EVALUATION OF MOVABLE BARRIER IN CONSTRUCTION WORK ZONES

Experimental Feature No. X(09)03

FINAL REPORT

Prepared For:
Utah Department of Transportation Research Division

Submitted By:
T.Y. Lin International

Authored By:
Doug Anderson, P.E.
David Eixenberger, P.E.
Ken Berg, P.E.

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By completing the project seven months early millions of dollars in user costs were saved. The use of movable barrier contributed to this savings. During construction the project was safer due to left turn restrictions between major intersections. Early completion of the project reduced negative impacts on businesses in the corridor.  
The use of movable barrier on high volume, urban projects should be considered to increase the work area and safety of the project. Early completion reduces user costs, improves safety, and reduces impacts on businesses. |
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**EXECUTIVE SUMMARY**

The use of movable barrier has increased in recent years to enhance the capacity and safety of highway construction projects. This report documents the impacts of using movable barrier on the reconstruction of 3500 South in West Valley.

The estimated completion date for the project has been reduced by about seven months. The use of the movable barrier system contributed to this early completion schedule. The congestion observed on the project was impacted somewhat by using movable barrier to move from a four lane to a three lane traffic control configuration. This was mostly a result of travelers stopping to make left turns although signing was in place prohibiting left turn movements.

The management of the congestion and reduced construction schedule had a positive impact on travel time, lower travel distances, less congestion on the bypass routes, and reduced impacts on businesses.

The safety of the traveling public and the construction workers on the project was enhanced. The positive separation reduced the chance for severe crashes such as head-on and left-turn collisions, and protected workers in the construction areas.

The benefits of using movable barrier on the project are estimated at $1.7 to 2.4 million. A very conservative benefit-cost ratio of about 4 to 1 was estimated for use of the system. Movable barrier is definitely beneficial in high volume corridors where the morning and afternoon traffic split vary significantly.

This traffic control strategy should be considered for use to reduce congestion and improve safety on future projects. The ability to provide more width for use by the contractor aids in completing the work more quickly. The early completion of urban projects results in very high benefits to the traveling public and the impacted community.
1.0 INTRODUCTION

Congestion on our highways has a very negative impact on the traveling public and adjacent neighborhoods. This is especially true where construction projects reduce open lanes, restrict turning movements, and eliminate shoulders. These impacts can be in the form of lost time, increased fuel usage, compromised safety, and reduced air quality.

Safety concerns in work zones are related to the numbers and severity of accidents, insufficient access for pedestrians, and less safe conditions for workers in the construction area. Data gathered both in Utah and nationally show that the fatality rate in work zones is about twice that of normal driving conditions.

The Utah Department of Transportation (UDOT) has consistently improved the way that highway construction projects impact traffic and communities in the state. UDOT has utilized state-of-the-practice methods to enhance how traffic is managed in construction zones, and implemented innovative techniques to minimize the time that these corridors are impacted.

Movable barrier has been an option for highway construction contractors for many years. The movable barrier allows for the traffic flow in a lane to be reversed as needed upon demand to increase the capacity in the corridor. The use of this method of traffic control has increased in Utah in recent construction seasons. The barrier systems have evolved over time in terms of the barrier used and the equipment used to move it.

The purpose of this report is to document the benefits and challenges associated with the use of movable barrier. Emphasis is placed on the 3500 South reconstruction project in West Valley since it is nearing completion and usable data and observations are available.

The 3500 South reconstruction project is on State Route 171 from Milepoint 5.8 to 7.4. The Average Annual Daily Traffic (AADT) ranges from about 39, 200 near Bangerter Highway and 48,800 at the I-215 interchange. Both the morning and evening peak hour volumes are about 10% of the AADT. The reconstruction of 3500 South was initiated to widen the corridor from a six lane to an eight lane facility from Bangerter Highway to the I-215 interchange. The two lanes in the center median will be dedicated for Utah Transit Authority's (UTA) first Bus-Rapid-Transit line. The area
will also get new curbs, gutters and sidewalks. Construction was started in November of 2008 and was scheduled to be finished in the summer of 2010. Figure 1 shows the general layout and location of the project.

One side of the highway was closed completely for construction while all traffic was diverted to the other side. The original traffic control plan called for two lanes of traffic in each direction. After some analysis the concept of movable barrier was instigated on the project to allow two lanes of travel in the direction with the highest traffic demand.
The objectives of this experimental feature are as follows:

1- Record the effectiveness of using movable barrier for traffic control in the 3500 South corridor and similar projects around the country.

2- Document the impacts on safety where the movable barrier system has been used to control traffic through construction projects on surface streets.

3- Document the benefits of early project completion achieved by expanding the available construction area for work by the contractor.

4- Estimate the benefits of using the movable barrier compared to the costs of deploying the system.
2.0 LITERATURE SEARCH

The authors conducted a literature search to document the history of movable barrier used in construction zones. The databases searched and the results of the search are shown in Figure 2.

Figure 2- Summary of the Movable Barrier in Construction Applications

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>URL</th>
<th>RESULT</th>
</tr>
</thead>
</table>
-Lower construction time |
| I-77 Canton, Ohio | [http://www.dot.state.oh.us/projects/Pages/default.aspx](http://www.dot.state.oh.us/projects/Pages/default.aspx) | -Saved $4.8 million in construction and eliminated one construction season  
-Reduced user delay |
| Dan Rathbone, Dallas project | [drathbone@lawleypublications.com](mailto:drathbone@lawleypublications.com) | -Reduced congestion  
-Lower fuel consumption and emissions |
| Chicago Skyway Project | [http://www.chicagoskyway.org/faqs/index.asp](http://www.chicagoskyway.org/faqs/index.asp) | -Reduced construction time by one-third  
-Very minor congestion |
3.0 APPLICATION AND METHODOLOGY

Standard movable barrier was used on the 3500 South project which included ABSORB 350 crash cushions protecting the barrier ends. The barrier was equipped with yellow reflective markings to add delineation at night as well as during the day. The equipment used to move the barrier was a standard transfer device, which moves the barrier a full 12 feet in one pass.

Just over one mile of barrier was used in the corridor and shifted as needed to provide two lanes in the peak traffic direction. The movable barrier allowed left-turn movements at five major intersections with crash cushions protecting all ends of the barrier at each intersection.

Figure 3- Movable Barrier Plan on 3500 South
Figure 4- Barrier being moved to reverse the lane

Figure 5- End Section with Crash Cushions
4.0 DATA, OBSERVATIONS, AND ANALYSIS

When the reconstruction project was initiated the level of service in the 3500 South corridor was reduced during the high volume hours of the day. Both the morning and afternoon commutes resulted in substantial congestion on the project as expected. Many commuters were forced to travel a significant distance out of their way to avoid the major back-ups.

As construction progressed the contractor needed more room in the corridor to keep the schedule short and their workers safe from traffic influences. Confused drivers occasionally turned into the construction zone. Left turns into businesses created an unsafe situation and accidents contributed to congestion. Reducing the number of lanes dedicated to traffic and providing a more protective barrier to traffic would be beneficial.

The key stakeholders on the project all agreed that a more innovative approach for the traffic control plan was needed. It was decided that a reversible lane could aid the traffic situation while providing an additional lane for use by the contractor. Barrier Systems of Vacaville, California was contacted to provide movable barrier to meet this need.

The expenditure of project funds to upgrade the traffic control plan must be justified in terms of benefits to the traveling public, the project owner, or the construction team. Certain criteria must be employed to estimate the benefits of utilizing the movable barrier system in the traffic control plan.

4.1 Congestion
Travel time information was obtained within the project in February, May and June of 2009 by Avenue Consulting. The impact of the project on congestion was minimal on some days and significant on others. Traveler delay and congestion were significant during peak hours throughout the construction period in the 3500 South corridor. The initiation of the movable barrier system on the project allowed the use of one more lane by the contractor.

Traffic was able to travel through the corridor while it was under construction in an acceptable manner. As construction progressed more commuters traveled to bypass routes to avoid the project.
4.2 Safety
The use of the movable barrier greatly enhanced the safety of the 3500 South reconstruction project. This was true for both the traveling public and the workers in the construction zone. The barrier reduced the tendency for the occurrence of the more severe type of accidents, such as left-turn and head-on crashes. The barrier reduced the chance for vehicles to enter into areas where construction workers were exposed to injury.

The 3500 South corridor prior to construction had some safety concerns that the project team needed to deal with during construction. The corridor averages about 250 to 260 accidents per year. This is an accident rate of about 8 to 9 accidents per million vehicle miles of travel. Typically 40 to 50 of these crashes (16 to 19%) resulted in an injury to the driver or a passenger.

A significant number of left-turn related crashes have occurred in the corridor over the years. Annually about 80 to 90 left-turn accidents were reported in the corridor which is about one-third of the total. These crash types tend to lead to more injuries than rear-end and side-swipe accidents that are generally proper damage only. The use of barrier on the project confined the left-turn movements to the major intersections. Restricting the midblock left turns reduced the conflicts within the corridor dramatically.

Considering the safety record prior to the beginning of construction, the use of movable barrier on the project is justified. The barrier restricted left-turn movements at all locations except the major intersections. It is estimated that use of the barrier resulted in the elimination of about 20 to 25 left-turn crashes while in operation. These accidents vary in severity and average cost to those involved (Appendix B). The estimated reduction in crash costs for these accidents is about $1,000,000 during the project (Appendix B).

4.3 Schedule
The use of movable barrier aided the contractor to complete the project in fewer working days. This was accomplished by allowing crews to get into areas of the project and work unimpeded for longer periods of time while the barrier was in place. Without the use of movable barrier the contractor would have needed to keep the travel lanes to two in each direction. This would have reduced the available area for construction crews within the construction zone. The movable barrier allowed the traffic to be reduced from a four lane to a three lane configuration.
The ability to keep the two lanes for peak traffic allowed the contractor to move from a three phase construction schedule to a two phase schedule. The movable barrier allowed the contractor to strike a balance between traffic and construction needs.

The estimated construction length has been reduced by about seven months. A December 2009 completion date has been established. A significant portion of this reduction in construction schedule has been attributed to the movable barrier traffic control plan. If the project continues as projected the contractor will be eligible for the early completion bonus offered in the contract.

The user savings achieved by completing the project seven months early are estimated at $1.3 to 1.4 million. Only a portion of the savings can be attributed to use of the movable barrier. This estimate is assuming a four minute reduction in travel time through the corridor, a 10% peak hour AADT (both AM and PM) of 3,920 vehicles, and a rate of $12 per hour. Vehicle operating cost savings were not included.

4.4 Business Impacts

As the project was initiated and three of the lanes were closed, many of the business owners along the project reported a reduction in business. The contractor continued to provide access to the businesses as specified in the contract.

The reduced construction schedule will minimize the negative impacts on the businesses in the corridor. The use of traditional construction methods would have resulted in a much greater loss of revenue for the business owners. By completing the project ahead of schedule it is believed that the businesses in the area were less impacted by the project.

The most productive steps that can be taken on behalf of the business owners along a construction zone are:

1- Complete the project as quickly as possible.
2- Provide access to the business during construction.
3- Maintain a safe environment during construction.
4- Avoid any damage to the business owner’s property.
5- Leave a quality, long lasting highway corridor behind upon completion.
The use of movable barrier played a significant role in achieving these goals. The enhanced capacity and improved highway facility will attract business to the corridor in the future.

4.5 Barrier and Equipment Costs
The costs of movable barrier systems are related to the following:

1- Barrier purchase or rental
2- Equipment to move the barrier in the form of rental costs
3- Mobilization of the barrier and equipment
4- Maintenance of the barrier and equipment

The total outlay of project funds on the project for movable barrier was about $410,000. This is a prorated amount based on utilizing the system for eleven of the eighteen month contract.

4.6 Estimate of Benefits
The benefits of utilizing movable barrier on the 3500 South reconstruction project are reduced user costs, shorter travel distances, improved safety, lower impacts to businesses, early project completion, less fuel use, and reduced air emissions.

Benefits that were calculated as part of this experimental feature are estimated at $1.7 to 2.4 million, based on a conservative estimate of time savings to users, and reduced left-turn crashes only. It does not include decreased travel distances, or lower vehicle operating costs resulting from early completion. Benefits to businesses in the corridor were not estimated but were certainly significant. Only a portion of the benefits of early completion of the project can be attributed to the use of movable barrier.
5.0 CONCLUSIONS

The conclusions of this experimental feature are as follows:

1- The estimated completion date for the 3500 South reconstruction project has been reduced by about seven months. The use of the movable barrier system contributed to this early completion schedule.

2- The congestion observed on the project was impacted somewhat by using movable barrier to move from a four-lane to a three-lane traffic control configuration. This was mostly due to left turn violations.

3- The management of the congestion and reduced construction schedule had a positive impact on travel time, lower travel distances, less congestion on the bypass routes, and reduced impacts on businesses.

4- The safety of the traveling public and the construction workers on the project was enhanced. The positive separation reduced the chance for severe crashes such as head-on and left-turn collisions, and protected workers in the construction areas.

5- The accident history in the corridor indicates that the number of crashes, types of collisions, and the severity of the accidents definitely warranted the use of barrier on the project.

6- The benefits of using movable barrier on the project are conservatively estimated at $1.7 to 2.4 million. The benefits available for analysis in this experiment feature provide a benefit/cost of about 4 to 1. This is limited to travel time reductions from early completion and the elimination of left-turn accidents between major intersections. It does not include other safety benefits, vehicle operating savings, reduced impacts to businesses, or lower air emissions. The authors believe that a benefit-cost ratio for use of the movable barrier to be greater than 10 to 1 if all benefits could be considered.
6.0 RECOMMENDATIONS/IMPLEMENTATION

1. Movable barrier is definitely beneficial in high volume corridors where the morning and evening traffic split vary significantly. This traffic control strategy should be considered for use to manage congestion, improve safety, and increase the construction footprint on future projects.

2. Previous studies illustrate the effectiveness of movable barrier on Interstate highways. This experimental feature demonstrates the effectiveness of the system on arterial surface streets. Movable barrier provides the ability to separate more of the highway corridor for use by the contractor which aids in completing the work more quickly.

3. A few factors must be considered when making an evaluation to utilize movable barrier on a construction project. Typically movable barrier is cost-effective when the traffic volumes are high, the directional split is significant, accident records indicate high left-turn conflicts, and the corridor has significant access points.
I-94 St. Croix River Bridge, Wisconsin - Minnesota

THE PROBLEM:

The St. Croix River Bridge carries I-94 from the Hudson area in Wisconsin to the Twin Cities in Minnesota. With 70,000 cars a day crossing the bridge, redecking the westbound bridge span posed serious problems. Redecking half the span at a time would take two construction seasons and incur massive user-delay costs, but traditional construction methods could not allow full closure of the westbound side and still keep traffic flowing. The solution was moveable barrier.

I-94 St. Croix River Bridge, Wisconsin - Minnesota

THE MOVEABLE BARRIER SOLUTION:

The westbound span was closed completely and a moveable median was deployed on the eastbound span. Twice a day, the Barrier Transfer Machine moved the barrier to accommodate peak traffic needs. The barrier transfer took about half an hour and provided three lanes for peak traffic at all times. The average commuter had only five to 10 minutes added to their drive time. With full closure on the construction side, the project was accelerated and completed in one construction season instead of two, with an estimated construction savings between $1,000,000 and $1,500,000.
I-94 St. Croix River Bridge, Wisconsin - Minnesota

THE RESULTS:

The average commuter saved 40 minutes in potential delays.

Total user-delay cost savings of $1.2 million.

Finished in one construction season: savings of over $1 million.

Allowed easy material delivery and room for more efficient equipment.

Use the controls to play or pause the video.

Back  THE PROBLEM  ➤  THE SOLUTION  ➤  THE RESULTS
# APPENDIX B

**UDOT Crash Costs by Severity**

<table>
<thead>
<tr>
<th>Crash Costs</th>
<th>Cost per Crash</th>
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<tr>
<td>1- Property Damage</td>
<td>$2,350</td>
</tr>
<tr>
<td>2- Possible Injury</td>
<td>$23,200</td>
</tr>
<tr>
<td>3- Bruises &amp; Abrasions</td>
<td>$46,500</td>
</tr>
<tr>
<td>4- Broken Bones or Bleeding Wounds</td>
<td>$465,000</td>
</tr>
<tr>
<td>5- Fatal</td>
<td>$465,000</td>
</tr>
</tbody>
</table>

**Five Year Crash Analysis**

416 left-turn crashes – 83 per year  
117 left-turn crashes between major intersections – 23 per year (28%)

**Five Year Left-turn History**

<table>
<thead>
<tr>
<th>Severity</th>
<th>Percent Left-turn</th>
<th>Number of Crashes</th>
<th>Cost per Crash</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49%</td>
<td>57</td>
<td>$2,350</td>
<td>$134,000</td>
</tr>
<tr>
<td>2</td>
<td>33%</td>
<td>39</td>
<td>$23,200</td>
<td>$905,000</td>
</tr>
<tr>
<td>3</td>
<td>13%</td>
<td>15</td>
<td>$46,500</td>
<td>$698,000</td>
</tr>
<tr>
<td>4</td>
<td>6%</td>
<td>7</td>
<td>$465,000</td>
<td>$3,255,000</td>
</tr>
<tr>
<td>5</td>
<td>-0-</td>
<td>-0-</td>
<td>$465,000</td>
<td>-0-</td>
</tr>
<tr>
<td>Total 5 years</td>
<td>100%</td>
<td></td>
<td></td>
<td>$4,992,000</td>
</tr>
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**Total One Year**  
$998,400

Note- Fatal crashes were omitted as a statistical event
## APPENDIX C

**ESTIMATED OPERATIONAL COSTS, EXCLUDING LABOR, FOR CONSTRUCTION BARRIER TRANSFER MACHINE (BTM)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Details</th>
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<tr>
<td>Fuel</td>
<td>5/gal/hour @ $1.75/gal</td>
<td>$ 8.75</td>
</tr>
<tr>
<td>Engine Oil &amp; Filter Change</td>
<td>filters supplied by BSI every 100 hours = $50.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Hydraulic Oil &amp; Filter Change</td>
<td>50 gal. every 400 hours = $200.00</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Per Hour $ 9.75</strong></td>
</tr>
</tbody>
</table>