SUBWAY UNDER ILLINOIS CENTRAL RAILROAD ON UNIVERSITY AVENUE, CHAMPAIGN, ILLINOIS

BY

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THESIS

FOR THE

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I recommend that the thesis prepared under my supervision by LEWIS WILMER SPENGLER entitled Subway under Illinois Central Railroad on University Avenue, Champaign, Illinois, be approved as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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INTRODUCTION

The present grade crossing of the Illinois Central Railroad at University Avenue is a menace to public safety and a detriment to the business interests of Champaign. The elimination of this grade crossing would benefit the cities of Champaign and Urbana by improving transportation between the business districts of the two cities; it would increase the efficiency of the street car service; and it would give the Illinois Central Railroad better switching facilities, besides reducing the likelihood of accidents.

University Avenue is one of the principal business streets of Champaign and is the most direct route between the business districts of the Twin Cities. Upon the part situated in Champaign is located an electric car line over which pass both local and interurban cars.

The Illinois Central passenger station is located just north, and the freight depot just south, of this avenue. Considerable switching is done in this vicinity during the entire day, causing the street to be blocked much of the time. This delay seriously affects the street railway service, since the cars are sometimes delayed five minutes or more at a time. When the crossing is not actually blocked, delay is caused by the necessity of the conductor going forward to see if the tracks are clear.

The city is affected by the delay from the fact that ve-
Vehicles and pedestrians are compelled to wait for passing trains. About 300 street cars, more than 50 interurban cars, and upwards of 3,000 vehicles use this crossing daily, while, by actual count, more than 400 persons passed this crossing in a single hour. Under such traffic conditions five to ten minute delays are not only very annoying but are a positive detriment to the wellfare of this growing city.

Traffic upon the Illinois Central is often delayed by the fact that long freights have to be "cut" in order that street traffic may not be delayed, in violation of statute, more than five minutes. The Illinois Central also has to take extra precaution in running its trains over the crossing to prevent accidents, and such precaution must necessarily promote delays.

To avoid these objectionable delays and to safe-guard the citizens of Champaign and Urbana against accident, and also to facilitate traffic on University Avenue, some means must be devised to eliminate the present grade crossing. A subway offers a solution of these difficulties, and the purpose of this thesis is to design such a subway.
**LEGAL PHASES**

Public wellfare demands that for safety of travel upon streets and railroads the road crossings should have different elevations. A city cannot compel a railroad or a street railway already constructed to alter its grades. Neither can a railroad require a city to change its streets. Contemplated changes must, therefore, be made by mutual consent and agreement. The State of Illinois has established a committee called the Board of Railroad and Warehouse Commissioners which is very efficient in arbitrating such matters. Although not vested with the authority to use drastic measures in enforcing their orders, they are, however, generally obeyed, or at least duly considered by the railroads and other corporations. Since the city has absolute control of its streets, the commission cannot compel it to build a subway. Probably the only way to secure the subway would be by the joint consent of the city, the Illinois Central Railroad and the Street Car Company to pay their just portions of the expense incurred, the apportioning of the expense to be decided by a board of arbitrators.
FIELD WORK AND COLLECTING OF DATA

The data for making the plot of the city in the vicinity of the proposed subway was obtained by making a transit survey of the proposed site. Levels were run on University Avenue and also back a few hundred feet on the streets crossing it. Levels were also run along the Illinois Central tracks to see if it was feasible to raise their elevation. It is seen from the profile of the Illinois Central track that the Station is already on a small summit with a grade of about 0.15 percent on either side. Many long heavy freights have occasion to stop at Champaign, and if the tracks were raised the grade would be increased and that would be objectionable in starting these freights. In addition to this objection, raising the tracks would also make it necessary to alter the subways at Second South Street and at Washington Avenue, recently put in, as well as to raise the passenger station and freight depot (see Map).
CONSIDERATION OF FEATURES AFFECTING THE DESIGN

Water from University Avenue for a distance of about 400 feet in either direction will run into the subway. It will be necessary to take care of storm water rapidly to prevent flooding of the passageway. From the profile of University Avenue (see plate 2) it is seen that the easiest method of draining is to lay a 12-inch tile from the subway east to the Boneyard Creek.

It is seen from plate 1 that First South Street merges into University Avenue just west of the railroad tracks. Much of the present traffic crosses the tracks on this street, and unless this street were closed, a subway under University Avenue would probably not be considered by the Illinois Central Railroad as the construction of a subway under First South Street as well as University Avenue would almost double the expense, and would not be entirely necessary. Traffic of First South Street east of the railroad can be taken care of by using Water Street, the entrance to the subway being at the junction of Water Street and University Avenue (see plate 6).

West of the Illinois Central tracks Chestnut Street will be carried over the subway as shown upon plate 6. Market Street will be cut down to meet the approach to the subway. East of the Illinois Central tracks Water Street will be cut down to meet the approach on the south side of University Avenue only.
Water Street is little more than an alley and would be closed entirely were it not for the fact that on the south side it must take care of the traffic from First South Street (see plates 1 and 6).

In order to maintain the present east house track of the Illinois Central and to preserve the necessary clearance in the subway, the subway would have to be lengthened considerably. This would cause additional expense in excavation, retaining walls, and extra girders, and other work required in spanning University Avenue. The importance of this siding would not warrant such additional expense, hence it will be cut off and made a spur on each side of University Avenue.

The street car line will be single track through the subway, and will be located in the center of the street. The width of University Avenue is 66 feet. The transverse distance between the two lines of columns is 14 feet, and the sidewalks are each 8 feet wide, thus leaving a net width of driveway of 12 feet on each side of the track (see plate 5). The turnout of the siding east of the railroad will be moved ahead and located east of First Street.

Heavy interurban cars use the street car tracks, so provision must be made to give them the necessary clearance. A clearance of 13-1/2 feet will be sufficient. The maximum load (including freight) handled by the Interurban Company would require that a maximum grade of not over four percent be used. A vertical curve will be used connecting the level sections under the subway with the 4 percent grade. Vertical curves will also be used at the upper ends of the approaches to connect the four
percent grades with the street level.

Business houses are located along the property line, therefore it will be necessary to keep the sidewalk at its present elevation. Water Street from the south will be cut down to meet the approach to the subway (see plate 6). At the crossing of Water Street ten steps with 6-inch risers will be used on the east side of Water Street. Oak Street will be closed and the sidewalk will descend on a six percent grade from the east line of Oak Street to the subway. The walk is level through the subway and is six feet above the street level. Twenty-two steps with 6-inch risers lead from the subway to the Illinois Central station platform. Between Chestnut and Market Streets the walk ascends with a one percent grade, reaching the elevation of the approach at the east line of Market Street. Market Street is cut down to meet the approach, but on account of the adjoining business houses the elevation of the sidewalks can not well be changed. This requires sixteen 6-inch steps on the east side of Market Street and twelve 6 inch steps on the west side of the same street.

Catch basins will be placed under both gutters at each end of the subway, and these will be connected to the street drain, which leads to Boneyard Creek.

The roadway will have a six-inch crown with a gutter along each side of the street. Brick will be used for the pavement, using a two inch sand cushion and a 6-inch portland cement concrete foundation made up in the proportion of 1:3:8.

The water and gas mains at present in the center of the street will be placed under the north sidewalk.
SPECIFICATIONS

LOADS

All portions of structure shall be figured for the following loads:

(a) Live load, (b) Dead load, and (c) Impact.

(a) Live load--A moving load for each track, consisting of trains each composed of two consolidated locomotives (with weights distributed as per the following diagram) followed by a uniformly distributed load of six thousand (6000) pounds per lineal foot. The maximum stresses arising from all positions of this moving load must be provided for:

(b) Dead load--For calculating the dead load, weights of material shall be assumed as follows:
Steel ............. 490 lbs. per cu. ft.
Concrete .......... 150 " " " "
Ballast .......... 100 " " " "
Track & Fastenings 100 " " lin. ft. of track

(c) Impact shall be calculated from the following formulae:

For all girders, cross girders and columns:

\[ \text{Impact} = \frac{LL}{LL + DL} \]

For I-beams incased in concrete:

\[ 0.75 \left( LL \times \frac{LL}{LL + DL} \right) \]

\( LL = \) Live Loads
\( DL = \) Dead Loads

**STRESSES**

In calculating stresses, the following conventional distances shall be assumed:

For plate girders, center to center of bearings.
For cross girders, center to center of columns.

All parts of the structure shall be so proportioned that the sum of the maximum dead and live loads together with the impact shall not exceed the following allowable stresses:

Tension ............. 16,000 lb. per sq. in.

\[ P = \frac{16,000}{L} \]

\( P = \) Allowable working stress per square inch in compression
\( L = \) Length of column (top of masonry to bottom of cross girder) in inches.
R = Least radius of gyration in inches.

**Shearing Stresses**

<table>
<thead>
<tr>
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<th>Lbs.</th>
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<tbody>
<tr>
<td>Web of plate girder--per sq. in. of net section</td>
<td>9,000</td>
</tr>
<tr>
<td>Shop rivets</td>
<td>11,000</td>
</tr>
<tr>
<td>Field rivets</td>
<td>8,800</td>
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**Bearing Stresses**

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<tbody>
<tr>
<td>Shop rivets (projected semi-introdose)</td>
<td>22,000</td>
</tr>
<tr>
<td>Field rivets (projected semi-introdose)</td>
<td>17,600</td>
</tr>
</tbody>
</table>

**BED PLATES**

All bed plates shall be of such dimensions that the greatest pressure per square inch due to any or all causes combined upon concrete masonry shall not exceed six hundred (600) pounds.

**I-BEAMS**

All I-beams shall be proportioned by their moment of inertia.

**PLATE GIRDERS**

No part of the web plate shall be estimated as flange area in proportioning plate girders except that part included between the top flange angles of girders with double top flange.

**LIMITING LENGTH**

No compression member shall have an unsupported length exceeding 100 times its least radius of gyration.
DESIGN

The plan and section of the abutments are shown in plate 5. The maximum live load carried by the bridge and the dead loads due to the weight of the bridge and masonry gives a pressure of 3.5 tons per square foot on the soil. The bearing power of the soil is from 4 to 6 tons per square foot (clay), hence the factor of safety is ample.

The plan and section of the piers are shown in plate 5. The total load carried at their foundations is 3.5 tons per square foot. This gives an ample factor of safety.

A general section of the retaining wall is shown in plate 6. This section is taken at the east line of Oak Street. The wall is designed to withstand an equivalent fluid pressure of 25 pounds per cubic foot. The batter on the face of the wall is 1 in 24 and on the back 5 in 24.

The west, or industrial track bridge is shown in plate 4. The railroad track is supported by ten 20-inch, 65-pound I-beams spaced fifteen inches center to center of webs. Concrete surrounds these I-beams and extends two inches below and two inches above the flanges. The bridge for the side track is designed for 75% standard loading (see specifications page 8) with no impact added, using the same unit stress as given in the specifications. The highway bridge was designed for a ten-ton vehicle on two two axles 8 ft. centers and 5 ft. gauge. The vehicle is assumed to occupy eight feet in width, and 100 pounds per square
foot is assumed over the remaining floor area. The allowable com-
pression in concrete is 750 pounds per square inch, and the
allowable tension in steel is 16,000 pounds per square inch. The
plan of the steel is shown on plate 4. Three spans will be used,
a twenty-three foot span at each end and a fifteen foot center
span. The middle span is supported upon "H" steel columns. The
columns are spaced 15 ft. center to center. There are eight of
these columns on each side of the street car tracks spaced 9'-3"
center to center, parallel to the track. Steel girders three
feet deep extend lengthwise of the street upon the tops of the
columns.

The plan and elevation of the main track bridge is shown
on plate 5. The bridge consists of ten 24-inch 80 pound I-beams
spaced 15 inches center to center of webs. The main track
bridge has the same arrangement of spans and columns as has the
industrial track bridge. The detail of the girders is shown on
plate 4. The I-beams are designed to carry all the load, but
the girders will be stressed by the deflection of the I-beam.
The girders are reinforced to prevent cracking due to temperature
and other stresses.
ESTIMATE OF COST

20,250 cu.yds. of earth excavation at $0.40 per cu.yd. 8,100.00
3,850 cu.yds. of concrete at $6.00 per cu.yd. 23,100.00
265,600 lbs. of steel at $0.03 per lb. 7,968.00
9,000 ft. of lumber for falsework $35.00 per M. 315.00
Erection of falsework (labor, spikes, bolts, etc.) 500.00
Erection of bridges 1,250.00
2,000 ft. of 1-1/2 in. pipe for railing at 20¢ per ft. 400.00
15,000 sq.ft. concrete sidewalk at 15¢ per sq.ft. 2,250.00
4,000 sq.yds brick pavement at $1.60 per sq.yd. 6,400.00
2200 ft. of curb at $1.00 per lineal foot 2,200.00
Relaying 1600 ft. of street car track 300.00
Relaying 2000 ft. of gas and water mains 1,200.00
Tile drain, 1200 ft. at 40¢ per ft. 480.00
4 catch basins at $75.00 each 300.00

Plus 10% for engineering and incidentals 5,486.00

Total Cost 60,349.00
PLATE 3

Profile of Illinois Central R.R.

North and South at University Avenue

Nur Scale: 1" = 20'0"

Vert Scale: 1" = 10'

To New Orleans

Top of Rail

To Chicago
PLATE 5
Main Track Superstructure
Showing
Section of Abutments
and
Plan of Tracks
Scale 1"=6'

Plan of Tracks Crossing Subway