for the elimination of grade crossings recently undertaken is the depression of the tracks of the Hastings and Dakota division of the Chicago, Milwaukee & St. Paul through the southwest part of Minneapolis. With but few exceptions, the elimination of grade crossings in cities has been brought about by the elevation of the tracks and the depression of the streets. In the work described herein, these methods are reversed, i. e., the tracks are being depressed from 18 to 20 ft., and the streets are being elevated from 2 to 4 ft. and carried across the depression on bridges. Thirty-seven grade crossings are to be eliminated and the depression extends for approximately three miles.

Just prior to the completion of the Puget Sound extension from Mobridge to Seattle in 1909, the double tracking of the line from Minneapolis through Aberdeen to Mobridge was commenced and the grading has now been practically completed from Minneapolis to Aberdeen, with the exception of a short stretch at the eastern terminus, which is being constructed as fast as the track depression progresses.

In the latter part of December, 1910, the St. Paul was ordered by city ordinance to depress its tracks westward through the city from Hiawatha avenue to Irving avenue, and to carry over its tracks on bridges, all streets within these limits which crossed the right of way at grade. Previous to the passage of this ordinance, Fourth and Fifth avenues, which are located about midway of the depression, formed natural undercrossings with the tracks due to the topography of the site. The ordinance



A Building Being Underpinned by Concrete Columns

requires that the street which originally passed under the tracks at Fourth avenue shall be carried over the tracks on a viaduct. Fifth avenue, however, is a less important street, and the ordinance allows this to become a grade crossing, thereby avoiding considerable property damages. Hennepin avenue, situated at the west end of the depression, had previously (in 1897) been carried across the tracks and no further change was required.

Work was started at the west end early in 1912, and has been carried on continuously, with the exception of two or three months during the winter seasons. The project is now approximately 75 per cent completed, and it is the intention to complete the work in the fall of 1916.

The tracks which are to be depressed pass through a portion of the better residence district of Minneapolis and although numerous industries line the right of way for the greater part of the distance, it was desirable to have the finished work give as pleasing an effect as possible. Considerable attention was, therefore, given to the selection of the most suitable type of bridge. The tracks cross practically all of the streets at an angle of approximately 90 deg. and the right of way was of sufficient width throughout, with one or two exceptions, where additional land had to be bought, to adopt a uniform span bridge. Although there was some variation in the width of streets and roadways as required by the city, it was thought that probably unit construction (building slab and bent units at a central plant and lifting them into place) could be adopted. Accordingly designs were made and estimates and methods of erection were studied, but after due consideration, it was decided

A Shovel Taking a Third Cut

to abandon the idea of unit construction and build the structures in place, for the following reasons:

(1) About 50 per cent of the concrete in each bridge would have to be built in place in both bridges, of unit construction and those of monolithic construction. This would have required a movable plant for the abutments, as well as a stationary plant for the slabs and bents, if the structures had been built as units.

(2) Estimates showed that a larger yardage of concrete would be required in the unit than in the monolithic construction, as well as more steel, due to erection stresses and simple instead of continuous beam action.

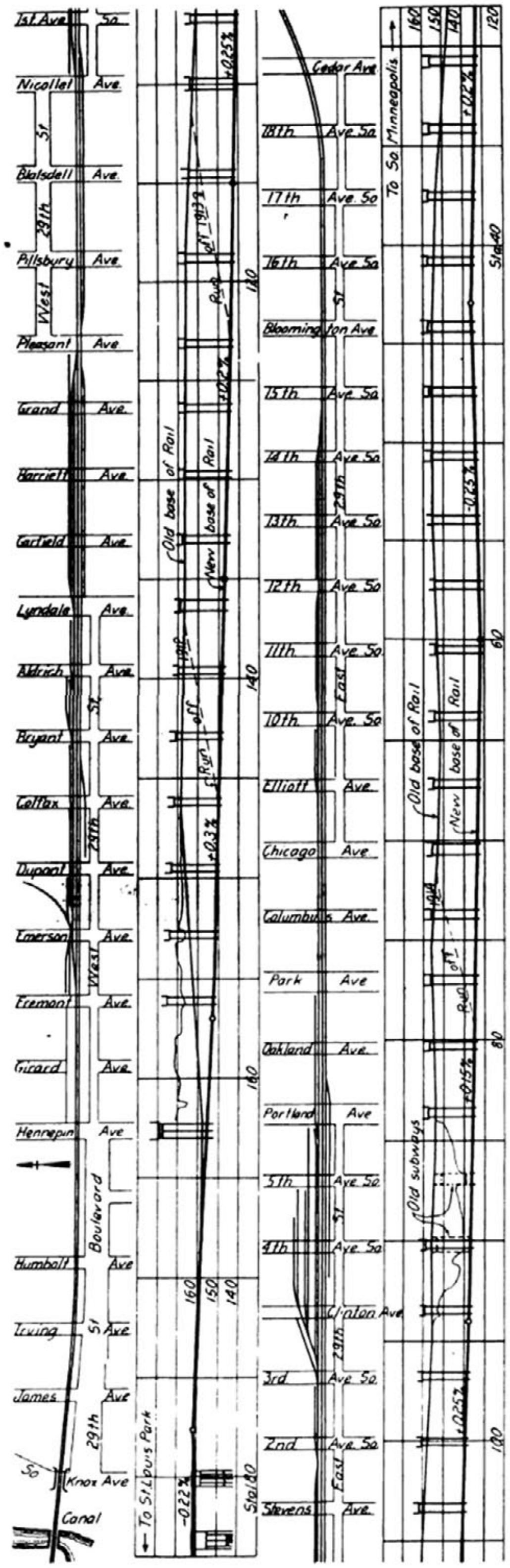
(3) The work would extend over three or four seasons, and in order to run the stationary plant efficiently, all the work on the different units would have to be done continuously, covering a period ot about nine months. This would have necessitated space for the storage of some of the slabs and bents for from one to two years, besides tying up a considerable amount of money for a long time before the structures would really be required.

(4) The mixing and placing of concrete would have been cheaper in the unit construction than it is in the monolithic construction, provided the stationary plant were run efficiently and a large number of the units were alike, so that the forms could have been used to advantage. It was estimated, however, that this difference in cost would be practically balanced by the additional yardage and additional cost of storing and erecting units after they were made.

(5) In the case of unit construction, it would have been necessary to know beforehand just how each crossing was to be treated, and no changes could have been made later without discarding units already made. The monolithic construction had the advantage over the unit construction in that it allows a modification of the bridges to meet local conditions up to the time each bridge is built.

(6) Owing to the excessive weight of the units, it would have been necessary to alter the heaviest erecting equipment of the railway in order that it might lift and swing these slabs into position. This would have prevented the use of the equipment for other work for two or three years.

(7) In the case of unit construction, there would have been occasion to interfere with traffic to a greater extent than with the monolithic



Layout and Profile of the Track Depression

construction. This would be caused by the hauling of the different units from the storage yard or plant to the bridge; shifting the position of the derrick car from one track to another, to facilitate the placing of the units; and, finally, the placing of the units themselves, which would weigh from 35 to 45 tons. These would have to be lifted and swung a considerable distance, making the chance of accident greater with the unit system than with the monolithic system.

BRIDGES

The type of structure finally adopted is that shown in the accompanying drawing. The bridges are of reinforced concrete and conform to a uniform design. On account of the various widths of roadways, the structures vary in width from 48 ft. to 68 ft. overall, including the roadway, two 8-ft. sidewalks and hand railings; and with the exception of two structures, they consist of three spans, the center one being 29 ft. 6 in., and the side spans 29 ft. in the clear. They are supported at the ends on abutments, and at the third points on skeleton piers or columns. This arrangement permits placing two main tracks under the center span. The side spans cover the slope of the cut where only two main tracks are depressed, but they are of sufficient width to allow the placing of two additional tracks on either side for industrial purposes or railway use, as conditions require, with the alteration of abutments only.

The two exceptions noted above, one at Fourth avenue and the other at Clinton avenue, are of 10 spans and 6 spans respectively, and carry those streets across a team yard which will be located about midway of the depression. Entrance to the team yard is to be made from Twenty-ninth street, which parallels the tracks, and also from Fifth avenue, which, as previously mentioned, is to become a grade crossing. The clearance over the main tracks is 18 ft. 6 in., and that over the side tracks or industry tracks is 18 ft.

The abutments used under these bridges are of three types:

(1) The small bank abutment used on bridges which do not make provisions for industry tracks under the side span.
(2) The intermediate height abutment, which is high enough to provide for one track under the side span.
(3) The high abutment, which is high enough to provide for two tracks under the side span.

The small bank abutments are of the ordinary gravity type. They are but 9 ft. high from bridge seat to foundation. The footing is 2 ft. thick, and the toe projects 12 in. beyond the neatwork. The abutments extend the full width of the street and have retaining walls, which extend back to the right of way line. They are built in two sections for the narrower streets, and in three sections for streets of 80- and 100-ft. widths. The intermediate height abutments are of the reinforced concrete counterfort type, and are 19 ft. high from bridge seat to foundation. The toe projects 3 ft. 6 in. beyond the face of abutment and the footing is stepped in the rear. Counterforts are provided every 12 ft. The high abutments are of the reinforced concrete counterfort type, and are 24 ft. 6 in. high from bridge seat to footing. The toe extends 4 ft. 6 in. in front of the abutment and is 3 ft. 6 in. deep. The base is stepped twice in the rear, the total width of base being 15 ft. 6 in. The bridge seat on all abutments is 18 in. wide, not including a 4-in. coping; 1:3:6 concrete was used in the gravity abutments, and 1:2½:5 concrete in the reinforced type.

The piers of the bridges are 25 ft. 6 in. high and consist of four, five or six columns, depending on the width of the bridges, and rest on spread footings of plain concrete. The columns are 2 ft. square, spaced about 11 ft. 6 in. center to center. The footings were poured in one run, reinforcing bars projecting about 4 ft. above the construction joint to form a splice with the main reinforcing steel in the columns. A key block 14 in. square is placed at the construction joint at the base of each column. The cross girders connecting the top of the columns are cast with the floor beams. These girders are 2 ft. thick and 4 ft. 6 in. deep and are joined to the columns by circular arches, which add materially to the strength and appearance of the structure. They are reinforced as a continuous beam with straight bars in the top and bottom and with stirrups and bent-up bars. The fillets or curved portion are reinforced with bars placed at 45 deg. The footings are of 1:3:6 plain concrete and the remainder of the bent is 1:2:4 concrete.

The accompanying illustration shows also the saddle which is used to protect the sewers crossing the right of way. This consists of an 8-in. layer of concrete forming an arch, reinforced with ¾-in. bars along the intrados and ½-in. bars along the extrados. A 1-in. layer of felt is placed between the concrete covering and the top of the sewer.

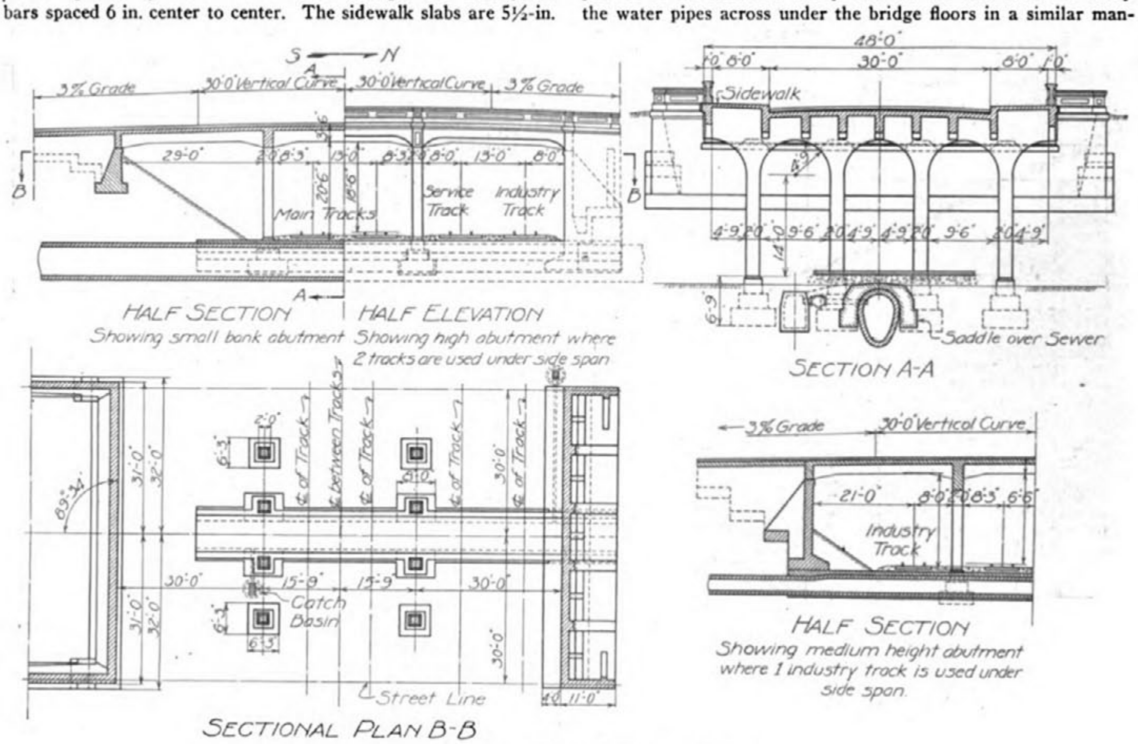
The floors of the bridges are of the T-beam type, are 3 ft. 6 in. deep, including 5 in. of paving, and are built continuous from abutment to abutment, a distance of 91 ft. 6 in., expansion joints being placed at the bridge seats. The stems of the beams under the roadway are 13 in. wide, spaced 5 ft. center to center. The sidewalk slab has a span of 8 ft. The outer beam under the sidewalk was given the form of three 3-centered arches for appearance. All other beams are straight on the bottom with fillets at the supports. The beams are figured as continuous for three spans and are reinforced with 1-in. and ¾-in. bars, part of which are bent up near the supports to provide for shear and negative moment over the supports. Vertical stirrups are also used in reinforcing for sheer. As a precaution against cracks, due to any unequal settlement which might occur at the abutments or piers, a small excess of steel is placed over the center supports and in the beams. The foundations are for the most part of good gravel, and, as the structures are designed for a bearing of only 2.5 tons per sq. ft. on the foundations, the danger of unequal settlement is slight.

The slabs between the T-beams vary in thickness from 6½ in. to 11 in., to provide for the crown of roadway and the grade on the bridge. They are reinforced with straight and bent ½-in. bars spaced 6 in. center to center. The sidewalk slabs are 5½-in. thick, have a 1-in. finishing coat on top, and are reinforced with ½-in. bent bars spaced 7 in. center to center. Concrete in the slabs, beams and cross girders is of 1:2:4 mix. A layer of 1:2 cement mortar is placed in the bottom of all beams and slabs to a sufficient depth to insure the covering of all bars before any concrete is poured. The hand rail is of the solid type reinforced concrete and is built in place, after the floor is completed.

Water and gas mains as well as numerous conduits of various utility companies were encountered at the majority of the streets. Ledges are provided on the side of the stems of adjacent T-beams to carry the conduits across the bridges. At first the gas and water mains were carried across the depression beneath the abutments and tracks. The cost of this, however, proved to be excessive and provisions are now made to carry the water pipes across under the bridge floors in a similar manner to that used for the conduits. A compressed fiber covering of about 3 in. in thickness is placed around the pipes, the fiber being moulded to fit the pipe. Wrought pipe with screw threads is used across the bridges in place of the usual cast iron pipe.

The bridges which do not carry street cars are designed to carry a moving concentrated load of 24 tons on two axles at

The Concrete Plant—A Temporary Foot Bridge in the Background



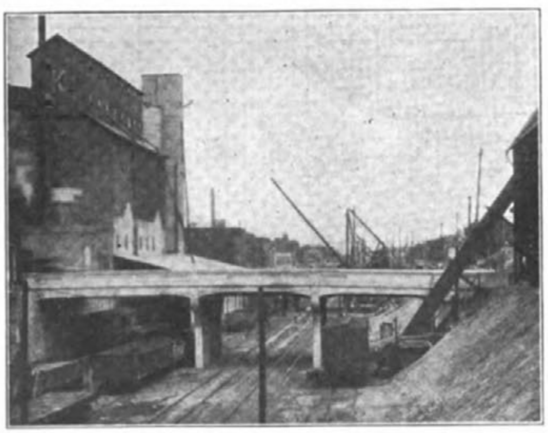
Typical Plan of Reinforced Concrete Viaducts

5-ft. gage and a load of 100 lb. per sq. ft. upon the remaining portion of the roadway. The six bridges which carry street cars are designed to carry two 40-ton cars and 100 lb. per sq. ft. upon the remaining portion of the roadway. The live loads are increased 50 per cent to provide for impact.

INDUSTRIES AND INDUSTRY TRACK FACILITIES

The majority of the industries are located on the north side of the tracks, Twenty-ninth street being adjacent to the right of way on the south side for nearly the full length of the depression. The presence of these industries introduced special problems and was the cause of considerable delay and numerous controversies.

The industrial concerns maintained that the railway company was liable for the cost of all changes to industries and industry tracks made necessary to continue service on the lower level after the main tracks had been depressed. The railway company, on the other hand, contended that the tracks were lowered by order of the city authorities as a measure of public safety, and not for the benefits, nor on the initiative of the railroad, and that therefore the industries should make any adjustments required at their own expense and also pay the cost of changing the tracks serving them. Litigation was avoided when the railway company decided, because of the many switches and the great amount of switching which would otherwise come off of the main track, to construct a third track from which to serve the industry spurs. As in practically all cases the right of way was only wide enough to depress two main tracks without resorting to retaining walls, the railway company contributed to the industries an amount approximately equivalent to what it would have had to expend to construct a retaining wall, within the right of way, adequate to provide for the third track, if the spur tracks were absent. The industries expended this money in altering their plants and providing the spur tracks, while the railroad was relieved from any further responsibility for retaining adjacent lands. Notwithstanding this decision of the railroad company, the result to the industries in providing



Elevation of a Typical Viaduct—Elevator for Raising Coal on the Right

themselves with industry tracks and adjusting their plants to the lower level, was a very large and burdensome expense, and it was also a large additionad burden to the railroad.

There are about 20 industries situated along the depression and no two were treated alike. Each industry required special treatment to meet the requirements of the particular situation. For the most part, each industry handled its work with its own engineers, although the railroad assisted to a considerable extent with suggestions. In some cases where the buildings were old and of little value, they were torn down and the entire property excavated to the new track level and new buildings constructed. Other concerns underpinned the buildings, and added shipping and receiving floors beneath, while still others allowed the slopes to extend under the building, supporting the buildings on skeleton framework. The accompanying photographs illustrate some of the methods used in solving the various problems.

CONSTRUCTION

The excavation work is being done with a 65-ton Bucyrus shovel, the material being removed by two trains of 20 standard gage 12-yd. air dump cars each. The excavated material varies from sand to gravel and is used largely for filling a site for a freight yard at Bass Lake, about nine miles from the depression, and also for taking out some sags in the main track immediately west of the work. The excavation for the abutments is made in many instances in advance of the shovel, the material being thrown in front of the abutment site and then loaded on cars as the shovel passes. Where this is impossible, material is loaded on wagons by hand and used for grading the street approaches to the bridges. Two train crews are employed to handle the cars to and from Bass Lake, each crew spotting its own cars at the shovel. A third crew and engine handle the cars at the yard, using a spreader.

In lowering the tracks, two methods were employed. The first 5,000 ft. of right of way is largely confined between private

A Building Underpinned by a Masonry Wall

property and was not of sufficient width to allow a temporary operating track to be constructed, without one or more shifts, while excavation to the final grade was being made. Excavation was consequently made in stages, the shovel making several cuts while the operating track was shifted several times to lower levels, before reaching its final position. The shovel worked in cuts of a length of about 2,500 ft., which is equivalent to about eight city blocks, with temporary run-offs to meet the original grade of the tracks on grades of from 2.5 to 3 per cent. On the remainder of the work, however, a temporary operating track was constructed along Twenty-ninth street, which is parallel and adjacent to the right of way. This permitted the shovel to operate in the cut unrestricted by regular train movements. After the shovel had started and was in operation, it was necessary to block traffic on seven or eight adjacent streets, until the excavation was completed to the final grade. A temporary timber bridge was then erected at one street to provide for street traffic until some one of the concrete bridges could be constructed and opened to traffic.

At the six streets where street car traffic had to be handled, a temporary bridge for street car traffic spanning the first cut of the shovel was constructed as soon as the shovel had made its first cut across the street. After the shovel passed through for the second time, however, street car traffic was discontinued across the cut and passengers were required to transfer from cars on one side of the cut to cars waiting on the other side, crossing the cut by steps leading down into the portion excavated in the first stages. As the shovel progressed and the cut became deeper, an overhead foot bridge was provided, which was lowered after each trip of the shovel, until on the approximate grade of the final bridge. The abutments for the bridges carrying street car traffic were, as a rule, in course of construction before street car traffic was discontinued, and the bridge was completed as soon as possible after service was discontinued.

For the first two seasons of work, stationary stiff leg derricks were erected at each bridge site at the original ground level and in such a position as to reach any portion of the structure. This allowed the derrick to be used in erecting the falsework, forms and reinforcing, and for placing the concrete for the whole bridge. During this last season, however, A-frame derricks fitted with hand crabs or hoists were used to erect the falsework and forms. The concrete was then placed from a portable concrete plant, traveling on the construction track at the low level. This consisted of a ½-yd. mixer of the drum type, mounted at the rear of a flat car. Following this was a track pile driver converted into an elevator, using the leads as guides for a specially designed ½-yd. dump bucket with the discharge door at the bottom of the forward side. The concrete was raised and then conveyed to the forms by chutes. The accompanying illustration shows the complete concreting plant in operation. Owing to the similarity of the bridges, unit forms are being employed to good advantage and are being used from three to five times with but slight alterations.

In all, there will be about 900,000 cu. yd. of material excavated about 33,000 cu. yd. of concrete and 900 tons of reinforcing bars will be required for the bridges, abutments and retaining walls.

According to usual practice on the St. Paul, the work is being done by company forces under the direction of C. F. Loweth, chief engineer. The plans are prepared under the direction of H. C. Lothholz, acting engineer of design, and the construction work is in charge of W. R. Powrie, district engineer, Minneapolis.

THE SHIPPING BILL

By W. L. Stoddard

Washington, Dec. 1

Signs are increasing that the fight for the shipping bill, which is to be one of the most important items in the Administration's program this winter, will be of more than cursory interest to the railroads. The congestion of freight in the east, due to lack of ships, is being used as an argument for government-owned freighters, and in a despatch from Washington early in the week, bearing all the marks of official inspiration, it is declared that the Interstate Commerce Commission, at the suggestion of the President, has been investigating ocean freight rates and the relations between rail carriers in the United States and trans-atlantic steamship companies. Some of the information thus collected, it is declared, reveals close relations between the land and sea carriers, "particularly in matters connected with through freight shipments from interior points to foreign ports. If power is granted to the shipping board to prescribe reasonable rates for steamship traffic, it probably would include the power to fix, possibly in conjunction with the Interstate Commerce Commission, joint through rates from the interior to ports in other countries."

In this connection it may be well to state that from interviews had with officers of the Administration who are in the thick of the work for the shipping bill, it would seem that the bill is almost certain to be received very favorably by Congress. During the last year, so the reports which come to Administration leaders have it, there has been a decided change of sentiment for the measure, and in spite of the opposition, traceable to the foreign shipowners and those who are constitutionally against government ownership, the President's pet scheme will have pleasant, if not absolutely successful, sailing in Congressional waters.

George W. Norris, former director of wharves at Philadelphia, made a statement here the other day which was issued by the Democratic committee as part of the propaganda for the shipping bill. "The conditions which exist in ocean transportation," said Mr. Norris, "and the theory upon which government intervention must be justified, are so wholly different from the railroad situation that there can be neither analogy nor comparison between the two. Moreover, as the government intervention would probably be temporary—ultimately yielding the field to private capital—and would probably show a balance on the wrong side of the ledger, the opponents of government ownership of railroads should rather welcome the experiment as likely to prove an illuminating object-lesson."

Interesting comments on the proposed shipping bill from a New England railroad man, E. D. Codman, former president of the Fitchburg Railroad, are contained in an interview, which is here presented for the first time. Mr. Codman believes that the government merchant marine line offers the only means of overcoming the discrimination enforced by the "shipping pool" against Atlantic seaboard ports.

His statement follows:

"Because I see no other way of relieving Boston of the burden of discrimination laid upon her commerce by the foreign-owned shipping pool, I feel I can endorse the idea of placing in commission a government-owned merchant marine. This government-owned service would seem to be able to deal with the present situation by establishing a fair transportation rate between here and Europe. At the same time it would give ports such as Boston a chance to enter on equitable terms the competition for the trade of South America.

"Take, for example, the rates from this port to Liverpool. We are so much nearer Liverpool than is New York to that English port, that a vessel can make a little better than eleven trips from Boston to Liverpool and back while she would be making ten trips from New York to Liverpool and back. Applied to freight rates, that saving in time should make a difference in our favor, and applied to passengers it should amount to enough to pay a $5 fare from New York to Boston on a first-class passenger.

"Yet under the conditions established by the shipping combine on the Atlantic, the railroads carrying a shipment from Chicago to be sent to Liverpool are allowed practically only the same amount to deliver that shipment on the docks in Boston as to deliver it on the pier in New York. On both exports and imports the rates allowed the railroads are so low as to afford only a slight profit. The fact that there is less profit in bringing shipments by rail to Boston than to New York discourages the railroads from developing their service here. Boston is the victim of this discrimination. Only when her ocean rates to Europe are readjusted on a basis of the shorter distance can she hope to get a fair chance at the export business. The trouble lies in the fact that the foreign-controlled shipping pool has arbitrary control of the rates.

"If the United States government will build and operate, or control the operation of, a merchant marine that will enter upon the task of correcting this injustice, the whole country will be the gainer. The public loses whenever rates are fixed on any other basis than that of a fair price for the service rendered, as in the case of ocean freight transportation. Let the government put on a line of ships temporarily, and the shipping pool will have to meet the rates which a government board shall determine are fair for the distance from Boston to Liverpool.

"I do not believe in government ownership of shipping where private capital can and does render equal service for a fair price. But I do believe that where private capital is so combined, and under control so far removed from the action of public opinion, as is the case with our trans-Atlantic shipping, and where it fails so notably to render to the public a reasonable service at a fair price, the government should step in with its own corrective power. The corrective power in this instance is not the legal regulation of the rates to be charged by the privately owned lines, but the temporary establishing of a shipping line which will set the desired standard of service.

"Boston will be the gainer if this is done."

APPENDIX C – Glossary

Glossary

Abutment – Component of bridge substructure at either end of bridge that transfers load from superstructure to foundation and provides lateral support for the approach roadway embankment.

Appraisal ratings – Five National Bridge Inventory (NBI) appraisal ratings (structural evaluation, deck geometry, under-clearances, waterway adequacy, and approach alignment, as defined below), collectively called appraisal ratings, are used to evaluate a bridge's overall structural condition and load-carrying capacity. The evaluated bridge is compared with a new bridge built to current design standards. Ratings range from a low of 0 (closed bridge) to a high of 9 (superior). Any appraisal item not applicable to a specific bridge is coded N.

Approach alignment – One of five NBI inspection ratings. This rating appraises a bridge's functionality based on the alignment of its approaches. It incorporates a typical motorist's speed reduction because of the horizontal or vertical alignment of the approach.

Character-defining features – Prominent or distinctive aspects, qualities, or characteristics of a historic property that contribute significantly to its physical character. Features may include structural or decorative details and materials.

Condition, fair – A bridge or bridge component of which all primary structural elements are sound, but may have minor deterioration, section loss, cracking, spalling, or scour.

Condition, good – A bridge or bridge component which may have some minor deficiencies, but all primary structural elements are sound.

Condition, poor – A bridge or bridge component that displays advanced section loss, deterioration, cracking, spalling, or scour.

Condition rating – Level of deterioration of bridge components and elements expressed on a numerical scale according to the NBI system. Components include the substructure, superstructure, deck, channel, and culvert. Elements are subsets of components, e.g., piers and abutments are elements of the component substructure. The evaluated bridge is compared with a new bridge built to current design standards. Component ratings range from 0 (failure) to 9 (new) or N for (not applicable); elements are rated on a scale of 1-3, 1-4 or 1-5 (depending on the element type and material). In all cases condition state 1 is the best condition with condition state 3, 4 or 5 being the worst condition. In rating a bridge's condition, MnDOT pairs the NBI system with the newer and more sophisticated Pontis element inspection information, which quantifies bridge elements in different condition states and is the basis for subsequent economic analysis.

Corrosion – The general disentegration of metal through oxidation.

Cutwater – The wedge-shaped end of a bridge pier, designed to divide the current and break up ice.

Decay – Deterioration of wood as a result of fungi feeding on its cell walls.

Delamination – Surface separation of concrete, steel, glue laminated timber plies etc. into layers.

Deck geometry – One of five NBI appraisal ratings. This rating appraises the functionality of a bridge's roadway width and vertical clearance, taking into account the type of roadway, number of lanes, and ADT.

Deficiency – The inadequacy of a bridge in terms of structure, serviceability, and/or function. Structural deficiency is determined through periodic inspections and is reflected in the ratings that are assigned to a bridge. Service deficiency is determined by comparing the facilities a bridge provides for vehicular, bicycle, and pedestrian traffic with those that are desired. Functional deficiency is another term for functionally obsolete (see below). Remedial activities may be needed to address any or all of these deficiencies.

Deficiency rating – A nonnumeric code indicating a bridge's status as structurally deficient (SD) or functionally obsolete (FO). See below for the definitions of SD and FO. The deficiency rating status may be used as a basis for establishing a bridge's eligibility and priority for replacement or rehabilitation.

Design exception – A deviation from federal design and geometric standards that takes into account environmental, scenic, aesthetic, historic, and community factors that may have bearing upon a transportation project. A design exception is used for federally funded projects where federal standards are not met. Approval requires appropriate justification and documentation that concerns for safety, durability, and economy of maintenance have been met.

Design load – The usable live-load capacity that a bridge was designed to carry, expressed in tons according to the AASHTO allowable stress, load factor, or load resistance factor rating methods. An additional code was recently added to assess design load by a rating factor instead of tons. This code is used to determine if a bridge has sufficient strength to accommodate traffic load demands. A bridge that is posted for load restrictions is not adequate to accommodate present or expected legal truck traffic.

Deterioration – Decline in condition of surfaces or structure over a period of time due to chemical or physical degradation.

Efflorescence – A deposit on concrete or brick caused by crystallization of carbonates brought to the surface by moisture in the masonry or concrete.

Extant – Currently or actually existing.

Extrados – The upper or outer surfaces of the voussoirs which compose the arch ring. Often contrasted with intrados.

Footing – The enlarged, lower portion of a substructure which distributes the structure load either to the earth or to supporting piles.

Fracture Critical Members – Tension members or tension components of bending members (including those subject to reversal of stress) whose failure would be expected to result in collapse of the bridge.

Functionally obsolete – The Federal Highway Administration (FHWA) classification of a bridge that does not meet current or projected traffic needs because of inadequate horizontal or vertical clearance, inadequate load-carrying capacity, and/or insufficient opening to accommodate water flow under the bridge. An appraisal rating of 3 or less for deck geometry, underclearance, approach alignment, structural evaluation or waterway adequacy will designate a bridge as functionally obsolete.

Gusset plate – A plate that connects the horizontal and vertical members of a truss structure and holds them in correct position at a joint.

Helicoidal – Arranged in or having the approximate shape of a flattened coil or spiral.

Historic fabric – The material in a bridge that was part of original construction or a subsequent alteration within the historic period of the bridge (i.e., more than 50 years old). Historic fabric is an important part of the character of the historic bridge and the removal, concealment, or alteration of any historic material or distinctive engineering or architectural feature should be avoided if possible. Often, the character-defining features include important historic fabric. However, historic fabric can also be found on other elements of a bridge that have not been noted as character-defining.

Historic bridge – A bridge that is listed in, or eligible for listing in, the National Register of Historic Places.

Historic integrity – The authenticity of a bridge's historic identity, evidenced by the survival and/or restoration of physical characteristics that existed during the bridge's historic period. A bridge may have integrity of location, design, setting, materials, workmanship, feeling, and association.

Inspections – Periodic field assessments and subsequent consideration of the fitness of a structure and the associated approaches and amenities to continue to function safely.

Intrados – The innner or lower surface of an arch. Often contrasted with extrados.

Inventory rating – The load level a bridge can safely carry for an indefinite amount of time expressed in tons or by the rating factor described in design load (see above). Inventory rating values typically correspond to the original design load for a bridge without deterioration.

Keystone – Wedge-shaped stone, or voussoir, at the crown of an arch.

Load Rating – The determination of the live load carrying capacity of a bridge using bridge plans and supplemented by field inspection.

Maintenance – Work of a routine nature to prevent or control the process of deterioration of a bridge.

Minnesota Historical Property Record – A documentary record of an important architectural, engineering, or industrial site, maintained by the Minnesota Historical Socitety as part of the state's commitment to historic preservation. MHPR typically includes large-format photographs and written history, and may also include historic photographs, drawings, and/or plans. This state-level documentation program is modeled after a federal program known as the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER).

National Bridge Inventory – Bridge inventory and appraisal data collected by the FHWA to fulfill the requirements of the National Bridge Inspection Standards (NBIS). Each state maintains an inventory of its bridges subject to NBIS and sends an annual update to the FHWA.

National Bridge Inspection Standards – Federal requirements for procedures and frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of state bridge inventories. NBIS applies to bridges located on public roads.

National Register of Historic Places – The official inventory of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture, which is maintained by the Secretary of the Interior under the authority of the National Historic Preservation Act of 1966 (as amended).

Non-vehicular traffic – Pedestrians, non-motorized recreational vehicles, and small motorized recreational vehicles moving along a transportation route that does not serve automobiles and trucks. Includes bicycles and snowmobiles.

Operating rating – Maximum permissible load level to which a bridge may be subjected based on a specific truck type, expressed in tons or by the rating factor described in design load (see above).

Pack rust – Rust forming between adjacent steel surfaces in contact which tends to force the surfaces apart due to the increase in steel volume.

Pier – A substructure unit that supports the spans of a multi-span superstructure at an intermediate location between its abutments.

Pointing – The compaction of mortar into the outermost portion of a joint and the troweling of its exposed surface to secure water tightness and/ or desired architectural effect (when replacing deteriorated mortar).

Pony truss – A through bridge with parallel chords and having no top lateral bracing over the deck between the top chords.

Posted load – Legal live-load capacity for a bridge which is associated with the operating rating. A bridge posted for load restrictions is inadequate for legal truck traffic.

Pontis – Computer-based bridge management system to store inventory and inspection data and assist in other bridge data management tasks.

Preservation – Preservation, as used in this report, refers to historic preservation that is consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties*. Historic preservation means saving from destruction or deterioration old and historic buildings, sites, structures, and objects, and providing for their continued use by means of restoration, rehabilitation, or adaptive reuse. It is the act or process of applying measures to sustain the existing form, integrity, and material of a historic building or structure, and its site and setting. MnDOT's *Bridge Preservation, Improvement and Replacement Guidelines* describe preservation differently, focusing on repairing or delaying the deterioration of a bridge without significantly improving its function and without considerations for its historic integrity.

Preventive maintenance – The planned strategy of cost-effective treatments that preserve a bridge, slow future deterioration, and maintain or improve its functional condition without increasing structural capacity.

Reconstruction – The act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location. Activities should be consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.*

Rehabilitation – The act or process of returning a historic property to a state of utility through repair or alteration which makes possible an efficient contemporary use, while preserving those portions or features of the property that are significant to its historic, architectural, and cultural values. Historic rehabilitation, as used in this report, refers to implementing activities that are consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties*. As such, rehabilitation retains historic fabric and is different from replacement. MnDOT's *Bridge Preservation, Improvement and Replacement Guidelines* describe rehabilitation and replacement in similar terms.

Restoration – The act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time. Activities should be consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.*

Ring stone – One of the separate stones of an arch that shows on the face of the headwall, or end of the arch. Also known as a voussoir.

Scaling – The gradual distentegration of a concrete surface due to the failure of the cement surface caused by chemical attack or freeze-thaw cycles or rebar too close to the surface and oxidizing from exposure to chlorides.

Scour – Removal of material from a river's bed or bank by flowing water, compromising the strength, stability, and serviceability of a bridge.

Scour critical rating – A measure of a bridge's vulnerability to scour (see above). MnDOT utilizes letter designations to represent specific descriptions of a bridges susceptibility and/ or present condition in regards to scour. Range in condition and scour susceptibility does not necessarily correlate alpha numerically to the

MnDOT scour code letters so it is important to understand the specifc scour description for each MnDOT scour code. The scour codes and descriptions can be found in the "MNDOT Bridge Inspection Field Manual".

Section loss – Loss of a member's cross sectional area and resulting strength usually by corrosion or decay.

Serviceability – Level of facilities a bridge provides for vehicular, bicycle, and pedestrian traffic, compared with current design standards.

Smart flag – Special Pontis inspection element used to report the condition assessment of a deficiency that cannot be modeled, such as cracks, section loss, and steel fatigue.

Spall – Depression in concrete caused by a separation of a portion of the surface concrete, revealing a fracture parallel with or slighty inclined to the surface.

Spring line – The imaginary horizontal line at which an arch or vault begins to curve. As example, the point of transition from the vertical face of an abutment to the start of arch curvature extending from abutment face.

Stabilization – The act or process of stopping or slowing further deterioration of a bridge by means of making minor repairs until a more permanent repair or rehabilitation can be completed.

Stringcourse – A horizontal band of masonry, generally narrower than other courses and sometimes projecting, that extends across the structure's horizontal face as an architectural accent. Also known as belt course.

Structural evaluation – Condition rating of a bridge designed to carry vehicular loads, expressed as a numeric value and based on the condition of the superstructure and substructure, the inventory load rating, and the ADT.

Structurally deficient – Classification indicating NBI condition rating of 4 or less for any of the following: deck condition, superstructure condition, substructure condition, or culvert condition. A bridge is also classified as structurally deficient if it has an appraisal rating of 2 or less for its structural evaluation or waterway adequacy.. A structurally deficient bridge is restricted to lightweight vehicles; requires immediate rehabilitation to remain open to traffic; or requires maintenance, rehabilitation, or replacement.

Sufficiency rating – Rating of a bridge's structural adequacy and safety for public use, and its serviceability and function, expressed on a numeric scale ranging from a low of 0 to a high of 100. It is a relative measure of a bridge's deterioration, load capacity deficiency, or functional obsolescence. MnDOT may use the rating as a basis for establishing eligibility and priority for replacement or rehabilitation. Typically, bridges which are structurally deficient and have sufficiency ratings between 50 and 80 are eligible for federal rehabilitation funds and those which are structurally deficient with sufficientcy ratings of 50 and below are eligible for replacement.

Through truss – A bridge with parallel top and bottom chords and top lateral bracing with the deck generally near the bottom chord.

Under-clearances – One of five NBI appraisal ratings. This rating appraises the suitability of the horizontal and vertical clearances of a grade-separation structure, taking into account whether traffic beneath the structure is one- or two-way.

Variance – A deviation from State Aid Operations Statute Rules that takes into account environmental, scenic, aesthetic, historic, and community factors that may have bearing upon a transportation project. A design variance is used for projects using state aid funds. Approval requires appropriate justification and documentation that concerns for safety, durability and economy of maintenance have been met.

Vehicular traffic – The passage of automobiles and trucks along a transportation route.

Voussoir – One of the separate stones forming an arch ring; also known as a ring stone.

Waterway adequacy – One of five NBI appraisal ratings. This rating appraises a bridge's waterway opening and passage of flow under or through the bridge, frequency of roadway overtopping, and typical duration of an overtopping event.

APPENDIX D – Guidelines for Bridge Maintenance and Rehabilitation based on the Secretary of the Interior’s Standards

The Secretary's Standards with Regard to Repair, Rehabilitation, and Replacement Situations

Adapted from:
Clark, Kenneth M., Grimes, Mathew C., and Ann B. Miller, *Final Report, A Management Plan for Historic Bridges in Virginia*, Virginia Transportation Research Council, 2001.

The Secretary of the Interior's Standards for the Treatment of Historic Properties, first codified in 1979 and revised in 1992, have been interpreted and applied largely to buildings rather than engineering structures. In this document, the differences between buildings and structures are recognized and the language of the Standards has been adapted to the special requirements of historic bridges.

1. Every reasonable effort shall be made to continue an historic bridge in useful transportation service. Primary consideration shall be given to rehabilitation of the bridge on site. Only when this option has been fully exhausted shall other alternatives be explored.

2. The original character-defining qualities or elements of a bridge, its site, and its environment should be respected. The removal, concealment, or alteration of any historic material or distinctive engineering or architectural feature should be avoided.

3. All bridges shall be recognized as products of their own time. Alterations that have no historic basis and that seek to create a false historic appearance shall not be undertaken.

4. Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.

5. Distinctive engineering and stylistic features, finishes, and construction techniques or examples of craftsmanship that characterize an historic property shall be preserved.

6. Deteriorated structural members and architectural features shall be retained and repaired, rather than replaced. Where the severity of deterioration requires replacement of a distinctive element, the new element should match the old in design, texture, and other visual qualities and where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.

7. Chemical and physical treatments that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the most environmentally sensitive means possible.

8. Significant archaeological and cultural resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.

9. New additions, exterior alterations, structural reinforcements, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.

10. New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

APPENDIX E – Design Exceptions and Variances for Historic Bridges prepared by MnDOT CRU in collaboration with MnDOT Bridge (2013)

DESIGN EXCEPTIONS AND VARIANCES ON HISTORIC BRIDGES: EFFECTIVE APPLICATION AND UTILIZATION GUIDELINES

INTRODUCTION

This document provides guidance on design exception and variance considerations on historic bridges projects (i.e., projects on bridges eligible for or listed in the National Register of Historic Places). Mn/DOT recognizes that historic bridges represent the Department's transportation engineering accomplishments, and that their preservation is important. These guidelines are meant to aid in the preservation of our engineering heritage.

Mn/DOT's Cultural Resources Unit (CRU) maintains the list of historic bridges in the state, and CRU should be contacted prior to any planning on a bridge project to determine if the bridge involved is historic.

Federal and state laws provide certain protections for bridges determined to have historic significance. For example, Section 4(f) of the USDOT Act of 1966 does not allow FHWA to fund a project that "uses" (i.e., impacts) a historic bridge unless there is no "feasible and prudent alternative". Because of these protections, if work needs to occur on a historic bridge, the preferred alternative of rehabilitation of the structure must be considered before all other alternatives. If the results of the rehabilitation study show that the there is a feasible and prudent rehabilitation alternative that meets the project's purpose and need, the rehabilitation option will be selected. Cost is merely one aspect of the prudence determination. It is not considered until after feasibility has been determined and *all* other aspects of prudence have been evaluated. If there is not a feasible and prudent rehabilitation alternative or a feasible and prudent avoidance alternative, then the preferred alternative will become replacement. However, whenever an historic bridge is replaced, federal preservation law will require negotiation of appropriate mitigation measures, such as relocating the historic bridge. Also, for state-funded projects, the Minnesota Historic Sites Act requires that agencies consult with the Minnesota Historical Society before undertaking or licensing projects that may affect properties listed in the State or National Registers of Historic Places.

PURPOSE AND NEED

The first step in any project is identifying what the transportation problem is that needs to be addressed. The NEPA process requires that a project clearly state what the transportation issue is, and identify a solution that avoids impacting a variety of resources (including historic bridges) through an alternatives analysis.

Because it is crucial to begin a project involving a historic bridge with an appropriate purpose and need statement, the project proposer must submit a draft purpose and need statement and information on which alternatives will be analyzed for each project involving a historic bridge. For Trunk Highway projects, the information must be submitted to the head of the Environmental Assessment Unit in Mn/DOT's Office of Environmental Services; and for State Aid projects, to the State Aid Project Development Engineer for federal projects. These respective groups will forward the information to FHWA. The purpose and need and alternatives can change over time as new information is obtained during the study, but a general agreement must be obtained between the project proposer and FHWA prior to in-depth CRU involvement.

While it is not possible to develop a standard purpose and need statement that will apply to all historic bridge projects, often, a statement such as the following will be an adequate P&N:

- *The purpose of this project is to provide a structurally sound crossing of the [Feature] for [both] motorized [and non-motorized] traffic.*

Statements that are not be included in the P&N statement:

- "The purpose of the project is to replace Bridge 0123."
- "The purpose of the project is to have a structure with a 75 year life span."
  - Design life is not the purpose for doing a project – it is just a consideration for the investment on a new structure.
- "The purpose of the project is to eliminate this fracture critical structure (or, "…to have a non-fracture-critical structure")"
  - There are many safe, functioning fracture-critical bridges in the state and nation. There is no federal guidance that says fracture critical bridges must be removed; therefore, it is not the purpose for doing a project.
- "The purpose of the project is to remove an unsafe bridge" (or "to build a safe bridge")
  - Safety should not be mentioned **unless** there is a documented history of safety issues. Safety issues cannot be expressed as a nebulous statement that the old bridge is not safe. Rather, safety concerns need to be supported through accident data that can directly tie an element on the bridge to the accidents.
- "The purpose of this project is to meet current design standards."
  - It is important to note that rehabilitation may have different standards that new bridge projects. The purpose of a project is not to meet new standards. Rather, the engineer meets whatever standards are required for the level of necessary work, OR the engineer is expected to get a design exception (for State jobs) or variance (for local jobs). Typically, statements about meeting design elements (such as ADA) or other federal requirements do not belong in a P&N statement – those are items that all projects must comply with, it is not the reason for doing the project.

For historic bridge projects, the rehabilitation alternative needs to be the main alternative studied. If rehabilitation is the selected preferred alternative, there will likely be no mitigation under Section 106 and no Section 4(f) issues.

BACKGROUND

The Federal Highway Administration (FHWA), State Historic Preservation Office (SHPO), Advisory Council on Historic Preservation (ACHP), the U.S. Army Corps of Engineers (USACE) and Mn/DOT signed a Programmatic Agreement (PA) in 2008 to substantially streamline the historic review process on bridge projects for bridges built prior to 1956. By establishing strict criteria for which bridges are significant, only a small percent of the total bridge population in the state were deemed historic. It was agreed that higher level of commitment would be given to select state-owned historic bridges, and that the Department would advocate for and assist in the preservation of historic bridges on the local system. In order to successfully preserve historic bridges, the following stipulation was included in the PA:

> **"STIPULATION 4. USE OF DESIGN EXEMPTIONS AND VARIANCES**
> Context Sensitive Solutions (CSS) is an integral part of FHWA and Mn/DOT projects. CSS is a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist. CSS principles include the employment of early, continuous and meaningful involvement of the public and all stakeholders throughout the project development process. The implementation of a CSS approach to navigating the project development process will ensure the best possible outcome to the process. Therefore, FHWA and Mn/DOT strongly encourage the development of historic bridge projects in a context sensitive manner, including the use of design exceptions and variances when practical.

A. Within one (1) year of the signing of this Agreement, Mn/DOT will develop and distribute guidelines on how to effectively apply and utilize design exceptions and variances on historic bridges. This document will be distributed to all Mn/DOT districts and offices and local agencies within three (3) months of its completion, and will be used in reviewing projects on historic bridges."

This document fulfills the above-referenced definition by including information on design exceptions and variances, as per the terms of the PA.

DESIGN EXCEPTIONS AND VARIANCES

The preservation of a historic bridge and its character-defining features through the use of a design exception and variance can be an appropriate application. Design exceptions and variances should consider the effect of the design deviation on the safety and operation of the structure, and its compatibility with adjacent sections of roadway. If there is a documented history of safety concerns on a bridge and it is directly related to an element for which a design exception or variance is being considered, there could be difficulty in obtaining a design exception or variance. However, if there are no documented safety issues related to the items for which the exception or variance is being sought or if safety concerns can be effectively mitigated, then a design exception or variance should be pursued in spirit of stewardship to the historic nature of the bridge.

PROCESS FOR OBTAINING A DESIGN EXCEPTION

Design exception requests should be discussed collaboratively with District Management, the State Bridge Engineer, the Bridge Office, the State Geometrics Engineer (and the State Design Engineer, as needed), Mn/DOT's Cultural Resources Unit, and the FHWA. Design exceptions should be documented in the Design Memo including a complete description and a thorough justification for each exception. If a design exception is identified after the Design Memo has been completed and approved, submit an addendum to the Design Memo. For more information on processing a design exception, see "Design Standards and Exceptions – Submittal Steps for Design Exceptions" in Mn/DOT's Highway Project Development Process (HPDP) guidance. For specifics on how to complete a design exception, please see: http://www.dot.state.mn.us/design/geometric/formal-design.html
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PROCESS FOR OBTAINING A DESIGN VARIANCE FOR LOCAL PROJECTS

It is anticipated that most historic bridge rehabilitation projects will occur with federal funds and no state aid funding, making the need for a local variance unlikely. However, if state aid funds are used, information on how to obtain a design variance can be found at http://www.dot.state.mn.us/stateaid/manual/sam07/chapter1/1-7.html

CRITICAL GEOMETRIC DESIGN CRITERIA

It is recognized that criteria spelled out in various manuals (Mn/DOT and State Aid Standards, the AASHTO Green Book, the Road Design Manual, etc.) are not all typically achieved with a bridge rehabilitation project. However, these standards need to be considered during the development process and design exceptions or variances from these standards should be pursued if it can be shown that there are minimal documented safety issues, or safety concerns can be effectively mitigated.

Despite the range of flexibility that exists with respect to virtually all the major road design features, there are situations in which the application of even the minimum criteria would result in unacceptably high costs or major impact on the adjacent environment. For such instances when it is appropriate, the design exception and variance process allows for the use of criteria lower than those specified as minimum acceptable values in the Green Book.

If the highway project is not on the NHS and is not a full federal oversight project, the State does not need FHWA approval for a design exception. For projects on NHS routes, FHWA requires that all exceptions from accepted guidelines and policies be justified and documented in some manner and requires formal approval for the 13 specific controlling criteria (listed in the "Design Exceptions" guidance document referenced in an earlier section above). The State Design Engineer approves design exceptions for State-administered projects on the NHS and State/local administered Federal-aid projects off of the NHS. The State Design Engineer *and* FHWA approve all design exceptions for full Federal oversight projects.

The following section was taken from *Guidelines for Historic Bridge Rehabilitation and Replacement* by Lichtenstein Consulting Engineers and Parsons Brinkerhoff (2007).

ANALYSIS OF GEOMETRY AND SAFETY FEATURES

This step provides guidance on how geometric and safety-feature data needs to be analyzed to determine if deficiencies can be brought into conformance with current standards/guidelines in a feasible and prudent manner without adversely affecting what makes the bridge historic. When working with historic bridges, geometry and safety-feature deficiencies often prove to be the most challenging to solve.

For a bridge to continue in use, it must be geometrically (functionally) adequate and safe. Geometric adequacy includes consideration of the number of travel lanes, roadway width, shoulder width, approach roadway width, vertical clearance over the roadway, under-clearances, horizontal clearances, sight distances across the bridge and at the approaches, proximity to intersections and the functional classification of roadways carried and any crossed. Safety features include the crashworthiness of guide rail and railing systems based on their capability to effectively redirect an errant vehicle and to safely stop it in a controlled manner.

Two parameters that are used to evaluate the geometric adequacy of a bridge are the functional classification of the roadway, which is based on whether it serves as an arterial, collector or local road and whether the setting is urban or rural, and the average daily traffic (ADT) count. The ADT also considers the percentage of that count that is truck traffic. Traffic volume affects historic bridges because they are often geometrically inadequate for today's usage demands. Since geometric adequacy is defined by the characteristics of the traffic serviced, ADT is an important consideration affecting the required number and width of lanes, shoulder widths, and roadway alignment. These parameters are often used together to set minimum acceptable geometric guidelines and standards.

Bridges with geometry or safety features that do not meet current design standards are classified as functionally obsolete. However, a bridge classified as functionally obsolete because it does not meet current guidelines should not automatically be considered unsafe and in need of replacement. Many functionally obsolete bridges perform adequately. For those instances, a design exception for width should be considered and used if it is appropriate. Design exceptions are based on in-depth studies that include data such as accident history, travel speed, etc., to support using a lesser design criteria. Under certain conditions, a reduced roadway width can be justified.

Geometry on Very Low Volume Local Roads

To account for the correlation between lower traffic volume and lack of accidents caused by substandard geometry, AASHTO in its 2001 *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT <400)* established geometric guidelines that are now part of its *A Policy on Geometric Design of Highways and Streets* (5th edition, 2004). The very low-volume local road guidance uses risk assessment in determining roadway and bridge width adequacy by weighing the cost effectiveness of the work against "substantial safety improvements." The AASHTO guidelines state that "existing bridges can remain in place without widening unless there is evidence of site-specific safety problems related to the width of the bridge." Based on this guidance, if the bridge is on a local road, is performing well, and is structurally adequate, it probably has rehabilitation potential. This policy supports and reinforces earlier guidance from AASHTO that a certain level of flexibility, when applied to bridges on low-volume roads, would allow lesser design values based on specific, minimal, "tolerable" criteria. Bridges that are functioning adequately now, and can be considered to do the same into the future with appropriate maintenance, are considered to have rehabilitation potential even though they do not meet current standards.

Many states have adopted their own bridge and roadway geometric policies for various classifications of highways. These policies are considered to be a starting point for bridge widths. Additionally, width of the approach roadways and their continuity with the bridge roadway width can be an important consideration that may affect the definition of "tolerable" and thus rehabilitation potential. If the bridge roadway width is equal to that of the approaches and neither the bridge roadway width or approach roadway width meet current design requirements, the bridge may still be a candidate for rehabilitation until such time as the approach roads are also upgraded and as long as other considerations, like accident history, demonstrate adequate safety performance. This concept is being used increasingly by state DOTs to "right-size" projects.

Using Accident History to Understand Deficiencies

Accident reports are an extremely useful source of specific information about what geometric features of the bridge, if any, are problematic. It is important to review specific accident reports to determine what types of accidents are attributable to the bridge itself, including its geometric characteristics and its safety features. The reports are generally compiled by highway segment, not for a bridge alone, so accidents may not be related to bridge deficiencies. A nearby intersection, for instance, may have turning movement-related accidents. Since the intersection and bridge share a common highway segment, all accidents will be reported with the bridge, which may in fact be functioning adequately. The review of accident reports will also assist with assessing risk management.

Considerations for Improving Geometry and Safety Problems

Common problems associated with geometry and safety are many and include bridge width, shoulder width, clearances, stopping sight distances (or vertical and horizontal alignment of the approaches that results in insufficient stopping sight distances), superelevation, proximity to intersections, and railing/barrier design. Additionally, there can be safety problems related to substandard geometry and roadside features at the ends of the bridge, like the blunt ends of superstructures above the roadway, lack of a proper barrier system (length, inadequate transition, inadequate attachment to the bridge railing), and crashworthiness of bridge railings.

While not comprehensive, the following are important questions to consider. The relevance of particular questions will vary depending on site constraints.

- Can a bridge be widened without adversely affecting its scale?
- Can the vertical clearance be increased to remain in scale with the bridge and not have an adverse effect?
- Does the original design make it possible to consider adding cantilevered deck sections? Can sidewalks be cantilevered from the superstructure?
- Can substandard approaches be improved to an acceptable level using techniques like adding shoulders, flattening curves, flattening side slopes, adding superelevation, removing hazardous features, etc.?
- Likewise, can sight distance be improved?
- Can any sidewalks be eliminated to provide more roadway width?
- Can signals or signage be installed to control alternating flow of traffic on a low-volume road?
- When the proposed improvement is for a highway or street that is already substandard, can minimally acceptable standards/guidelines be used?
- Can custom or context-based railings appropriate for the bridge type and setting be used?
- Can a crashworthy traffic barrier be placed at the curb line, and the historic railing retained?
- Would a design exception result in maintaining the [historic integrity of the] historic bridge and meeting the project goals?
- Can the roadway be reclassified?
- Can the historic bridge be retained and used for pedestrian sidewalks/bikeway in combination with a new vehicular bridge using a funding source other than the Highway Bridge Replacement and Rehabilitation Program (HBRRP)? Using the historic bridge to maintain some of the functionality of the upgraded crossing may result in being able to keep it on-system and thus eligible for future maintenance funds.
- Can a parallel bridge be constructed to create a one-way pair? If so, visual changes should not be considered adverse when the historic bridge is preserved.
- Can the scale and proportions of a bridge contributing to a historic district be maintained by a new, replacement bridge and have no adverse affect to the district?
- Is it prudent to avoid use by constructing a bypass? This frequently means that the historic bridge will not remain on-system and will require a new owner.

CONSIDERATIONS IN DETERMINING A HISTORIC BRIDGE'S LOAD CAPACITY

It is critical that the actual load capacity on a historic bridge is known, and that the analysis is fair to the historic bridge. In some cases, in order to accurately determine allowable stresses, material strength tests may be needed. These results provide solid, scientific data that bring credibility to the decision-making process, especially when SHPO or members of the public are involved in a project.

Three-dimensional finite element analysis coupled with load-testing and strain-gauging may be appropriate especially on larger bridges. The results from this analysis often results in a finding that the bridge is capable of supporting more load than was computed using conventional methods.

The NBI ratings (inventory and operating) can be used as a starting point, but an independent analysis must also be made. It is during this point of the project that methods to reduce dead load should also be considered and evaluated. Under some circumstances, it may be appropriate to consider a lesser design vehicle, such as an H15 vehicle for roadways where there is a nearby detour route for heavier truck traffic.

There are several common methods to address load-carrying deficiencies:

- Increasing the live-load capacity of the members either by strengthening individual members or member replacement using higher strength material.
- Reducing dead load by replacing the existing deck with a new, lighter-weight deck.

Methods for Improving Load-Carrying Capacity

As discussed above, inadequate load-carrying capacity can be caused by deteriorated members, inadequate load capacity of the original design to meet current requirements, too much dead load, simplistic analysis that does not reflect the true capacity of a bridge, and roadway classification. At a minimum, for historic bridge projects, the following approaches to addressing load-carrying capacity deficiencies should be analyzed.

- Can dead load be reduced by replacing the deck with a lighter one?
- Can carbon-fiber reinforcing polymer wrapping be used to strengthen concrete components?
- Can material be added to individual members to increase capacity? This includes installing high-strength rods as well as plates.
- Can the roadway be reclassified? This could result in a different definition of adequate.
- Can deteriorated members or sections of members be replaced in kind to restore structural integrity and/or increase capacity?
- Can use of the bridge be restricted? Is there a full-capacity crossing nearby?
- Can a parallel bridge be constructed to create a one-way pair and thus reduce the live load? If so, any visual changes should not be considered adverse when the historic bridge is preserved.

Arch Bridges

- Can existing fill material be replaced with lighter-weight fill or engineered fill to decrease dead load?
- Can a relieving slab or auxiliary member be placed to carry some or all of the live loads?

Truss and Girder-Floorbeam Bridges

- Can the flooring system be replaced in kind with higher capacity members? Upgrading floorbeams and stringers can increase load-carrying capacity significantly.
- Can the truss lines or girders be used to support themselves and any sidewalks as part of a new superstructure? The usefulness of this alternative is predicated on many factors including original dimensions and how much the bridge can be widened so that scale of the bridge is not compromised.
- Can post-tensioning be used?

RESOURCES FOR ADDRESSING BRIDGE WIDTH STANDARDS

• *A Policy on Design Standards Interstate System*, AASHTO, 2005.
• *A Policy on Geometric Design of Highways and Streets*, AASHTO, 2004.
• *Roadside Design Guide*, AASHTO, 2002.
• *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)*, AASHTO, 2001.

BRIDGE RAILING

The railing is an important safety feature on the bridge, and is often a character-defining feature that makes the bridge historic. For typical rehabilitation projects, rail replacement with a TL-4 railing is required by Mn/DOT standards if minimum strength and safety levels are not met. For historic bridges, Mn/DOT is willing to apply the AASHTO standards as follows:

1. The rail may be left in place if there is no documented crash history or other evidence of crash history; and the rail strength, by analysis, meets criteria:
   - TL-3 for design speeds 45 mph or more(LRFD 10 ton load analysis method)
   - TL-2 for design speeds of less than 45 mph

2. If rail has been damaged by collision or deterioration is beyond repair, the railing should be replaced. A new bridge railing should be provided as described in *Mn/DOT's Bridge Design Manual.* If the rail is not a character-defining historic feature, a new rail meeting strength criteria will be provided. Standard new railing will be used when possible; however, consideration to the scale, form, shape of the railing on the character-defining elements of the historic bridge may require that non-standard new railing be used. Consideration should be given to the long-term structural integrity and maintenance implications of installing a non-standard railing.

   If the railing is a character-defining feature, it shall be replicated to the extent possible with a railing meeting either the Mn/DOT Standards or the AASHTO standards, when applicable. In addition, there are other railings which have passed NCHRP 350 crash tests for specified test levels. If one of these rails is desired to be used for a specific project, the documentation to be provided is as follows:
      a. An acceptance letter from the FHWA that approves the device for use;
      b. Complete details for the device, either showing actual successful crash tested results or calculated results.

3. For historic bridges where the existing or reconstructed original railing design has a 6-inch or less opening, the AASHTO Standards for pedestrian railing will be followed and a design exception or variance will be sought. The height of the rail must be at least 42 inches. Protective screening, that would normally be required, may be waived if there is no history of problems and the bridge is not carrying pedestrians over a highly traveled roadway.
4. If original railing created maintenance or safety issues such that modifications were made to it over time, those maintenance or safety issues should be considered in design of the rehabilitation.

Approach guardrail may remain if crash history shows no recent repairs were required. If there is indication of crashes or if the guardrail must be replaced, a proper end anchor post must be provided on the bridge or as a separate post adjacent to the bridge rail end. For many historic bridges, the addition of a separate post is preferable to anchoring the guardrail to the structure; however, each property needs to be individually evaluated to determine the most appropriate approach.

The following section was taken from *Guidelines for Historic Bridge Rehabilitation and Replacement* by Lichtenstein Consulting Engineers and Parsons Brinkerhoff (2007).

Railings

- Can deficient railings be replaced “in kind” with no adverse effect, i.e., with a design that incorporates modern load and safety features with the historic design?
- Can an aesthetic, crash-tested design be used as an in-kind replacement
- Can crashworthy traffic railings be installed at the roadway, leaving the historic railings in place?
- Can an adequate guide rail system be placed in front of historic railings, which will be left in place?
- Can a stone parapet be rebuilt in reinforced concrete capable of meeting current codes and faced with a stone veneer that matches the historic pattern?
- Can members be added to increase height or reduce opening size?

APPENDIX F – Individual Bridge Summaries and Management Plans