PRELIMINARY ENGINEERING REPORT

BRIDGE NO. 9340

T.H. 35W OVER MISSISSIPPI RIVER

MINNEAPOLIS

PROJECT I 35W-3-(47)112

PREPARED FOR

STATE OF MINNESOTA

DEPARTMENT OF HIGHWAYS

APRIL 1963

By

SVERDRUP & PARCEL AND ASSOCIATES, Inc.
ENGINEERS-ARCHITECTS
ST. LOUIS, MISSOURI

TABLE OF CONTENTS

INDEX OF PLATES FOR PRELIMINARY STUDIES

FOREWORD

This report summarizes the results of preliminary studies and presents preliminary layouts and cost estimates for a proposed eight-lane Mississippi River Bridge (Minnesota No. 9340) to carry Trunk Highway 35W across the river approximately 300 feet upstream from the existing "Tenth Avenue Bridge" in Minneapolis.

The report and plans are submitted in accordance with Agreement No. 53433, dated October 22, 1962, between the State of Minnesota and the firm of Sverdrup & Parcel And Associates, Inc.

Submitted by:
[redacted]
A. E. Mannes
SVERDRUP & PARCEL AND ASSOCIATES, Inc.
Registered Professional Engineer
Minnesota No. 5789

SCOPE OF WORK

Under the terms of its agreement with the State of Minnesota, Sverdrup & Parcel And Associates, Inc., is required to furnish the following preliminary design and related services:

1 - Make preliminary studies using preliminary design and survey data prepared by the State and furnished to the Consultant as a basis for development of bridge plans.

2 - Prepare drawings showing all pertinent information that may affect the determination of locations and types of substructure and superstructure units.

3 - Include studies to determine the most feasible and advantageous arrangement of both the truss and girder spans.

4 - Present a narrative report and cost estimate based on unit prices and estimated quantities. The narrative report will give reasons for basic selections of recommended types.

5 - Furnish to the State for review four copies and one paper transparency of the preliminary studies.

SUMMARY AND RECOMMENDATIONS

The engineering services called for in the agreement have been performed, and preliminary studies and designs, cost estimates, and design criteria for use in final design have been prepared, and the results incorporated in this report.

The location of the proposed eight-lane bridge was determined by others prior to the start of this study. Minnesota Highway Department will furnish the roadway geometrics, superelevation requirements and profile grades which will be the basis for final plan preparation. In accordance with the agreement, deck truss spans were specified to be used for the river crossing. The truss span arrangement shown on Plate 1 is dictated by river width, existing facilities, topography and roadway geometrics.

Two cross sections for the deck truss spans were considered feasible, and the studies for each included preliminary designs, drawings, quantity computations and cost estimates. They are identified as the two-truss and the four-truss layout.

The two-truss layout which features a floor truss to carry the roadway deck is recommended for economic reasons. It is estimated that the construction cost will be $390,000 less than for the four-truss arrangement; the saving is reflected in both the superstructure and substructure.

For the truss approaches, multiple steel beams and girders are considered the economical and practical types of superstructure construction except at the north end of the bridge. Voided concrete slab spans at this location are believed advantageous for the main roadway and Ramp 2 geometrics, although cost studies indicate approximately equal costs for either steel or concrete superstructure construction for these spans.

SUMMARY OF ESTIMATED PROJECT COSTS

Approach Spans	$1,500,000
Truss Spans (Two-truss layout)	2,980,000
Lighting (Roadway and navigation)	35,000
TOTAL ESTIMATED CONSTRUCTION COST	$4,515,000

DECK TRUSS SPANS FOR RIVER CROSSING

The decision to use deck trusses for the main river spans at this location was made by others prior to the start of this study. At one time the use of girder spans was considered, which would require locating a pier about midway between the river banks. However, subsurface exploration at the proposed pier location revealed questionable foundation conditions and it was decided to use deck trusses and span the waterway at normal pool elevation.

Deck trusses are aesthetically well proportioned and particularly suited to the requirements and location. A three-span continuous truss with the ends cantilevered one panel to support the girder approaches was selected as the most advantageous arrangement. The truss spans, 266ft-456ft-266ft are dictated by the river width, existing facilities, topography and roadway geometrics.

Two deck truss cross sections are considered feasible and were studied in order to determine the most advantageous and economical arrangement. They are identified as the two-truss and the four-truss layout, both having the same span arrangement.

The layout with two trusses in cross section, see Plates 2 and 4, features a floor truss to carry the eight-lane roadway deck because of the great width between trusses, 72'-4", and the fact that floorbeam depth is not limited. A large roadway cantilever is possible with this arrangement, and the reduction in over-all substructure width is appreciable when compared with the four-truss layout. Since

DECK TRUSS SPANS FOR RIVER CROSSING (CONT'D)

welded truss members are planned, it is possible to make efficient use of the various high-strength steels with a heavy two-truss layout and decrease the number of members sized in accordance with minimum thickness requirements.

A K-system of bracing is planned for the upper and lower laterals of the two-truss layout, as shown on Plate 3. The K-system upper laterals will support each floor truss at its midpoint and have ends at each truss panel point which are upset for full depth truss chord support. The K-system bottom laterals will support each strut at its midpoint. Erection difficulties will be eased with the K-system because camber in the welded two-truss layout will be considerable.

The layout with four trusses shown on Plates 2 and 5 can be called the conventional arrangement with floor beams and brackets to support the roadway deck. The top laterals would be a single member in each panel which can take tension or compression. Bottom laterals would consist of cross bracing in each panel.

Erection of the truss spans would present no unusual problems. The end spans would most likely be erected first by use of falsework bents, and the center span would be placed by cantilevering out from each side and closing near the center.

Truss spans for the main river crossing in combination with girder approach spans would have pleasing proportions. The cantilever panel at each end of the continuous truss permits an easy transition

DECK TRUSS SPANS FOR RIVER CROSSING (CONT'D)

from deck truss to shallow girder approach spans. At the ends of the truss cantilevers, a cross girder for supporting the approach spans requires special consideration. The detail planned is shown on Plate 3 and is adaptable to either truss cross section layout.

The roadway conditions at the two ends of the truss are different. On the north end, roadway widening is indicated for the Ramp 2 take-off. At the south end, roadway curvature is on the truss. Either truss cross section layout can be adapted to these conditions.

APPROACH SPANS

Approach span lengths were dictated to a large extent by existing railroad facilities and the topography of the area. The south approach passes over the tracks of the Chicago, Great Western Railroad and the Chicago and Northwestern Railroad. The north approach passes over a railroad yard of the Great Northern Railroad and over 2nd Street, S.E.

With the exception of the beam spans and concrete slab types of construction planned for the ends of the bridge, multiple welded girder spans with girders spaced at about 8-foot centers are indicated for the truss approaches. (Refer to Plate 6.) Erection of the steel spans can be accomplished with a minimum of interference to the rail traffic below. Steel spans will be composite with the roadway deck.

As shown on Plate 6, voided concrete slab type construction is planned for the three spans at the north end of the bridge. While comparative costs between concrete and steel are approximately the same, the use of concrete spans for this location is considered advantageous because of the curving and variable roadway widths. The shallow superstructure depth possible with concrete spans will result in a minimum of alteration work on 2nd Street, S.E. in order to provide the necessary vertical clearance. It is assumed that traffic on 2nd Street, S.E., can be rerouted during construction or that reduced vertical clearance can be provided by the falsework so as to minimize the inconvenience to traffic as much as possible.

APPROACH SPANS (CONT'D)

It is planned to provide slab spans (designed for H-10 loading) in the space between Ramp 2 and the main roadway for safety purposes, as shown on Plate 6. These spans will be placed flush with the top of 10-inch roadway curbs.

9340_F011_001.pdf

SUBSTRUCTURE

Deck Truss Spans

The substructures planned for the two-truss and four-truss layouts are shown on Plates 4 and 5 respectively. At Piers 5 and 8, the exterior truss piers, subsurface information and location indicates that no unusual construction problems will be encountered. Pier 6 is located near a U.S. Corps of Engineers' Guide Wall to a navigation lock, which greatly affects construction procedure and pier details. Pier 7 is at the edge of waterway at normal pool elevation, which, along with the subsurface conditions at this location, will have an effect on pier details.

Based on a study of existing conditions at the Pier 6 location, as shown on Plates 4 and 5, it is felt that concrete-filled cylindrical caissons to rock are the most practical foundation. The available boring information indicates rock profiles as shown, but there is a considerable difference between these and the approximate top of sandstone which was shown on the Guide Wall plan. The caissons can be advanced by driving and by drilling so that vibration is kept to a minimum, and it is believed that no damage to the Guide Wall will occur as a result of their placement. At the closest point, the centerline of caisson at the top will be about 10 feet from the Guide Wall sheet piling.

After the caisson is seated on the rock a socket would be drilled into the rock, and the concrete filling would extend into this socket carrying the load into the rock itself by bearing and by bond. This would be especially advantageous at Pier 6 because of the sloping

SUBSTRUCTURE (CONT'D)

rock surface.

The approximate top of sandstone shown on the Guide Wall plan is indicated on the Pier 6 layout, and the variation from the boring information is apparent. Because of this, and regardless of the advantage of using caissons with a sloping rock surface, it is felt that additional boring information should be obtained before construction in order to be certain of subsurface conditions. It should also be pointed out that the nearest boring to Pier 5 is about 25 feet from its centerline, and that only one boring was made at Pier 8.

Pier 7 construction as planned would be similar to the river pier construction used for the new Washington Avenue Bridge, Minnesota No. 9360. The footing would be tremie concrete and would have dowels for the ice-breaker section grouted into it after the tremie concrete was set and the interior of the cofferdam was pumped dry. The ice-breaker section would end at Elev. 748, which is above the Extreme High Water Elev. 747.44. Again at Pier 7, the boring information available is not conclusive as far as outlining the sandstone surface. It would be desirable to investigate subsurface conditions farther west of the pier to determine if the top of sandstone continues to drop off at the same rate.

The same pier outlines are recommended for both truss cross sections considered. It is felt that the round column shaft is especially advantageous for the heavy loads from the eight-lane truss structure. Stress from horizontal moment producing forces will be small in comparison with the stress from direct loads.

SUBSTRUCTURE (CONT'D)

Approach Spans

The substructures selected for the approach spans are shown on Plate 7. It was felt that piers with round column sections and caps which cantilever beyond the columns are most advantageous for the steel spans. Horizontal and vertical clearances adjacent to the bents often dictate the span lengths, and some advantage is obtained from the use of piers of the type shown. They are considered an efficient type and readily adapt to the variable roadway width. Interior piers for the voided concrete slab spans will also have round columns, but will be poured monolithically with the concrete slab as indicated on Plate 6.

The location of the proposed substructure units is such that rail traffic passes close to some of them. One of the first considerations affecting substructure type was what protection, if any, should be provided in the nature of collision walls. When consideration is given to the slow speed of rail traffic in this area, and the fact that any rail traffic probably has already passed through immediately adjacent areas with minimum lateral clearance, it is believed that collision walls are not required.

All approach substructures will be carried down to rock or supported on steel piles driven to rock.

GENERAL CONSTRUCTION FEATURES

Roadway Deck

The roadway deck will be reinforced concrete with 10-inch curbs, 18-inch parapets and steel handrails as shown on the various plates. A 4-foot wide median barrier having 10-inch high curbs and an 18-inch high parapet is planned in order to divide the northbound and southbound traffic and act as a deterrent to head-on collisions. The usual base openings for bridge parapets will also be used for the median parapet.

Composite action with the roadway slab is planned for the design of the steel approach spans, which will result in an inherently rigid structure as well as an economical one. For the relatively short continuous stringer spans on the trusses, it is not considered advantageous to design for composite action.

Minnesota standard cast iron floor drains will be provided for roadway drainage.

Structural Steel Fabrication

The truss spans and steel girders will be designed utilizing various structural steels consistent with stress requirements and overall economy. Welding is planned throughout for the make-up of girders and truss members and, in this connection, high yield strength steel conforming to Minnesota Specification 3318 will be used extensively. Field connections will be made with high tensile bolts.

Steel girders when used for curved roadway superstructure construction will be fabricated to the curvature of the roadway.

GENERAL CONSTRUCTION FEATURES (CONT'D)

It should be noted that welded truss construction with bolted field connections is apparently beyond the trial stage, and is fast receiving general acceptance. According to cost studies made for riveted and welded structures similar to this crossing, using high strength steels to the best possible advantage, an all welded structure would require approximately 20% less steel than a riveted structure, with a probable resultant cost saving of more than 10%.

Inspection Walk

It is believed that access should be provided on the truss spans for maintenance personnel to inspect the underside of the structure. The catwalk arrangement proposed for the two-truss layout is shown on Plate 4. Also, catwalks and ladders would be provided for access to bearing assemblies and to navigation lights.

Bearing Assemblies

The bearing assemblies for the conventional four-truss layout and approach spans would be similar to those used on other Minnesota bridges. However, it is believed that assemblies for the two-truss layout should be special because of heavy loads and the distance of 72'-4" between trusses. As shown on Plate 3, an assembly with a spherical bearing surface is planned because it permits deflection in any direction. The number of rollers required for expansion assemblies will be dependent upon the reactions.

GENERAL CONSTRUCTION FEATURES (CONT'D)

Bridge Lighting

The Illuminating Engineering Society (IES) recommends that 1.2 average maintained foot-candles be provided on heavily traveled streets with the lowest value at any point not less than one-fourth of this figure. It is believed that this value should represent a minimum for this bridge.

Preliminary study indicates that the recommended minimum illumination can be provided with a multiple system operating at 480 volts using 400-watt mercury vapor luminaries with built-in ballast. Luminaires will be mounted on bolt-down-base poles which are located on both sides of the bridge.

It is assumed that adequate power supplies will be available near both ends of the structure. Construction plans will make provisions for bridge roadway lighting and navigation lighting facilities with the systems ending at a junction box at each end of the bridge.

The bridge structure will be grounded by embedding ground wires in selected piers and connecting to piling or driven ground rods.

The bridge will be provided with navigational lighting in accordance with United States Coast Guard regulations.

Minnesota's steel handrail will be used as a raceway for lighting cables. Light poles will be offset from the line of the handrail in order to make the line of the rail continuous. The rail joints will be provided with sleeves to make this possible.

BRIDGE DESIGN CRITERIA

Construction

The Minnesota Department of Highways Specifications for Highway Construction, dated May 1, 1959 and submitted for approval by the Division Engineer of the Bureau of Public Roads on March 26, 1959, including any subsequent revisions and additions to the Specifications, shall govern.

Design

The design of the structure shall be in accordance with Division 1 of the AASHO, Standard Specifications for Highway Bridges, 1961 edition, including the 1961 interim additions, and with the provisions, exceptions and interpretations as noted in the paragraphs below.

Roadway

As shown on plates. Live loads shall be kept within designated lanes for design of structure.

Roadway Slab

Shall be of reinforced concrete and shall include a ½" integral wearing course.

Safety Curb and Parapets

As shown on plates. Curb heights at raised center median and at outside gutter lines shall be 10" high, sloped 1½". Parapets, 1'-6" high, shall be provided on safety curbs and raised center median.

Railings

One-line flat tube steel rail mounted on 1'-6" high parapets

BRIDGE DESIGN CRITERIA (CONT'D)

as indicated on plates. Railings shall be used as a raceway for lighting cables.

Roadway Drains

To be Minnesota standard cast iron floor drains.

Deck Lighting

Bridge deck lighting shall be in accordance with the best present day practice as recommended by the Illuminating Engineering Society.

Navigation Lighting

All navigation lights shall be in accordance with the requirements of the U. S. Coast Guard.

Clearance

Minimum vertical clearance over 2nd Street, S.E. to be 15'-0". Minimum vertical clearance over tracks on the south side of the river and the main line track on the north side of river to be 23'-0". Minimum vertical clearance over local tracks on the north side of river to be 22'-0". Horizontal clearances at railroad tracks and at 2nd Street, S.E. to be as indicated on Plate 1.

Navigational clearances to be as required by the War Department.

Deck Details

Roadway expansion devices at the ends of the truss shall be of the cast steel finger type. Expansion devices located over or near railroad tracks shall be a sealed type similar to the expansion joints in the pedestrian deck on Minnesota Bridge 9360. Expansion devices for safety curbs and raised median shall be the solid plate type.

Filled joints shall be provided in the slab over stringer

BRIDGE DESIGN CRITERIA (CONT'D)

expansion points on the truss spans and at Pier 11 where the slab on steel beams joins the voided slab construction. A compressed rubber retainer for the joint seal shall be provided.

Dead Load

Weight of earth assumed to be 100 lbs per cu ft, except compacted fill back of abutments assumed to be 120 lbs per cu ft. Submerged earth assumed to weigh 125 lbs per cu ft.

Live Load

H20-S16-44 with alternate military loading as required for Federal Interstate Routes.

For truss spans the concentrated load to be used in combination with a lane live laod shall be 26,000 lbs for both shear and moment.

Impact

No impact shall be applied below superstructure bearings.

Longitudinal Forces

Friction at sliding bearings and pin friction for rocker shoes shall be assumed to be 25% of the dead load supported. This force is not to be considered in a loading case that includes live load.

Thermal Effects

Provide for a range of temperature from minus 30°F to 120°F, with 45°F considered normal temperature.

Forces From Stream

Investigate stability of piers for a pressure of 12" thickness of floating ice applied to the upstream face of river piers at elevation 745. The forces exerted by the ice shall be taken as 400 psi, with other flow forces neglected.

BRIDGE DESIGN CRITERIA (CONT'D)

Concrete

Concrete for substructure and superstructure shall be assumed to have a minimum strength of 4,000 psi at 28 days, f_c = 1600 psi.

Reinforcing Steel

All reinforcing shall be intermediate grade, fs = 20,000 psi. Bars shall be lapped not less than 24 diameters at splices.

Bearing Assemblies

To be cast steel except for sliding plate types.

Jacking Beams

Provisions for jacking will not be made as substructures will be founded on rock.

Welding

All welding shall be in accordance with the current standard Specifications for Welded Highway and Railway Bridges of the American Welding Society, supplemented as required. Field welding will not be permitted for stress carrying members.

Structural Steel

Structures shall be designed utilizing various structural steels consistent with stress requirements and over-all economy.

Wind Forces

The design shall be based upon a maximum wind velocity of 100 miles per hour in accordance with the Standard AASHO Specifications.

Foundations

Truss Piers 5, 7 and 8 shall be founded on rock. Truss Pier 6 adjacent to the Guide Wall shall be founded on 30-inch diameter concrete filled caissons which are socketed into rock.

BRIDGE DESIGN CRITERIA (CONT'D)

Approach substructures, excepting Pier 4, shall be supported on steel piles driven to rock. Pier 4 shall be founded on rock.

Two sizes of steel piles, 10BP42 and 14BP73, are planned. Maximum allowable loads on steel piles shall be limited to 6000 lbs per sq in of point area with allowable increases for different combinations of loading as covered in the AASHO Specifications.

The allowable bearing pressure for footings on rock shall be 10 tons per sq ft.

The allowable load, P, on 30-inch caissons shall be as follows:

$P = 0.225 f'_c \ Ac + Asf'_s$

f'_c = Compressive strength of concrete in psi at 28 days

Ac = Cross sectional area of concrete in sq in.

As = Cross sectional area of steel shell in sq in.

f'_s = Nominal working stress in the steel shell to be taken as 13,200 psi.

The caisson load shall be transferred to the rock by bonding of the concrete to the rock into which the socket is drilled and by direct bearing at the bottom of the socket. The allowable bearing pressure at the bottom of the rock socket shall be limited to 10 tons per sq ft on an assumed effective spread footing having a radius equal to the depth of socket. The diameter of the effective spread footing shall not exceed the caisson spacing.

COST ESTIMATES

Preliminary design studies have been completed in sufficient detail to permit the estimation of preliminary quantities. The cost estimates in this report are based on today's prices as determined from experience and reports on similar items. A 10 percent contingency item is included in the estimates to provide a margin for possible variations in quantities and probable variations in the estimate of today's prices. Also, the contingency item is intended to cover miscellaneous items which cannot be estimated at this time. These estimates do not include costs for engineering, inspection, and administration, or provide for a possible major price increase in the over-all cost of construction.

SUMMARY OF ESTIMATED PROJECT COSTS

Approach Spans	$1,500,000
Truss Spans (Two-truss layout)	2,980,000
Lighting (Roadway and navigation)	35,000
TOTAL ESTIMATED CONSTRUCTION COST	$4,515,000

PRELIMINARY ESTIMATE OF COSTS
MINNESOTA BRIDGE 9340

DECK TRUSS SPANS - TWO TRUSS LAYOUT

SUPERSTRUCTURE

	Unit	Quantity	Unit Price	Amount
A36 Steel	Lb.	3,410,000	$ 0.28	$ 954,800
A441 Steel	Lb.	660,000	0.31	204,600
High Yield Strength Steel	Lb.	1,360,000	0.38	516,800
Cast Steel	Lb.	130,000	0.90	117,000
Concrete	Cu.Yd.	2,900	90.00	261,000
Reinforcing Steel	Lb.	720,000	0.15	108,000
Handrail (Steel)	Lin.Ft.	1,064	10.00	10,640
Sub-total				$2,172,840

SUBSTRUCTURE

	Unit	Quantity	Unit Price	Amount
Preparation of Foundation (Pier 6)	Lump Sum			$ 70,000
Preparation of Foundation (Pier 7)	Lump Sum			100,000
Class U Excavation	Cu.Yd.	1,040	20.00	20,800
Class DR Excavation	Cu.Yd.	90	50.00	4,500
Concrete Filled Caissons	Lin.Ft.	1,000	60.00	60,000
Seal Concrete	Cu.Yd.	1,050	40.00	42,000
Concrete	Cu.Yd.	3,520	52.00	183,040
Reinforcing Steel	Lb.	360,000	0.15	54,000
Sub-total				$ 534,340
TOTAL				$2,707,180
CONTINGENCIES ± 10%				272,820
TOTAL COST				$2,980,000

PRELIMINARY ESTIMATE OF COSTS
MINNESOTA BRIDGE 9340

DECK TRUSS SPANS - FOUR TRUSS LAYOUT

SUPERSTRUCTURE

	Unit	Quantity	Unit Price	Amount
A36 Steel	Lb.	4,920,000	$ 0.28	$1,377,600
A441 Steel	Lb.	660,000	0.31	204,600
High Yield Strength Steel	Lb.	990,000	0.38	376,200
Cast Steel	Lb.	110,000	0.70	77,000
Concrete	Cu.Yd.	2,900	90.00	261,000
Reinforcing Steel	Lb.	720,000	0.15	108,000
Handrail (Steel)	Lin.Ft.	1,064	10.00	10,640
Sub-total				$2,415,040

SUBSTRUCTURE

	Unit	Quantity	Unit Price	Amount
Preparation of Foundation (Pier 6)	Lump Sum			$ 80,000
Preparation of Foundation (Pier 7)	Lump Sum			110,000
Class U Excavation	Cu.Yd.	1,780	21.00	37,380
Class DR Excavation	Cu.Yd.	140	50.00	7,000
Concrete Filled Caissons	Lin.Ft.	1,100	60.00	66,000
Seal Concrete	Cu.Yd.	1,250	40.00	50,000
Concrete	Cu.Yd.	4,280	55.00	235,400
Reinforcing Steel	Lb.	460,000	0.15	69,000
Sub-total				$ 654,780
TOTAL				$3,069,820
CONTINGENCIES, ± 10%				300,180
TOTAL COST				$3,370,000

9340_F011_001.pdf

PRELIMINARY ESTIMATE OF COSTS
MINNESOTA BRIDGE 9340

APPROACH SPANS

SUPERSTRUCTURE

	Unit	Quantity	Unit Price	Amount
A36 Steel	Lb.	2,250,000	$ 0.22	$ 495,000
Cast Steel	Lb.	178,000	0.80	142,400
Concrete	Cu.Yd.	3,460	85.00	294,100
Reinforcing Steel	Lb.	980,000	0.15	147,000
Handrail (Steel)	Lin.Ft.	1,960	10.00	19,600
Sub-total				$1,098,100

SUBSTRUCTURE

	Unit	Quantity	Unit Price	Amount
Class U Excavation	Cu.Yd.	1,830	10.00	$ 18,300
Concrete	Cu.Yd.	1,750	72.00	126,000
Reinforcing Steel	Lb.	270,000	0.15	40,500
Steel Piles (14BP73)	Lin.Ft.	3,820	9.00	34,380
Steel Piles (10BP42)	Lin.Ft.	4,420	6.50	28,730
Slope Protection	Sq.Yd.	1,400	10.00	14,000
Sub-total				$ 261,910
TOTAL				$1,360,010
CONTINGENCIES, ± 10%				139,990
TOTAL COST				$1,500,000