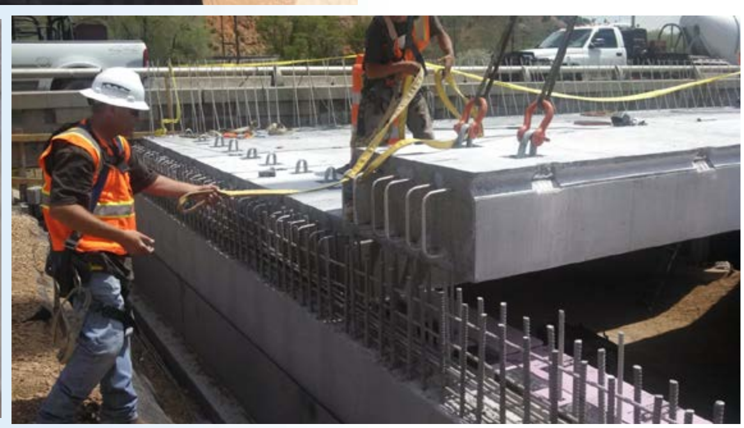
Utah Demonstration Project:

# Geosynthetic Reinforced Soil Integrated Bridge System on I-84 near Salt Lake City

**Draft Report**
**February 2014**

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.



U.S. Department of Transportation
**Federal Highway Administration**

# FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. Such "innovations" encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community's culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decision makers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

# NOTICE

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16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration (FHWA) under the Highways for LIFE program, the Utah Department of Transportation (UDOT) was awarded a $1 million grant to demonstrate the use of proven, innovative accelerated bridge construction technologies to deliver this $5 million project in substantially less time than conventional construction.

The project involved replacing twin bridges located on the westbound and eastbound routes of I-84 over Echo Frontage Road in Summit County. The structure to be replaced was constructed in 1971 and carried a designation of D-783 in UDOT's bridge management system. The project limits extended approximately between milepost118 and milepost120. The innovative construction techniques adopted were as follows:

- Use of the geosynthetic reinforced soil-integrated bridge system (GRS-IBS) method of design and construction.
- Use of prefabricated bridge elements and systems (PBES).
- Use of a lateral bridge slide.

This was the first GRS-IBS project in Utah and also the first GRS-IBS project on an interstate in the U.S. It was also the first GRS-IBS project in the U.S. to incorporate a lateral bridge slide. On this project, UDOT used a price + time or price + time + lane rental bidding process.

To estimate the cost savings for the GRS-IBS method, the total costs were computed for both the as-built and baseline (cast-in-place) scenarios by adding the agency costs and user costs (delay + safety costs). The results indicated around 7 percent cost savings during the as-built scenario compared to the baseline because of significantly reduced user costs.


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| Highways for LIFE, geosynthetic reinforced soil, integrated bridge system, GRS-IBS, lateral bridge slide, ABC, PBES | No restriction. This document is available to the public through the Highways for LIFE website:<br>http://www.fhwa.dot.gov/hfl/ |

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| Unclassified | Unclassified | 79 | |

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## SI* (MODERN METRIC) CONVERSION FACTORS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| (none) | mil | 25.4 | micrometers | μm |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | millimeters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| °F | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela per square meter | $cd/m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | Newtons | N |
| $lbf/in^2$ (psi) | poundforce per square inch | 6.89 | kiloPascals | kPa |
| $k/in^2$ (ksi) | kips per square inch | 6.89 | megaPascals | MPa |
| | | **DENSITY** | | |
| $lb/ft^3$ (pcf) | pounds per cubic foot | 16.02 | kilograms per cubic meter | $kg/m^3$ |

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| μm | micrometers | 0.039 | mil | (none) |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE** | | |
| °C | Celsius | 1.8C+32 | Fahrenheit | °F |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| $cd/m^2$ | candela per square meter | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | Newtons | 0.225 | poundforce | lbf |
| kPA | kiloPascals | 0.145 | poundforce per square inch | $lbf/in^2$ (psi) |
| MPa | megaPascals | 0.145 | kips per square inch | $k/in^2$ (ksi) |

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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# ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| AADT | annual average daily traffic |
| ABC | accelerated bridge construction |
| ADT | average daily traffic |
| AASHTO | American Association of State Highway and Transportation Officials |
| CMU | concrete masonry unit |
| CPI | consumer price index |
| DOT | department of transportation |
| ECI | employment cost index |
| FHWA | Federal Highway Administration |
| GRS | geosynthetic reinforced soil |
| HCM | Highway Capacity Manual |
| HfL | Highways for LIFE |
| IBS | integrated bridge system |
| IRI | International Roughness Index |
| MOT | maintenance of traffic |
| MVMT | Million vehicle miles traveled |
| OBSI | onboard sound intensity |
| OSHA | Occupational Safety and Health Administration |
| PBES | prefabricated bridge elements and systems |
| PDO | property damage only |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users |
| SMU | segmented masonry unit |
| SPMT | self-propelled modular transporter |
| UDOT | Utah Department of Transportation |
| VECP | value engineering change proposal |
| VOC | vehicle operating cost |

# INTRODUCTION

## HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration (FHWA) initiative to accelerate innovation in the highway community, provides incentive funding for demonstration construction projects. Through these projects, the HfL program promotes and documents improvements in safety, construction-related congestion, and quality that can be achieved by setting performance goals and adopting innovations.

The HfL program—described in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—may provide incentives to a maximum of 15 demonstration projects a year. The funding amount may total up to 20 percent of the project cost, but not more than $5 million. Also, the Federal share for an HfL project may be up to 100 percent, thus waiving the typical State-match portion. At the State's request, a combination of funding and waived match may be applied to a project.

To be considered for HfL funding, a project must involve constructing, reconstructing, or rehabilitating a route or connection on an eligible Federal-aid highway. It must use innovative technologies, manufacturing processes, financing, or contracting methods that improve safety, reduce construction congestion, and enhance quality and user satisfaction. To provide a target for each of these areas, HfL has established demonstration project performance goals.

The performance goals emphasize the needs of highway users and reinforce the importance of addressing safety, congestion, user satisfaction, and quality in every project. The goals define the desired result while encouraging innovative solutions, raising the bar in highway transportation service and safety. User-based performance goals also serve as a new business model for how highway agencies can manage the project delivery process.

HfL project promotion involves showing the highway community and the public how demonstration projects are designed and built and how they perform. Broadly promoting successes encourages more widespread application of performance goals and innovations in the future.

### Project Solicitation, Evaluation, and Selection

FHWA has issued open solicitations for HfL project applications annually since fiscal year 2006. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, and contacted applicants to discuss technical issues and obtain commitments on project issues. Documentation of these questions and comments was sent to applicants, who responded in writing.

The project selection panel consisted of representatives of the FHWA offices of Infrastructure, Safety, and Operations; the Resource Center Construction and Project Management team; the Division offices; and the HfL team. After evaluating and rating the applications and supplemental information, panel members convened to reach a consensus on the projects to recommend for approval. The panel gave priority to projects that accomplish the following:

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- Use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1 year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the applicant department of transportation (DOT) to participate in technology transfer and information dissemination activities associated with the project.

### HfL Project Performance Goals

The HfL performance goals focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. States are encouraged to use all applicable goals on a project:

- **Safety**
    - Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
    - Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.
    - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.
- **Construction Congestion**
    - Faster construction —Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
    - Trip time during construction — Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
    - Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).
- **Quality**
    - Smoothness—International Roughness Index (IRI) measurement of less than 48 in/mi.

- Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

- **User Satisfaction**—An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

## REPORT SCOPE AND ORGANIZATION

This report documents the Utah Department of Transportation (UDOT) HfL demonstration project for replacing two bridges located on the westbound and eastbound routes of I-84 near Echo Frontage Road in Summit County using innovative construction techniques such as geosynthetic reinforced soil-integrated bridge system (GRS-IBS), prefabricated bridge elements and systems (PBES), and lateral bridge sliding. The report presents project details relevant to the project innovations, HfL performance metrics measurement, and economic analysis. Technology transfer activities that took place to disseminate the project results and lessons learned are also discussed.

# PROJECT OVERVIEW AND LESSONS LEARNED

## PROJECT OVERVIEW

The project involved the replacement of the eastbound and westbound bridges located on Interstate 84 (I-84) over Echo Frontage Road near Echo in Summit County, Utah (50 miles east of Salt Lake City).The structure was constructed in 1971 and carries the designation D-783 in UDOT's bridge management system. The project limits extended approximately from milepost 118 to milepost 120. The innovative techniques adopted for the replacement of the bridges were as follows:

- Use of the GRS-IBS method of foundation design and construction.
- Use of (PBES).
- Use of accelerated bridge construction (ABC) lateral bridge slide.

This was the first GRS-IBS project to be conducted in Utah and also the first GRS-IBS project on an interstate in the U.S. Also this was the first GRS-IBS project to incorporate a lateral bridge slide. On this project, UDOT used a price + time or price + time + lane rental bidding process.

This project involved a three-phase construction sequence, as described below:

1. Phase 1: Construct the new eastbound bridge superstructure on GRS abutments in the median (temporary location).
2. Phase 2: Replace the I-84 westbound bridge in place. Once the median bridge was constructed, the westbound bridge was closed, and the westbound traffic was diverted to the median crossover. The existing westbound bridge structure was then demolished and reconstructed using the GRS-IBS method. After construction completion, the westbound traffic was moved back from the median bridge to the new bridge.
3. Phase 3: Replacement of the I-84 eastbound bridge. After the westbound bridge was opened to traffic, the eastbound bridge was closed and its traffic shifted to the median crossover bridge. The eastbound bridge structure was then demolished and reconstructed using the GRS-IBS method. On August 17, 2013, the median superstructure was transversely slid to the eastbound bridge with a single overnight closure (27 hours) to its permanent GRS abutments. The roadway approaches were then completed with asphalt overlay and required tie-ins. The completed bridge was opened to eastbound traffic on August 18, 2013. During the closure, the existing eastbound traffic was detoured across US 30 Old Highway route from milepost 115 to exit 169 leading to the Echo Reservoir.

The newly constructed bridges had 57'8" ft span lengths. The superstructure of each bridge weighed about 800,000 lbs. The bridge decks for both the eastbound and westbound bridges were prepared using precast concrete components, which helped reduce the construction time considerably for this important interstate corridor.

The construction phasing and accelerated bridge construction techniques used on this project, for which UDOT is well known around the country, significantly reduced the amount of time the roadway was out of service thereby reducing traffic impacts considerably.

To estimate the cost savings for the GRS-IBS method, the total costs were computed for both the as-built and baseline (cast-in-place) scenarios by adding the agency costs and user costs. The results indicated a cost savings of around 8 percent over the baseline scenario mainly attributable to the significantly reduced user costs of the as-built scenario.

### HfL Performance Goals

Safety, construction congestion, quality, and user satisfaction data were collected before, during, and after construction to demonstrate that innovations can be an integral part of a project while simultaneously meeting the HfL performance goals in these areas.

- **Safety**
  - Work zone safety during construction—No incidents occurred during the entire construction period including the closure period. This meets the HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate.
  - Worker safety during construction— One worker was injured on the project. However, the contractor achieved a score of less than 4.0 on the OSHA Form 300 thus meeting the HfL goal for this category.
  - Facility safety after construction— This project did not explicitly address safety improvements to the facility. This HfL goal is therefore not applicable.

- **Construction Congestion**
  - Faster construction—The GRS approach shortened the duration of traffic impacts from an estimated 194 days using traditional construction methods to 34 hours of full closure. The HfL goal of a 50 percent reduction in the time traffic is impacted compared to traditional construction methods was met.
  - Trip time— The temporary median bridge helped the project meet the HfL goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions.
  - Queue length during construction—The project met the HfL goal of less than a 1.5-mile queue length in urban areas, as there was no queuing observed.

- **Quality**
  - No IRI and OBSI data was collected for this project since the bridges were too short (less than 100 feet) for any meaningful data to be obtained. However, UDOT personnel have observed the ride over both GRS-IBS bridges to be extremely smooth (in contrast to the majority of other bridges over the Utah metropolitan areas).

### Economic Analysis

The costs and benefits of this innovative project were compared with those of a project of similar size and scope delivered using a more traditional approach. The economic analysis showed that UDOT's approach to this project resulted in a calculated cost savings of approximately $360,000 or 8 percent of the total project over conventional construction practices. A significant amount of this reported cost savings was attributable to reduced user costs. Per the Contractor's Project Manager, the selection of the GRS-IBS system over the conventional deep foundation system resulted in lower bid costs.

## LESSONS LEARNED

Through this project, the UDOT gained valuable insights with regard to the innovative construction techniques and materials used. The following were some of the lessons learned:

- There is a need to evaluate the use of two crane system for bridge slide to facilitate better management of the slide control.
- Although not an issue on this project, better coordination is desired among various disciplines of the agency including central office, traffic operations, construction, geotechnical, structures etc., to expedite delivery in future projects.
- Development of a more contractor-involved approach is recommended in order to ensure the proper installation and protection of instrumentation.
- For projects involving ABC bridge moves, adequate consideration should be given to ensure appropriate (optimum) moisture levels during the placement of untreated base course for bridge approaches. Providing sufficient time between final base course placement and paving operations would allow for stabilization of moisture levels in the untreated base course.

The contractor also had the following inputs for future projects related to the bridge construction:

- Flexibility in the boom of the crane could be better accounted for to allow smoother bridge slide operation.
- For the bridge slide, a bulkhead could be placed on the back side of the end diaphragm to provide a solid place to push off from when the jacks are used.
- For future slides, there is a need to get familiar with the equipment. The slide on this project did not require the lifting of the bridge to either remove track or lubricate tracks. However, on future slides, a scenario that requires the lifting of the bridge cannot be ruled out.

## CONCLUSIONS

UDOT gained valuable insights on the use of GRS-IBS bridge abutments and the improvements needed to make this process a more viable tool. The use of innovations such as GRS-IBS and lateral bridge slide met the HfL performance goals by reducing construction time, reducing costs, improved rideability, reducing congestion, and increasing motorist and worker safety.

# PROJECT DETAILS

## BACKGROUND

The project involved the replacement of the eastbound and westbound bridges located on Interstate 84 (I-84) over Echo Frontage Road near Echo in Summit County, Utah (50 miles east of Salt Lake City). The existing bridges, constructed in 1971, comprised of a three span cast-in-place rigid frame structures with steel column bents and pile foundations (designated as D-783 in UDOT’s bridge management system). Figure 1 shows the project location.

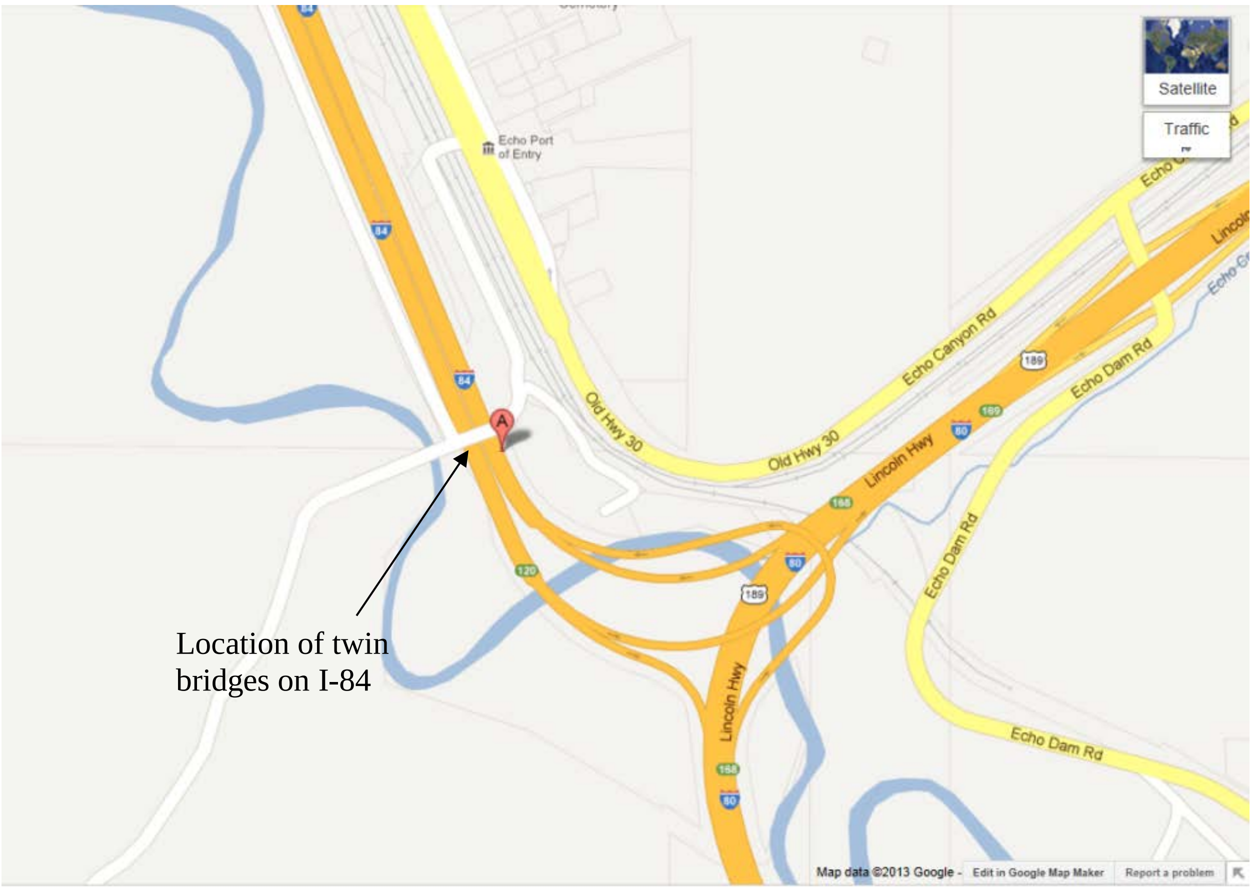



Figure 1. Map. Project location.

Figure 2 presents a view of the one of the bridge structures bridge. The Echo Frontage road located below the existing bridges has been shown in figure 3.

Figure 2. Photo of one of the I-84 bridge structures (source: Google Maps).

The project limits extended approximately from milepost 118 to milepost 120 on I-84. Figure 4

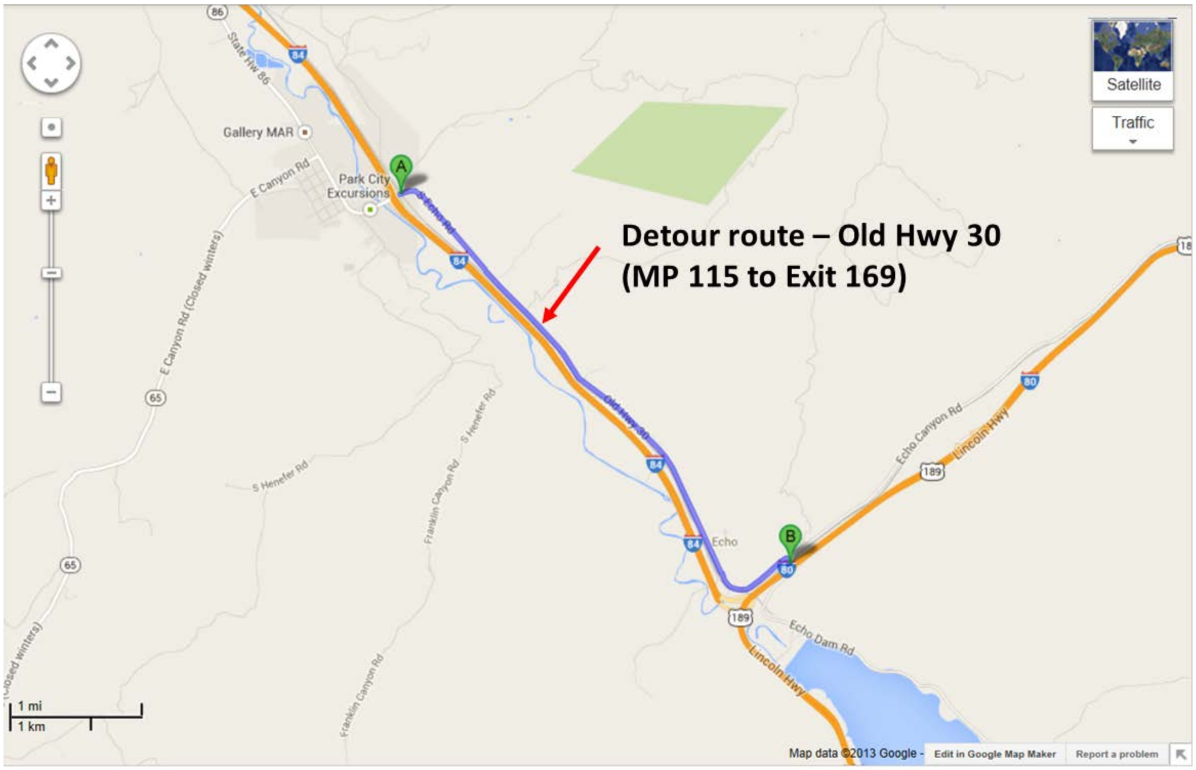



Figure 4. Map. Detour route – Old Highway 30 (highlighted in blue).

## PROJECT DESCRIPTION

### Existing Bridge Information

The existing eastbound and westbound bridge structures were deemed structurally deficient. In addition, they did not provide the desired 15-foot vertical clearance beneath the structure. The existing bridges consisted of a three-span superstructure providing a total span length of approximately 86 feet and carried two lanes of traffic in each direction. The total width of each bridge superstructure was 44 ft and 4 inches. The superstructure was a cast-in-place reinforced concrete solid-slab structure with a slab thickness varying between 1 foot 3 inches to 2 feet and an approximate 3-inch asphalt overlay provided over the concrete slab. The abutments and bent caps were supported by steel piles and were aligned perpendicular (90 degrees) to the longitudinal axis of the superstructure.

### Contract and Bidding Information

UDOT aggressively pursues the goals of reducing road user and worker impacts during construction on all its bridge construction projects while balancing its other goals of cost-effectiveness and quality. It has long used accelerated bridge construction (ABC) methods for bridge replacements. In its endeavor to continually evolve its ABC toolkit, the Department also constantly seeks to research and introduce new construction solutions. For this project, it was determined that the lateral bridge slide approach combined with GRS-IBS would provide an optimal solution. GRS-IBS has never been used by the agency and it is an innovation being promoted under the FHWA Every Day Counts (EDC) initiative. However, the UDOT geotechnical engineer for the Project had served on the first two NCHRP research committees for GRS-IBS bridges (along with the FHWA partners who spear-headed its development).

Considering that the GRS-IBS technology was never previously used in conjunction with the lateral bridge slide in Utah, the agency's experienced personnel were closely involved in the in-house design process and construction coordination as well. In this way, UDOT provided a level playing field for the contractors, as even first-time bidders with no prior GRS-IBS experience were considered. Table 1 presents the contract time information for this project.

Table 1. Contract time for the I-84 GRS-IBS project.

| **Project Contract Time** |
|---|
| 110 calendar days (winning bid by contractor) |
| 120 calendar days (engineer's estimate) |
| Allowed calendar days – minimum 90 to maximum180 (per UDOT Specifications) |

This project used a price + time or price + time + lane rental bidding process. This project also included an incentive/disincentive clause. The time incentive/disincentive for the I-84 closures for the eastbound bridge slide was as follows:

- Less than 26 hours—$10,000/hr (2 hours maximum) incentive.
- 26 hours to 26 hours 59 minutes—$0.
- 27 hours to 32 hours 59 minutes—$2,500/hr disincentive.
- 33 hours to 38 hours 59 minutes—$5,000/hr disincentive.
- 39 hours to unlimited—$10,000/hr disincentive.

The maximum incentive for this project was $20,000. The clause also included an additional disincentive of $500/hr, for an unlimited amount of time, for exceeding closures of the frontage road beneath I-84. Per the contract, time savings resulting from a value engineering change proposal (VECP) were not to be financially compensated to the contractor above the maximum dollar amount eligible for incentive payment. No VECP was submitted for this project.

At the end of this project, the contractor was awarded full incentive of $20,000 for the bridge slide. The key milestones from the project schedule are shown in table 2.

Table 2. Key project milestones.

| **Activity** | **Date** |
|---|---|
| Project begin | April 22, 2013 |
| Preparation for bridge slide to be completed | August 10, 2013 |
| Bridge slide | August 17, 2013 |
| Bridge open to traffic | August 18, 2013 |
| Project completion (substantial completion) | August 25, 2013 |

**New Bridge Specification**

The newly constructed EB and WB bridges had a 57’8”-ft span, and a total bridge width of 45 ft and 53 ft respectively.

The cross-section details of the new bridge and the GRS abutment details for both westbound and eastbound directions are provided in figures 5 through 7.

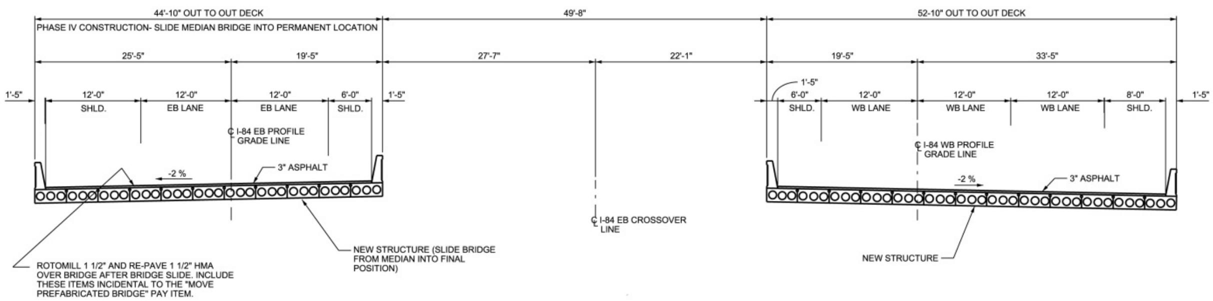



Figure 5. Diagram. Cross-section details of the new bridge (courtesy: UDOT).

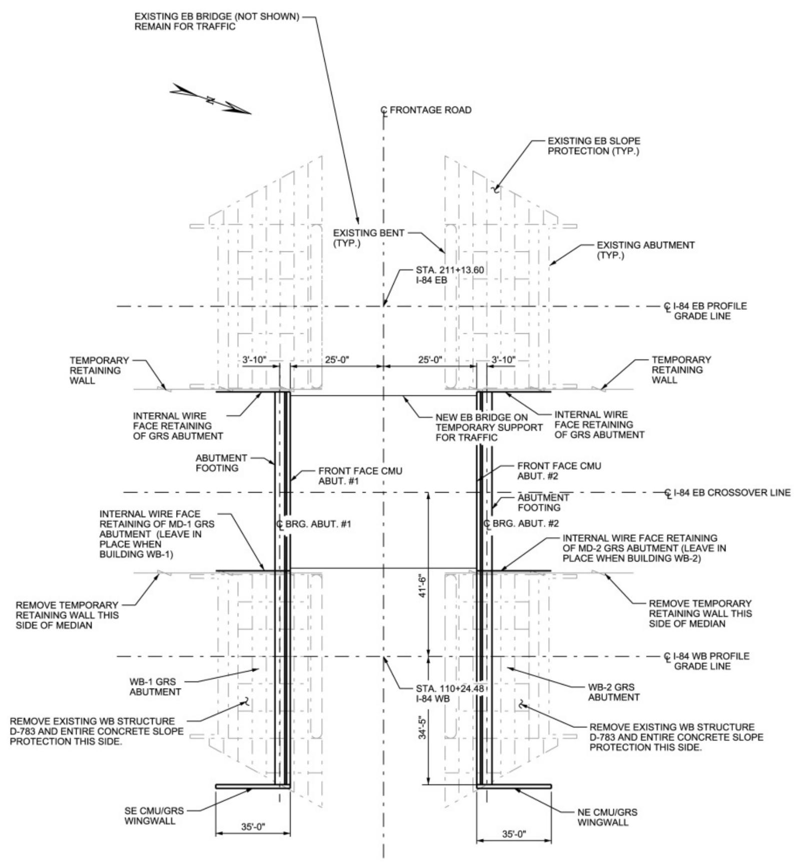



Figure 6. Diagram. Westbound GRS abutment details (courtesy: UDOT).

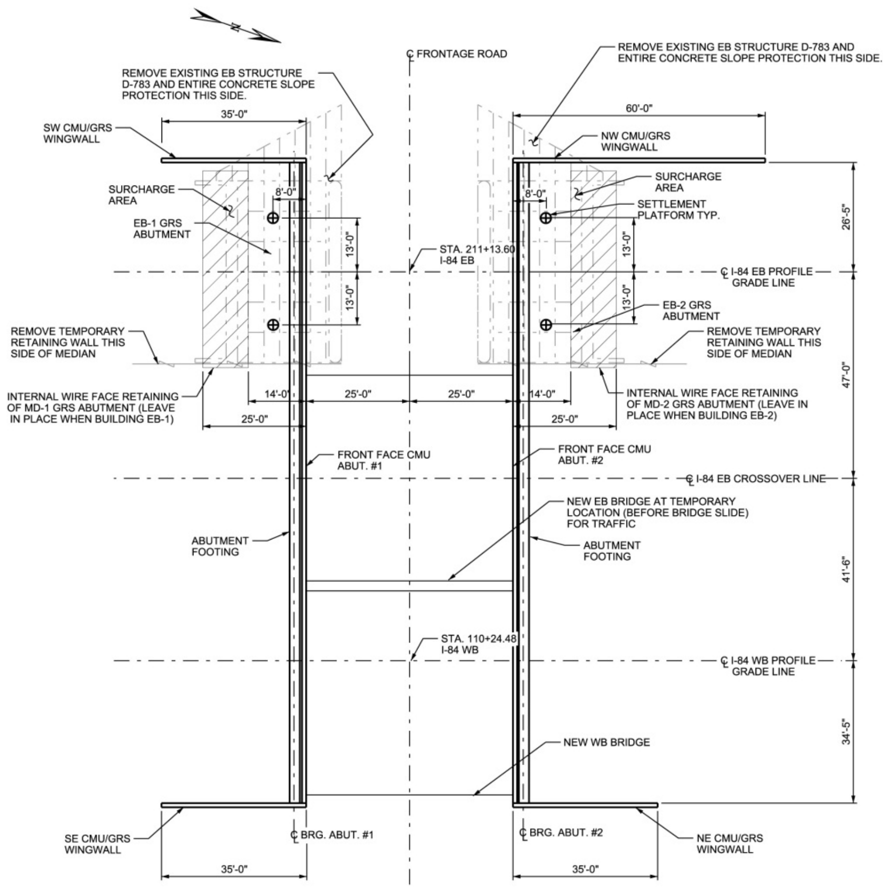



Figure 7. Diagram. Eastbound GRS abutment details (courtesy: UDOT).

## Environmental Impact

This project was found to have no significant impacts on the environment, and there were no unusual circumstances as described in 23 CFR 771.117(b). This project was thus categorically excluded from the requirements to prepare an environmental assessment or environmental impact statement under the National Environmental Policy Act.

## Public Involvement Plan

As with all their ABC projects, one of UDOT's goals was to maintain a high level of public involvement and communication throughout this project. Specific groups targeted were the trucking industry and recreational travelers. Messaging included an explanation of the need, impacts, and detours associated with the project. Another goal was to highlight UDOT's leadership in innovation with regard to the GRS technology to the general public at large as well as bridge practitioners nationwide. To accomplish this, a public involvement team was formed for the project to coordinate and help UDOT host a project showcase in coordination with and support from the HfL program. A project time lapse video and a short informational video on the GRS-IBS technology and its key advantages were also developed.

Although the project is not located near any large metropolitan area within Utah, the I-84 interchange in Echo is traveled by public traveling to and from Salt Lake Valley to northeastern Utah and Wyoming. Although Echo has never had a sizable population, the town is historically significant and draws visitors from across the State. In addition, the Echo Reservoir, situated a few miles southeast of the project area, receives high volumes of traffic through the summer months from people seeking to use the reservoir for recreational purposes.

As most of the construction occurred during the peak recreational season, the project public involvement team had to strategically communicate closures and possible delays in a timely manner to the traveling public. The public involvement team was required to regularly inform local emergency services, highway patrol, and trucking industry of impacts or closures on the project as well.

The public involvement tasks included:

- Coordinating with the contractor and setting expectations, project details, and benefits by holding one kickoff meeting prior to the construction, in April 2013.
- Emailing project updates to a stakeholder opt-in list every 2 weeks between May and October 2013 (or through project completion) to inform recipients of upcoming impacts and progress.
- Successfully pitching at least one positive story in Utah about UDOT's innovative use of GRS technology.
- Developing two videos, one time lapse and one short educational piece, about GRS technology and presenting at an HfL showcase.
- Hosting an HfL showcase the day after the bridge slide at the conclusion of the project.

**Stakeholder Outreach**

The primary stakeholder groups were identified as:

- Local Echo residents/business owners.
- Wide-load truck traffic.
- General traffic.
- Ragnar Relay (area event that happened during the construction).

Table 3 describes the outreach approaches taken with each of these stakeholder groups.

Table 3. Stakeholder outreach approach. (courtesy: UDOT)

| Stakeholder Group | Outreach Approach |
|---|---|
| Local residents/business owners | The homes and businesses surrounding the project site were contacted. The local businesses at the east frontage road along I-84 were periodically contacted to check for any concerns they had that could be resolved. Hotline and email addresses were established for the project. |
| Wide-load truck traffic | Echo Port of Entry was regularly updated to inform the wide-load truck traffic of any restrictions that were put in place on I-84 during construction. They were made aware of all changes in wide-load restrictions. |
| General traffic | Weekly updates were provided for the Renovate 80 website. These updates gave detailed descriptions of what traffic impacts to expect within the project limits. |
| Ragnar Relay | The planners of the Ragnar Relay race were contacted through email in case they needed to get in touch with the project team. The project team actively sought to reduce any impacts that might affect the race, since the route ran directly through the project limits. The contractor facilitated the removal of all traffic control and construction activities for the weekend of the race. |

**ABC Process and Selection**

The design team surveyed the existing structure to understand the geometry constraints before finalizing the specific ABC approach. UDOT's design process involved evaluating the feasibility of adopting ABC based on site conditions and geometry. Different criteria were evaluated, including project schedule, environmental issues, total project cost, site conditions, and indirect costs. UDOT's standard ABC rating procedure was also used for determining the ABC rating score for the project. Figure 8 shows UDOT's standard ABC rating decision flowchart.

The final ABC method was chosen based on the coordination with roadway and the project design team. The ABC method evaluation was carried out using the elimination criteria. The following ABC techniques were evaluated:

- Self-propelled modular transporter (SPMT) moves.
- Launching.
- Crane lift.
- Lateral slide.

The SPMT and launching options were eliminated because they were expensive. The SPMT move would have cost UDOT substantially more than what they finally spent on the project for the bridge move. Furthermore, the limited spacing between bridges made the use of both SPMT and launching infeasible.

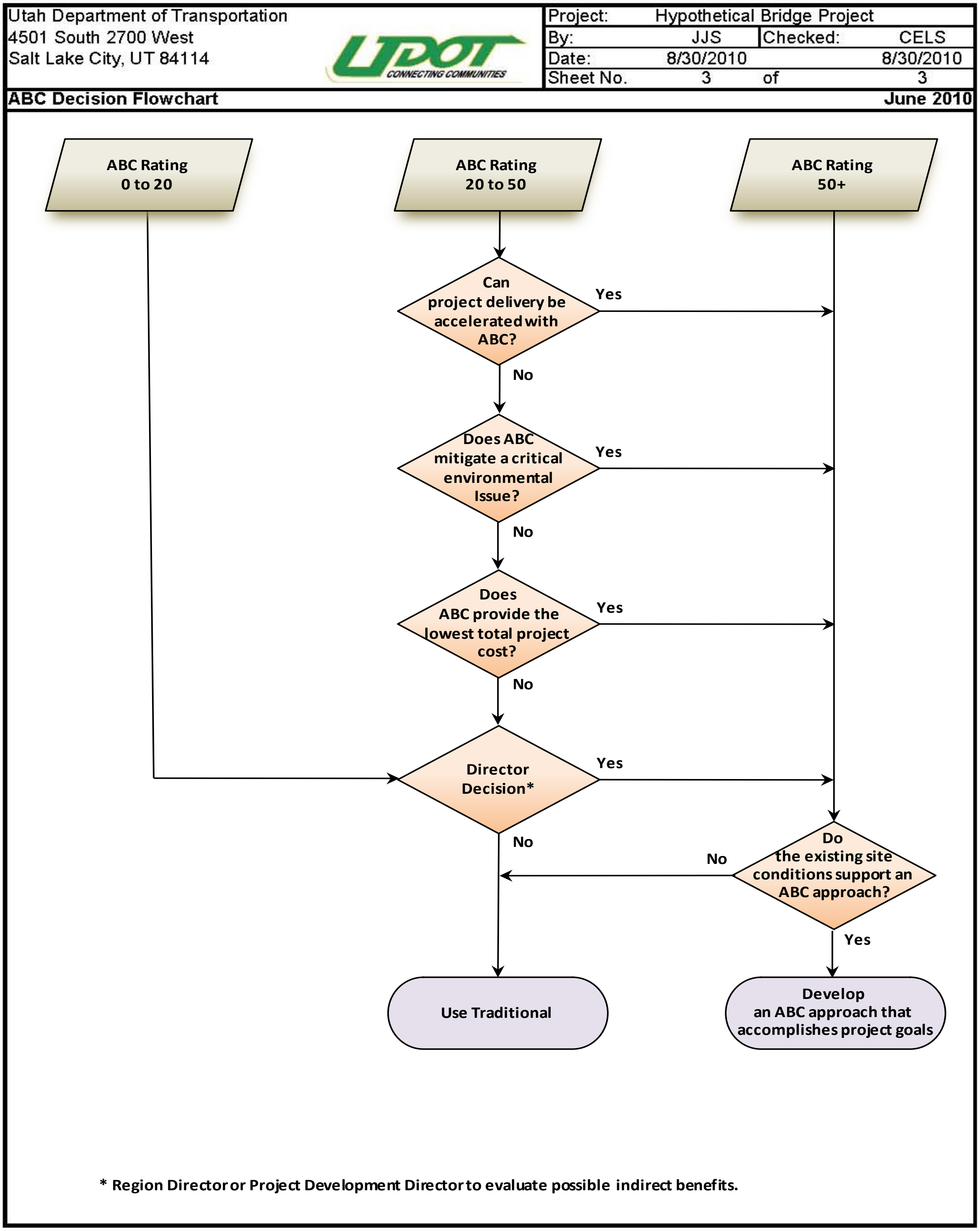



Figure 8. Chart. UDOT standard ABC decision flowchart (source: UDOT).

The lateral slide was selected because it was deemed the best fit for the desired maintenance of traffic (MOT) plan and because it would result in minimum traffic impacts given the 27-hour full closure.

**Geotechnical Design**

From a geotechnical investigation perspective, compared to the mechanically stabilized earth wall systems, more attention was given to soil compressibility and to the strength parameters at the upper strata. Eight borings were taken to analyze soil samples. The soil strata were found to be favorable for GRS-IBS, with a soil profile consisting of several layers of gravel, clayey sand, lean clay, and silty clayey sand. The bridge superstructure had a dead load of about 12,000 lbf and live load of 7,000 lbf. The design bearing capacity was 4,000 psf (consistent with the maximum recommended by FHWA recommendations), and the maximum service load was 3.5 ksf (dead load = 2.3 ksf, live load = 1.2 ksf). In the design, to accomplish the phasing system to accept the ABC slide approach, a pair of GRS abutments was planned for each of the three phases: the median, the westbound, and the eastbound construction, with the modular block facing for all three phases lined up to provide a continuous wall face.

To accomplish the median approach, a sturdy system consisting of an internal wire-facing approach along with the geotextile burrito-wraps was intended to retain the backfill. Figure 9 shows the internal wire-facing approach intended for the phased abutment construction. The Contractor however, proposed to use sacrificial modular blocks in lieu of the wire-facing, which the Department accepted and was successfully accomplished in providing sturdy fill retainage for the temporary traffic conditions.

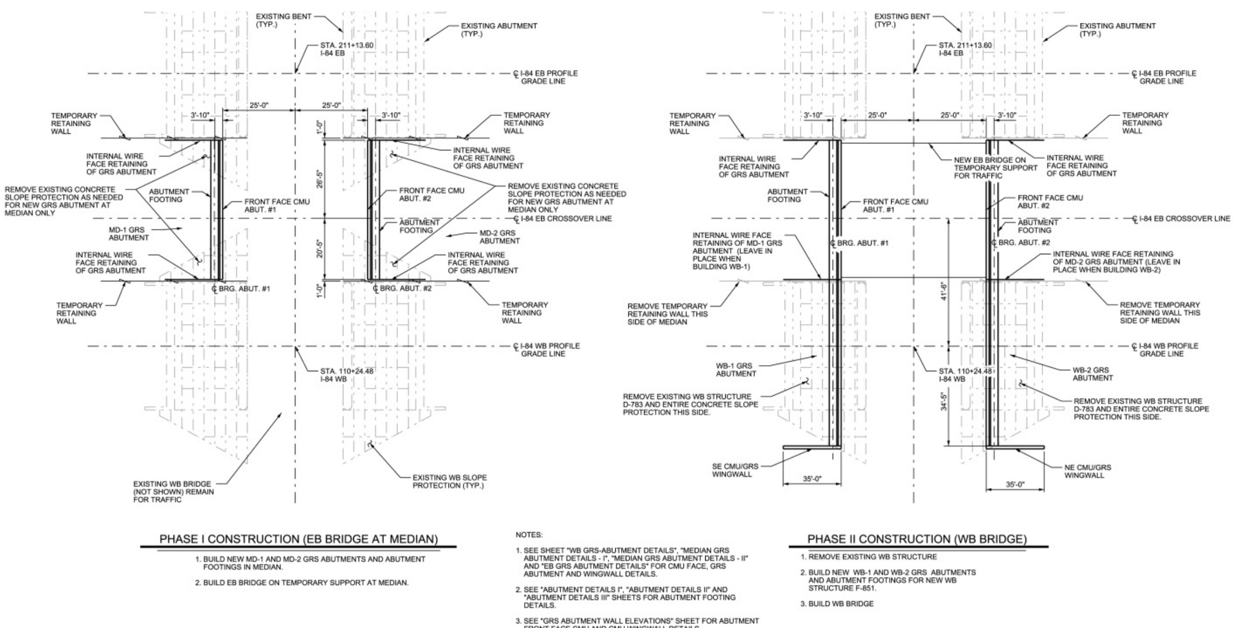



Figure 9. Diagram. Plans showing the internal wire face retaining of the GRS abutment (courtesy: UDOT).

For the GRS wall construction, a geotextile material made of 4800 lb/ft woven biaxial polypropylene and a high-quality backfill with a design friction angle of 42 degrees were chosen (the latter of which lies at the far upper end of the current GRS design guidelines). Two gravel sources, 3 and 6 miles away from the project site, provided the backfill. The gravel consisted of UDOT-approved untreated base course material. To assess the quality of the backfill material, the UDOT geotechnical team had the samples from both sites tested for direct shear at the FHWA Turner-Fairbank Highway Research Center. The test results indicated that one of the pit sources had a friction angle of 52 degrees and the other had a friction angle of 57 degrees. The high friction angles confirmed that the material was of top quality.

To accommodate the GRS abutments, a voided slab system/precast box system was used for the superstructure because they were lightweight and helped in faster construction.

The geotextile material directly underneath the bearing footing was placed at 4 inches, half of the regular thickness of 8 inches. These upper layers of reinforcement are called the bearing bed layer.

While the westbound GRS abutments were designed based on the standard designs recommended by FHWA, the median and eastbound GRS abutment designs were modified to include provision for the bridge diaphragm that had to be slid over the footing to facilitate the slide. A 2-ft thick zone of over-excavation and replacement foundation was called for in the design of the westbound and eastbound abutments; however, based on geotechnical observations during construction, portions of this prescribed over-excavation was waived due to presence of competent granular soils The footing, or bearing sill as it is normally called, is placed directly on the GRS mass. The bearing sill used for the median and eastbound abutments were 2.5 inches thick and 4 feet, 4 inches wide. While the FHWA standards recommend a sill thickness of 6 to 12 feet, a conservative design with a heavily reinforced 2.5-ft thick bearing footing was adopted for this project to conservatively account for potential sliding forces for the bridge slide. A clean gravel zone (designed at 2 ft 4 in, but 1 ft, 4 in wide was actually used) was provided alongside and above the bearing footing for ease of fill placement, compaction and removal during the ABC closure period. This compacted gravel zone was covered with the geotextile. Figure 10 and 11 present schematic diagrams for the abutments.

Webbed segmental block units from Amcor in North Salt Lake, Utah (a division of Oldcastle) weighing 94 lb were selected by the Contractor for the project. Fiberglass pins (Contractor’s option), as shown in figure 12, were used to align the segmental block units.

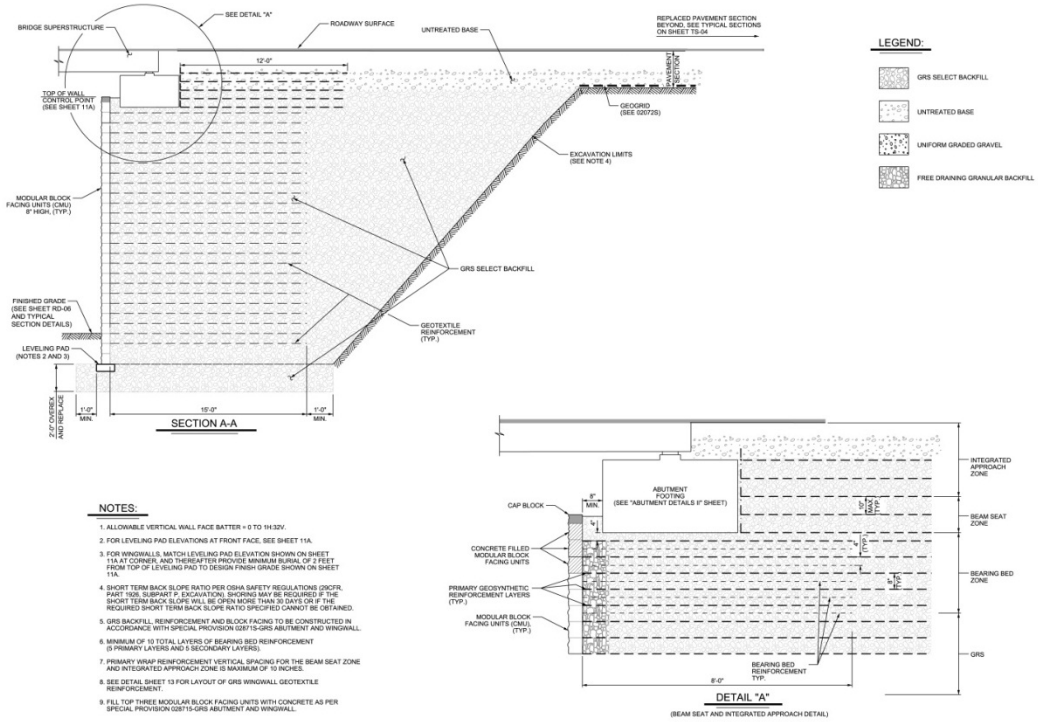



Figure 10. Diagram. Schematic of the westbound abutments.

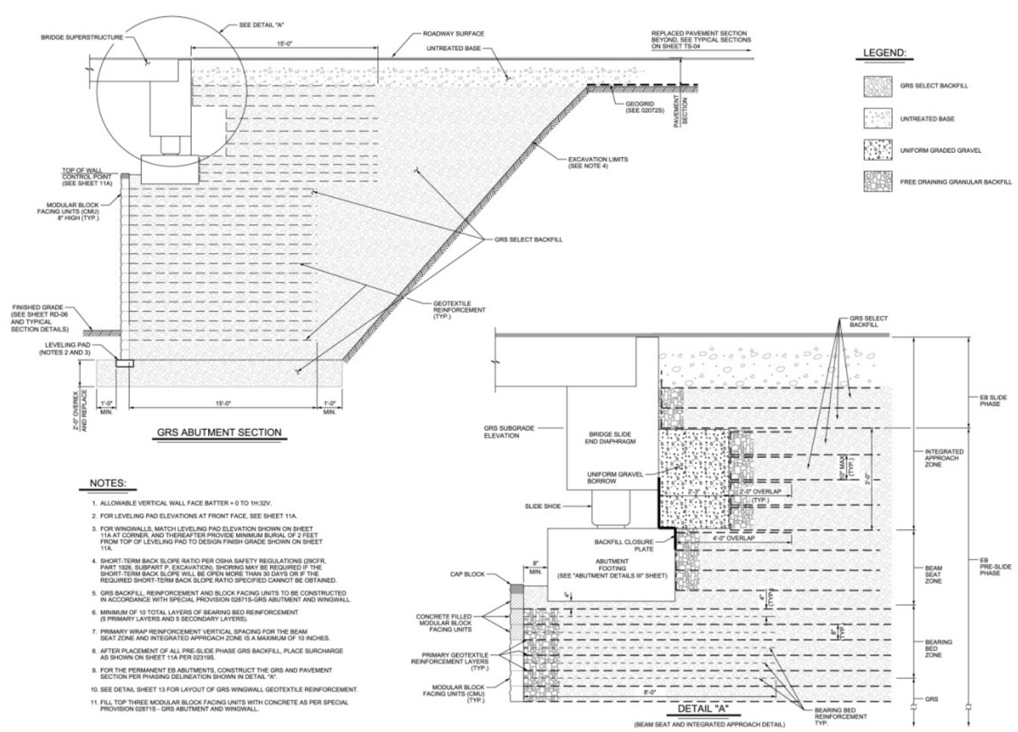



Figure 11. Diagram. Schematic of the eastbound and median abutments.


Figure 12. Photo. Segmental block units with fiberglass pins.

The origin-restoring friction damper methodology was used for seismic design. Seismic design factors, particularly seismic sliding, were accounted for during the design. The peak horizontal ground acceleration design value was 0.25 g (g is the acceleration due to Earth's gravity, equivalent to g-force). Successful full-scale shake table tests, conducted by the NCHRP 12-59(01) GRS research project at a loading level of 1.0 g (considerably higher acceleration value) to assess the seismic design of bearing capacity, indicated that the GRS-IBS bridges would be able to withstand earthquakes of higher magnitudes.

## Instrumentation Program

As shown in figure 13, UDOT’s Structures Division funded an array of survey targets as a part of the instrumentation program for the project. A couple of pressure cells were installed on the inside and the outside of the footing. IRI profile data were collected before the traffic was placed on the eastbound bridge.

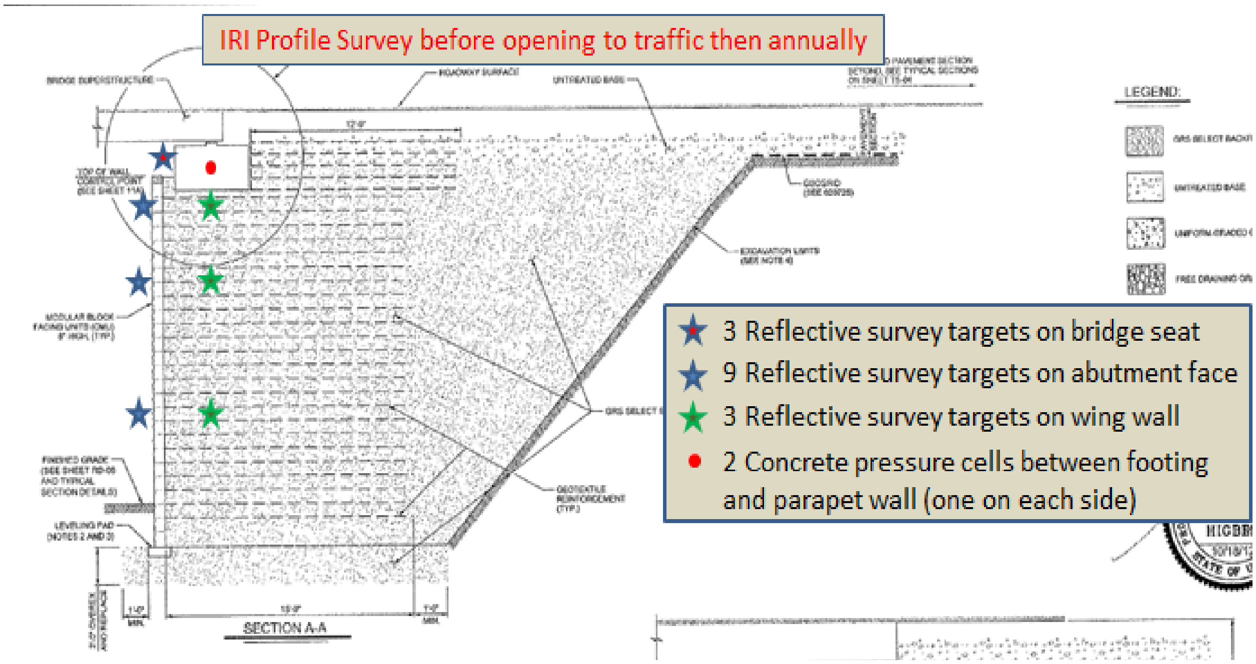



Figure 13. Diagram. Survey targets for I-84 bridges (courtesy: UDOT).

The soil structure at the GRS base location was composed of a dense sandy gravel layer with an underlying stiff clay layer. Due to the presence of the Weber River about 100 feet east of the eastbound bridge, the clay layer thickness was greater for the eastbound bridge than the westbound bridge. With the additional presence of compressible soils on the eastbound bridge location, and because of the bridge slide, a surcharge along with two settlement platforms was used for the abutment on the eastbound bridge. The surcharge and settlement platforms are shown in the plans illustrated in figure 14. Figure 15 shows the surcharge placed on the eastbound bridge.

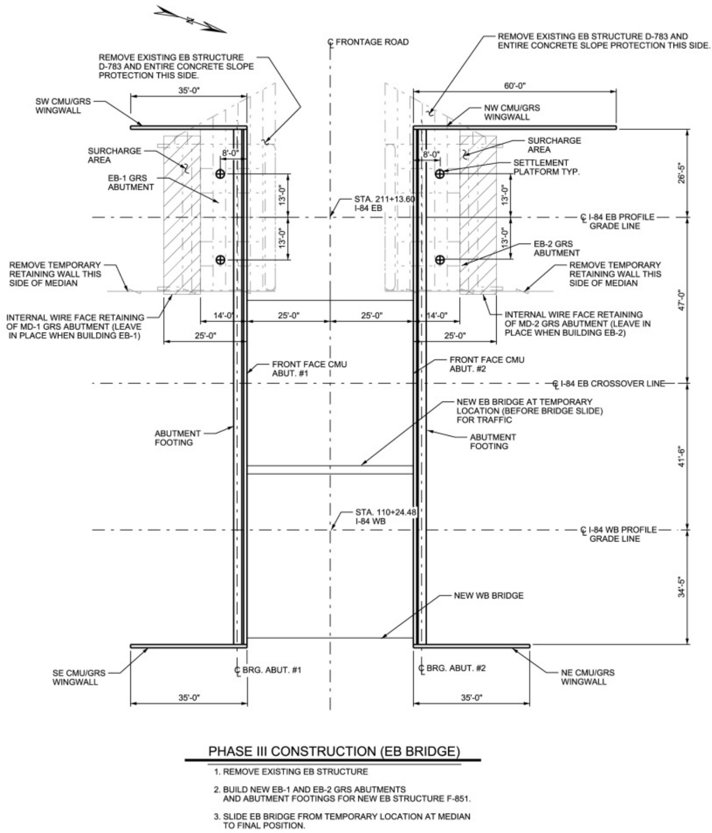



Figure 14. Diagram. Eastbound surcharge and settlement platforms.

Figure 15. Photo. Surcharge placed on the eastbound bridge (courtesy: UDOT).

Manometer-type settlement platforms were used to observe the settlement of the surcharge on the eastbound bridge. Figure 16 shows the settlement platform used to measure the surcharge settlement.

As per the contract, the necessary settlement was expected in 3 weeks, but the surcharge was removed after 14 days due to less-than-expected settlement. As shown in figure 17, survey targets, an inclinometer, and two horizontal pressure cells were placed on the westbound bridge north wall face. For this particular project, FHWA felt that the use of this instrumentation plan on the bridge wall would be beneficial for research purposes.

Figure 16. Photo. Settlement platforms.

Figure 17. Photo. Survey targets and inclinometers placed on the eastbound bridge wall (courtesy: UDOT)

Figure 18 presents the inclinometer results. UDOT engineers estimated the maximum cumulative displacement of the wall on July 23, 2013, to be around 0.07 inches, and they felt the value was well within reasonable limits, thus further indicating high stability of the wall.

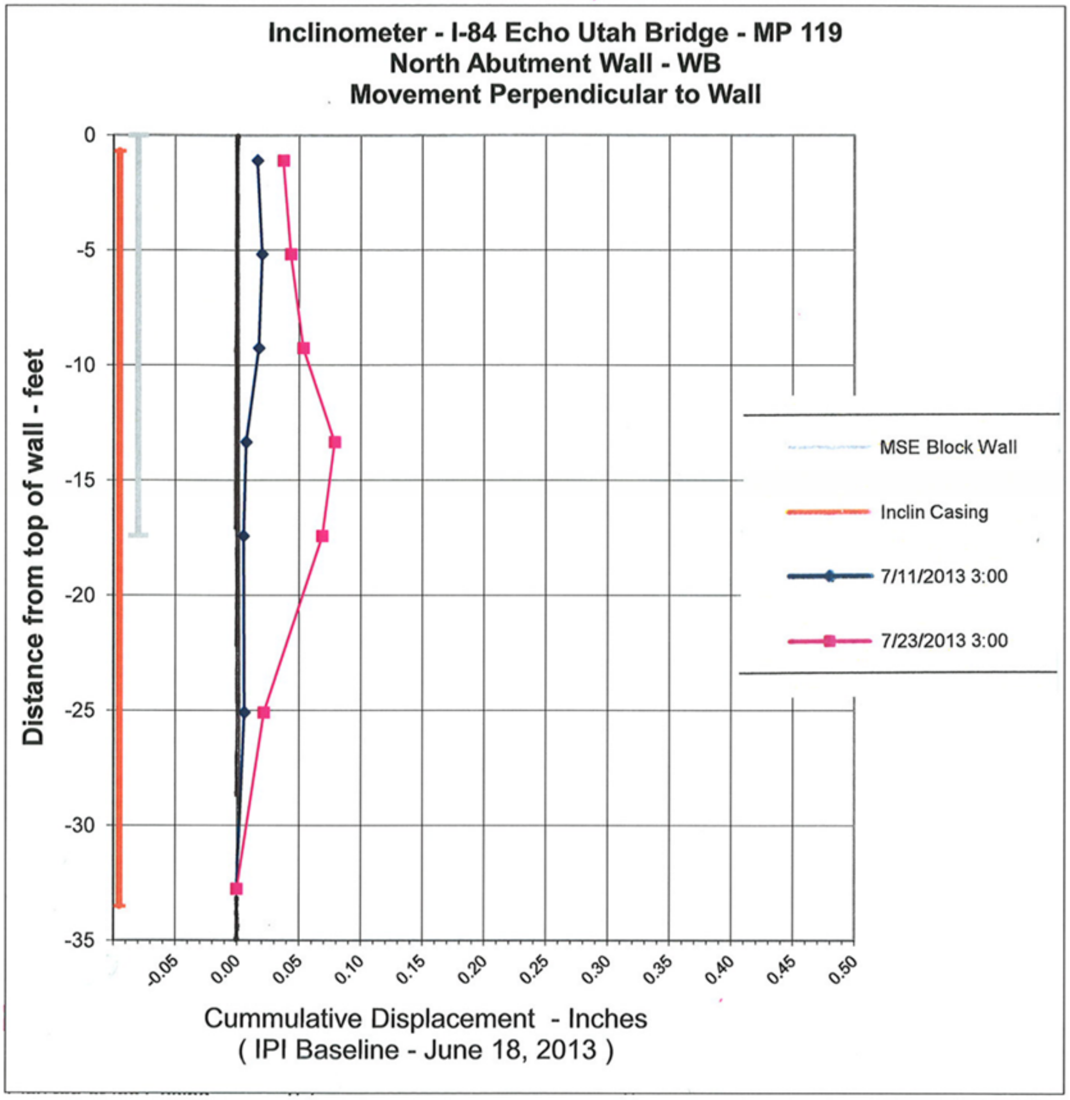



Figure 18. Graph. Inclinometer results.

Figure 19 shows the pressure cell readings from the instrumentation program.

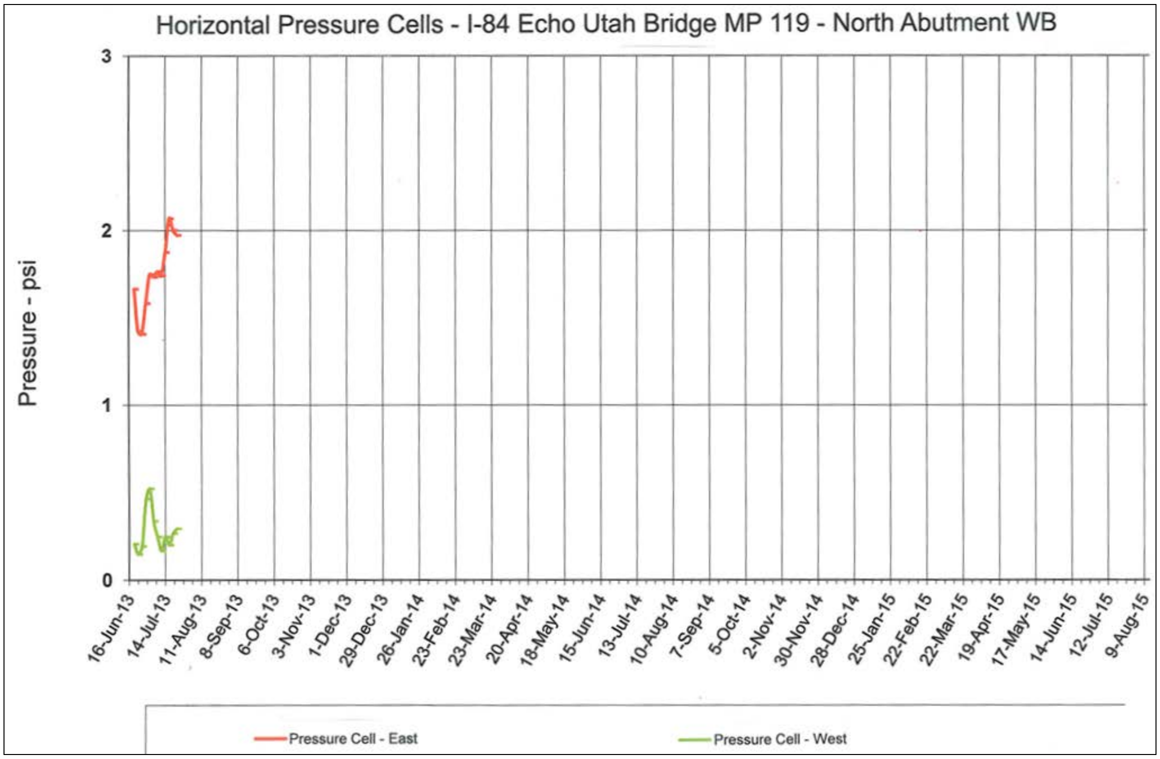


Figure 19. Graph. Pressure cell readings from instrumentation program.

**Innovative Technologies**

The innovative techniques involved during the replacement of the twin bridges on I-84 are as follows:

- GRS-IBS.
- PBES.
- Lateral bridge slide.

The span length and site conditions made this project an attractive candidate for the use of the GRS-IBS method of design and construction. With the original bridge length of 88 ft, GRS-IBS allowed for the new supports to be constructed such that the bridges were reduced to a single clear span of 50 ft each. The ABC approach was adopted to minimize traffic impacts during construction.

The design consisted of twin precast prestressed concrete voided slab girders and an asphalt overlay wearing surface. A single clear span of 50 ft was planned to provide an increased underpass width for the county road and save on the overall structure length. The new eastbound bridge would carry two 12 ft traffic lanes, a 12 ft outside shoulder, a 6 ft inside shoulder and two 1.5 ft wide parapets for a total bridge width of 45 ft. The new westbound bridge would carry three 12 ft traffic lanes, an 8 ft outside shoulder, a 6 ft inside shoulder and two 1.5 ft wide parapets for a total bridge width of 53 ft.

The project involved a three-phase construction sequence as described below:

1. Construct eastbound bridge in median (temporary location). In the initial stages of the construction, a median crossover bridge was constructed between the existing twin bridges, using the GRS-IBS method. This involved the following steps:
    i. Preparing ground and placing the GRS fill.
    ii. Constructing spread footing for the eastbound bridge.
    iii. Constructing the superstructure.
    iv. Constructing temporary westbound roadway crossover approaches to this median bridge.
    v. Placing an asphalt overlay.
    vi. Moving/diverting westbound traffic to the median bridge and closing access to the westbound bridge.

2. Replace the I-84 westbound bridge. Once the median bridge was constructed, the westbound bridge was closed, and the westbound traffic was diverted to the median crossover. The second phase involved the following steps:
    i. Removing existing westbound bridge structure.
    ii. Constructing new westbound bridge (built in place):
        - Preparing ground and placing the GRS fill.
        - Constructing spread footing.
        - Constructing superstructure.
        - Building roadway approaches to new westbound bridge.
        - Placing asphalt overlay.
        - Moving westbound traffic from median bridge back to westbound bridge (new bridge).
        - Constructing temporary eastbound roadway crossover approaches to median bridge.

3. Replace the I-84 eastbound bridge. After the westbound bridge was opened to traffic, the traffic from the eastbound bridge was shifted to the median crossover bridge. The third phase of construction involved the following steps:
    i. Removing existing eastbound bridge structure.
    ii. Constructing eastbound substructure:
        - Preparing ground and placing the GRS fill.
        - Constructing spread footing.
        - Building roadway approaches.
        - Closing eastbound traffic for an intended 27 hours to facilitate the transverse slide.
        - Sliding eastbound bridge from median to final location.
        - Completing roadway approaches, asphalt overlay, and required tie-ins and opening bridge to eastbound traffic.

The project consisted of two closures, an overnight closure and an intended 27-hour closure during the eastbound bridge slide. The overnight closure occurred during removal of two overhead sign structures, which were later replaced with two new overhead sign structures (with flashing beacons). During the closures, the existing eastbound traffic was detoured across US 30 Old Highway from milepost 115 to exit 169 leading to the Echo Reservoir.

## GRS-IBS Construction

As mentioned earlier, this project involved construction of eastbound, westbound, and median bridges using GRS method. The purpose of constructing a median crossover bridge for this project was to help users avoid taking frequent detours during the construction process, thereby minimizing the traffic impacts and vehicle delay costs. Prior to commencing the median bridge construction, traffic controls were placed and temporary striping was carried out on both the eastbound and westbound routes of I-84. Variable message signs cautioning roadway users of ongoing construction and reduced speeds were also displayed on various segments of I-84 westbound and eastbound, as well as on I-80 route from Salt Lake City to Coalville.

Construction on the median crossover bridge started on April 23, 2013. The first 2 days involved roadway excavation and shoring for the GRS walls. Two dump trucks and two roadway excavators were used during this process. Figure 20 shows the roadway excavation being carried out for the median crossover bridge.

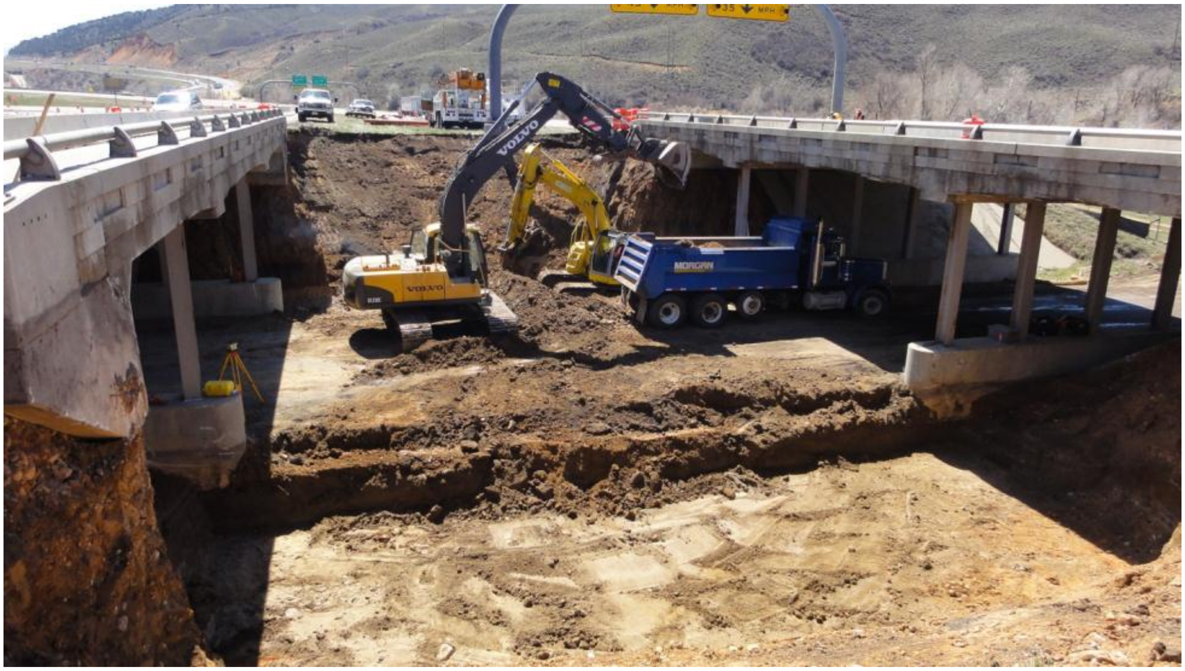


Figure 20. Photo. Roadway excavation for the median crossover bridge.

The shoring involved placing panels to provide lateral support to the GRS walls, as shown in figure 21. The shoring panels also served to retain the existing backfill.

Figure 21. Photo. Shoring panels.

After the project Geotechnical Engineer confirmed that over-excavation was not required for this subgrade area, the roadway excavation was followed by backfill and leveling of the surface. An experienced skid-loader operator, lasers and landscape rakes were used to level off the backfill. For the GRS backfill, the moisture conditioning was done at the source so that moisture was not lost when the materials were transported to the site. Dump trucks were used to transport the necessary soil for backfill purposes, as shown in figure 22. Figures 23 and 24 show the soil being distributed across the site location and the roller operations being conducted.


Figure 22. Photo. Dump trucks unloading soil for backfill purposes.


Figure 23. Photo. Soil being distributed across the site.

Figure 24. Photo. Roller operations.

The rolling operations were carried out to prepare the surface for pouring leveling pads for both of the abutments. Two different 5-ton rollers, one on each side of the abutment, were used for more effective rolling. The equipment operated roughly 3 feet away from the facing blocks. Figure 25 shows the formwork being placed for pouring concrete to prepare the leveling pad upon properly placed and compacted fill, as presented in figure 26.

Figure 25. Photo. Formwork for leveling pads.

Figure 26. Photo. Preparation of leveling pad.

The leveling pad, 18 inches wide and 6 inches thick, was allowed to cure for a period of 12 hours before the modular blocks could be placed. The concrete poured for the leveling pad had a compressive strength of 4000 psi. It should be noted that the concrete leveling pad is a nonstructural element that is used primarily to provide a level base to the GRS wall.

After curing, the first GRS layer was constructed over the leveling pad. The layer construction involved three major steps:

1. Placing a row of facing modular block.
2. Placing and compacting a layer of granular fill.
3. Laying a sheet of geosynthetic reinforcement.

This process was then continued for every layer constructed until the required height of abutment was reached. During the layer construction it was ensured that the excavator movement was limited towards the back of the abutment where it could reach and place material without having to be moved. The GRS wall construction process required a smaller crew of laborers and equipment operators.

For the GRS wall construction, UDOT allowed the contractor to choose between the concrete masonry units (CMU) and the segmented masonry units (SMU). Due to the time involved with getting the free stock tests done for the CMU blocks, the contractor opted for the SMU blocks. Despite being more expensive and heavier than the CMU blocks, the SMU blocks facilitated the early start of the project.

The first course of SMU blocks were placed on top of the cured leveling pad. For ensuring accurate and acceptable results, full contact was achieved between block units of the first course and the leveling pad. The first course was thus checked for level and alignment. The second course of SMU blocks was then placed on top of the first one. Figure 27 shows the SMU blocks with fiberglass pins inserted between the two courses. A stringline was used to check for the alignment of the second course, and the SMU blocks were adjusted using a mallet, as shown in the figure. Figure 28 shows the two completed courses of SMU blocks.

Figure 27. Photo. Aligning the second course or SMU blocks.

Figure 28. Photo. Two completed courses of SMU blocks.

Although the FHWA standard recommendations require the top three courses of CMU blocks to be grout filled and occasionally rebared for geo and seismic stability, UDOT decided to forgo that requirement for the SMU blocks since the SMU shape was not compatible with grout filling.

After every course of SMU units was placed, the surface was filled and compacted using granular material. A maximum loose lift of 10 inches was specified; however, the contractor found that only about 9-inch loose lifts of the high-quality backfill were required to achieve the 8-inch lift thickness. Figure 29 presents the density measurements conducted on the compacted surface.

Figure 29. Photo. Density measurements being taken.

Table 4 shows the maximum dry density values obtained on field density measurements. Only about 15 percent of the initial test readings were below the specified 95 percent of the AASHTO T-99-10 specification (Standard Proctor), which states that, for well-graded fills, the backfill material shall be compacted to at least 95 percent maximum dry density.

Table 4. Maximum dry density measurements. (source: UDOT).

| **Maximum Dry Density** | **Percent** |
|---|---|
| < 95% | 14.9% |
| 95-98% | 58.6% |
| > 98% | 26.5% |

The geotextile material used for reinforcement purposes on this project was made of high-density biaxial, woven, polypropylene resin, polymer tensile fabric. The woven geotextile material, selected by the Contractor as shown in figure 30, was of Tencate-Mirafi HP570 grade.

Figure 30. Photo. Woven geotextile material.

After the SMU blocks were placed and the surface compacted with granular fill, the geosynthetic reinforcement was placed. The geosynthetic material was rolled out on top of the compacted surface, as shown in figure 31.

Figure 31. Photo. Geotextile reinforcement placed on the compacted surface.

The placement of geosynthetic material was followed by the placement of the next course of SMU blocks (with fiberglass pins still being inserted for alignment purposes) and granular fill on top of it. The granular fill was then compacted, and the three steps were repeated for every course. Figure 32 presents the granular fill placed on top of the geosynthetic material.

Figure 32. Photo. Granular fill placed on top of the geosynthetic material.

The reinforcement spacing was 8 inches for the bottom layers and 4 inches for the top four courses. As shown in figure 33, the top four courses included wrapped geotextile layers that were used to wrap the face of the soil lifts to provide a near-vertical face to accommodate sliding of the superstructure into place.

Figure 33. Photo. Top four courses of geotextile-wrapped layers (courtesy: UDOT).

Figure 34 shows the bridge bearing sill/abutment footing, which was placed adjacent to the top layers. The bearing footings were 2.5 feet thick and 4 feet, 4 inches wide, and were double-mat reinforced with No. 5 bars. The footing was conservatively designed to accommodate perceived possible lateral stresses from the superstructure ABC slide.

Figure 34. Photo. Bearing sill/footing (courtesy: UDOT).

Once the bearing footing forms were placed, the concrete was poured in it and allowed to cure. Preparation of GRS-IBS median abutments was followed by placement of the design EB superstructure onto the GRS abutments. With the design of the voided-slab superstructure this construction went quickly. The traffic cross-over onto this bridge was then made on the evening of May 30, 2013. The existing I-84 westbound bridge was then demolished, which was followed by diversion of westbound traffic from the westbound bridge to the median bridge and closing access to westbound bridge, construction of westbound GRS fills with facing blocks (using same procedures as for the median GRS abutments), and placement of the prefabricated (voided slab) bridge deck elements for the new westbound bridge.

Once the new westbound bridge was constructed, on June 26, 2013 the WB traffic from the median bridge was diverted back to the westbound bridge. Soon following this, the traffic from eastbound bridge was diverted to the median bridge and access to the existing eastbound bridge was closed. The eastbound bridge was then demolished and reconstructed using GRS-IBS abutments. Figure 35 shows the demolition of the eastbound bridge.

Figure 35. Photo. Eastbound bridge being demolished (courtesy: UDOT).

As discussed earlier, the GRS abutments for the median and eastbound abutments were substantially different from the standard GRS design used for the WB abutments, in order to accommodate bridge slide. To provide access for the diaphragm base for the ABC slide, four additional geotextile wrap layers were placed above the bearing footing level for both the median and eastbound bridges, as shown in figure 36. The space between the additional wrapped layers above the abutment footing and bridge diaphragm base was filled with uniform gravel borrow after the slide was completed. This space was designed to be 2.3 feet wide to accommodate a worker with compaction equipment. However, the Contractor felt that approximately 1 foot wide would provide adequate space; this request was accepted by the Department and proper compaction within this zone did not appear to be compromised.

Figure 36. Photo. Geotextile-wrapped layers placed above the bridge footing (courtesy: UDOT).

**Prefabricated Bridge Elements**

Prior to the slide, the prefabricated (voided-slab) bridge superstructure elements were transported to the project site. The bridge elements were then efficiently installed by tying the slab elements together and then post-tensioning. Although the plans detailed a cast-in-place abutment diaphragm base, the contractor suggested using a precast diaphragm base. UDOT accepted this idea, as the use of the precast diaphragm provided more horizontal and vertical control during installation. Figures 37 through 39 show the bridge deck elements being moved to the bridge location.


Figure 37. Photo. Bridge deck elements being moved to the bridge location using a crane (courtesy: UDOT).


Figure 38. Photo. Bridge deck elements being placed (courtesy: UDOT).


Figure 39. Photo. Bridge deck on the median bridge (courtesy: UDOT).

## Lateral Bridge Slide

The lateral bridge slide of the eastbound bridge was determined to be conducted during the HfL showcase site visit. A 27-hour full closure was enacted for the eastbound bridge lateral slide. The lateral slide considerations for this project were as follows:

- Transposing structure.

  - Elevations at temporary location should match final location (settlement control was crucial in this regard).
- Providing redundancies.
  - Need to provide strength and rigidity for slide so that the critical elements of the bridge are not compromised.
  - Need for realistic tolerances for strength, geometry, and deflections.
- Evaluating sliding methods.
  - Use of rollers, sliding pads.
  - Use of push/pull jacks, cables.
  - Estimate of lateral control.

Prior to the actual bridge slide, the ground work for the slide had to be carried out. For the eastbound bridge slide scheduled on August 17, 2013, the preparation was completed by August 10, 2013. The ground work included preparation of the sliding pads on the abutment footings and setting up of the anchorage mechanism for the slide cables.

The contractors felt that the slide process was easier since the precast beams were lighter. The absence of an approach slab made the bridge lighter, and the slide tolerances could be cut down. Figure 40 shows the bridge diaphragm being delivered to the project location.

Figure 40. Photo. Bridge diaphragm being delivered to the site (courtesy: UDOT).

As a design contingency, slide shoes were prescribed for use during the slide process. The use of slide shoes, with access in between, provided an option for lifting the bridge and accessing the bearings in case there was a need to level surfaces. The slide shoe provided a cost-effective option for UDOT. The slide shoes used during this project were 6 feet long and 14 inches wide clad with stainless steel at the bottom. The slide shoes are shown in figures 41 and 42.

Figure 41. Photo. Slide shoes.

Figure 42. Photo. Slide shoe (side view).

For this project, sliding pads were used instead of rollers. Sliding pads provided better cushion than rollers and did not require higher tolerances, as in the case of rollers where the sliding surface had to be leveled before the slide took place. The sliding pads used for this project were 1.75 inches thick.

The slide shoes were slid on the Neoprene bearing pads that were 1 foot by 1 foot in size. The static friction of the Neoprene pads was about 10 percent when lubricated, and the moving friction (during the slide) was 3 to 4 percent. Each slide shoe rested on five Neoprene pads. The spacing between the pads was around 12 to 14 inches. Figure 43 shows the Neoprene pads placed on the bearing sill before the commencement of the slide.

Figure 43. Photo. Neoprene pads for slide (courtesy: UDOT).

Figure 44 shows the bridge diaphragm being placed at the center median. The slide involved using cranes, which provided better control. The crane was parted as an eight-part system to slow down the amount of cable (shown in figure 45) taken up as much as possible and to have control of the pressure on the system. The cable came down through a snatch block that was redirected through the end diaphragms, as shown in figure 46. The contractors were given an option to choose between push/pull jacks and cables for the slide itself; they chose to use the cables for the bridge slide.

Figure 44. Photo. Bridge diaphragm being placed at the center median (courtesy: UDOT).

Figure 45. Photo. Cable used for bridge slide.

Figure 46. Photo. Snatch block connecting to the cable.

A 40,000-lb load from each abutment was transferred through each cable. This load was taken through the footing through the connection bracket to the deadman bracket. The cable terminated at the backside of the bridge. Figure 47 shows the cable termination point.

As one might visualize from Figures 45 and 46, as the slide reached the end of its run, the skew angle of the cable from horizontal increased, thereby increasing the required tensile cable force from the downward vector component drag, making the slide somewhat more difficult.


Figure 47. Photo. Cable termination point.

Figure 48 shows the pink rigid foam pads that were used as filler material between the bridge diaphragm base and the bridge deck.


Figure 48. Photo. Rigid foam pads used as fillers.

As shown in figure 49, to have better horizontal control over the bridge slide, push/pull jacks were used to adjust the piece of timber in the gap between the bridge deck and the ground surface.

Figure 49. Photo. Push/pull jacks employed for better horizontal control during the slide.

There were times during the slide when even backhoes had to be used to control the horizontal slide of bridge towards one direction, as shown in figure 50.

Figure 50. Photo. Backhoe used to control the horizontal slide in one direction.

Figures 51 through 53 present the bridge sliding process.

Figure 51. Photo. Bridge being slid across.

Figure 52. Photo. Bridge slide completed.

Figure 53. Photo. Eastbound bridge slid into final location.

Figure 54 shows backfilling the gaps between bridge deck and the approaches and overnight paving.

Figure 54. Photo. Overnight paving in the eastbound direction.

On August 18, 2013, the eastbound bridge was opened to traffic. From August 18 to August 25, 2013, paving and other activities were carried out on Echo Frontage Road below the I-84 twin bridges. The project met substantial completion on August 25, 2013.


Figure 55. Photo. Eastbound bridge opened to traffic (courtesy: UDOT).

# DATA ACQUISITION AND ANALYSIS

Data on safety, traffic flow, quality, and user satisfaction before, during, and after construction were collected to determine if this project met the HfL performance goals. The primary objective of acquiring these types of data was to quantify project performance and provide an objective basis from which to determine the feasibility of the project innovations and to demonstrate that the innovations can be used to do the following:

- Achieve a safer work environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Produce a high-quality project and gain user satisfaction.

This section discusses how well the UDOT project met the HfL performance goals related to these areas.

## SAFETY

The HfL performance goals for safety include meeting both worker and motorist safety goals during construction.

There was one contractor injury or incident during construction. While pulling nails from 2x4s, an employee stepped on a nail. The injury was minor and did not result in loss of work for the worker. Overall, the contractor exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate).

There were no work zone related crashes or motorist injuries during construction. Work zone safety was ensured by completely closing the bridge to traffic, accelerated construction, use of prefabricated bridge components, and use of a detour route.

Table 5 provides the preconstruction crash data based on severity type for the project location. These data from UDOT were collected for a total of 0.51 miles (from milepost 119.00 to milepost 119.51) on I-84, which covered the project limits. The preconstruction crash data provided the history of crashes, based on severity type, from 2008 through 2011.

Table 5. Preconstruction crash statistics (Source: UDOT).

| **Crash Severity** | **Number of Crashes** |
|---|---|
| 5-Fatal | 0 |
| 4-Incapacitating Injury | 0 |
| 3-Non-Incapacitating Injury | 3 |
| 2-Possible Injury | 0 |
| 1-No Injury/PDO | 8 |
| Crash Period: 01-01-2008 to 12-31-2011 (1461 days) | |
| Crash Limits: I-84 Milepost between 119.00 and 119.51 (i.e. 0.51 miles) | |

The average daily traffic (ADT) and million vehicle miles traveled (MVMT) information from 2008 through 2011 is provided in table 6. The ADT data were obtained from the traffic statistics provided on the UDOT website.

Table 6. ADT and MVMT information

| Year | ADT | Length | MVMT |
|---|---|---|---|
| 2008 | 9,500 | 0.51 | 1.773270 |
| 2009 | 9,485 | 0.51 | 1.765633 |
| 2010 | 8,715 | 0.51 | 1.622297 |
| 2011 | 8,045 | 0.51 | 1.497577 |

Based on the preconstruction crash statistics and the MVMT information, the total crash rates, fatality rates, injury rates, and property damage only (PDO) rates were calculated. The calculated crash rates are provided in table 7.

Table 7. Calculated preconstruction crash rates.

| Parameters | Pre-construction (2008 to 2011) |
|---|---|
| Days of Coverage | 1461 |
| Average ADT from 2008-2011 (vpd) | 8936 |
| Section Length (mi) | 0.51 |
| Million Vehicle Miles Traveled | 6.7 |
| Total Crash Rate (crashes/MVMT) | 1.65 |
| Fatality Rate (crashes/MVMT) | 0.00 |
| Injury Rate (crashes/MVMT) | 0.45 |
| PDO Rate (crashes/MVMT) | 1.20 |

## CONSTRUCTION CONGESTION

The accelerated construction techniques used in this project reduced the time highway users were affected by more than 50 percent. Under the traditional construction scenario, the roadway closure time would have been slightly more than 6 months. During this project, the total roadway closure was 34 hours (7 hours during removal of overhead sign structures and 27 hours during bridge slide). The days of impact were April 17 and August 25, 2013.

### Check for Queuing

Since the traffic was diverted from two lanes on I-84 in a single direction to one lane in a single direction on the detour route of Old Highway 30, a two-lane undivided highway, it was necessary to check for queuing. Per the Highway Capacity Manual (HCM) [1], the capacity in one direction for a two-lane highway is 1,700 passenger cars per hour (pc/h) under base conditions and 1,500 pc/h when the opposing flow is maximum. After adjusting the base capacity of the two-lane highway for heavy vehicles, the capacity of Old Highway 30 was calculated to be 1,560 pc/h. The heavy vehicle adjustment factor was determined using the equation shown in figure 56.

$$f_{hv,ATS} = \frac{1}{P_T(E_T-1)}$$

where $f_{hv,ATS}$ = heavy vehicle adjustment factor for ATS estimation
$P_T$ = proportion of trucks in the traffic stream (decimal), and
$E_T$ = passenger car equivalent for trucks

Figure 56. Equation. Calculation of the heavy vehicle adjustment factor.

The peak hour volume on the detour Old Hwy 30 was assessed based on results from Automatic Traffic Recorders (ATR) stations presented on the UDOT Traffic Statistics webpage. Since there were no ATR stations in the near vicinity of the project site, the hourly traffic volume trends on the detour were estimated based on the ATR counts at milepost 92.593 on I-84 at Morgan County. (2) The ATR data was used to determine average percent peak hour volumes for the month of August 2013, in both traffic directions. Figure 57 presents the traffic trends on milepost 92.593 of I-84 in the month of August, 2013.

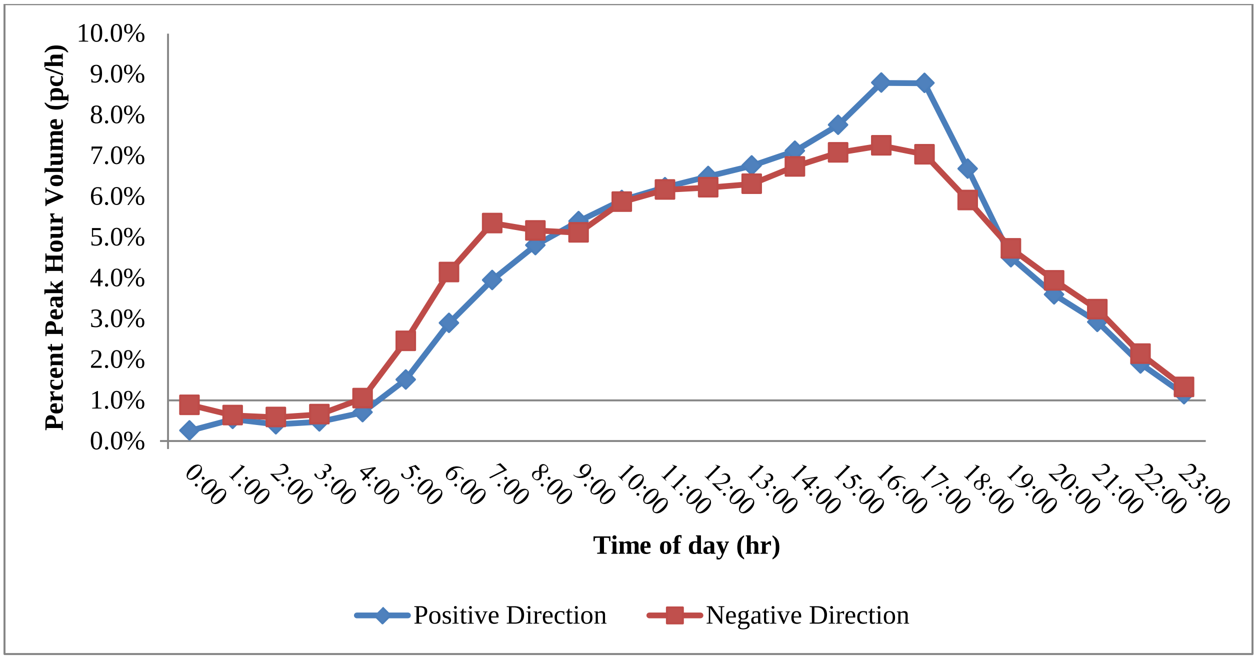



Figure 57. Percent peak hour volumes at I-84, milepost 92.593

The trends indicate that the maximum value of average peak hour volume for August 2013 was 8.8 percent. Assuming the traffic trends at the project location (I-84, milepost 115 to milepost 120) to be similar to that on I-84, milepost 92.593, the peak hour volume for the detour Old Hwy 30 was calculated as 356 vehicles/hr. The hourly volume data for milepost 92.593 in August 2013 also indicated that the maximum peak hour traffic on a single day in August 2013 was 11.4%. For 11.4% traffic, the maximum peak hour volume on Old Hwy 30 was 462 vehicles/hr, which is far less than previously established lane capacity of 1560 pc/h. Thus, it can be safely assumed that in the month of August 2013, there was no queuing on the detour route of Old Hwy 30.

This project thus met the HfL goal of less than a 1.5-mile queue length in urban areas, as there was no queuing observed.

### TRAVEL TIME

Data were collected utilizing the floating vehicle methodology in an effort to match the driving speeds of other vehicles along the eastbound and westbound I-84 routes as well as the detour route on Old Highway 30.

A preliminary assessment of the annual average daily traffic (AADT) data on I-84 route revealed historically lower traffic volumes, as shown in table 8. Additionally, the hourly data collected at the nearest weigh-in-motion station on I-80 indicated that the traffic hits a plateau between 10 am and 5 pm (see figure 58). Considering these two factors of low traffic volume on I-84 and absence of distinct peak hour trends, it was assumed that there is no need to collect travel time data for morning, noon, and afternoon peak hours separately. Thus, it was decided that the travel time data would be collected five times per direction on both eastbound and westbound routes.

Table 8. Route details.

| Route Name | Beg. Accum. Mileage | End Accum. Mileage | Location Description | AADT | | |
|---|---|---|---|---|---|---|
| | | | | 2011 | 2010 | 2009 |
| 84 | 115.399 | 119.773 | SR 65 East Henefer - I 80 | 8,045 | 8,715 | 9,485 |

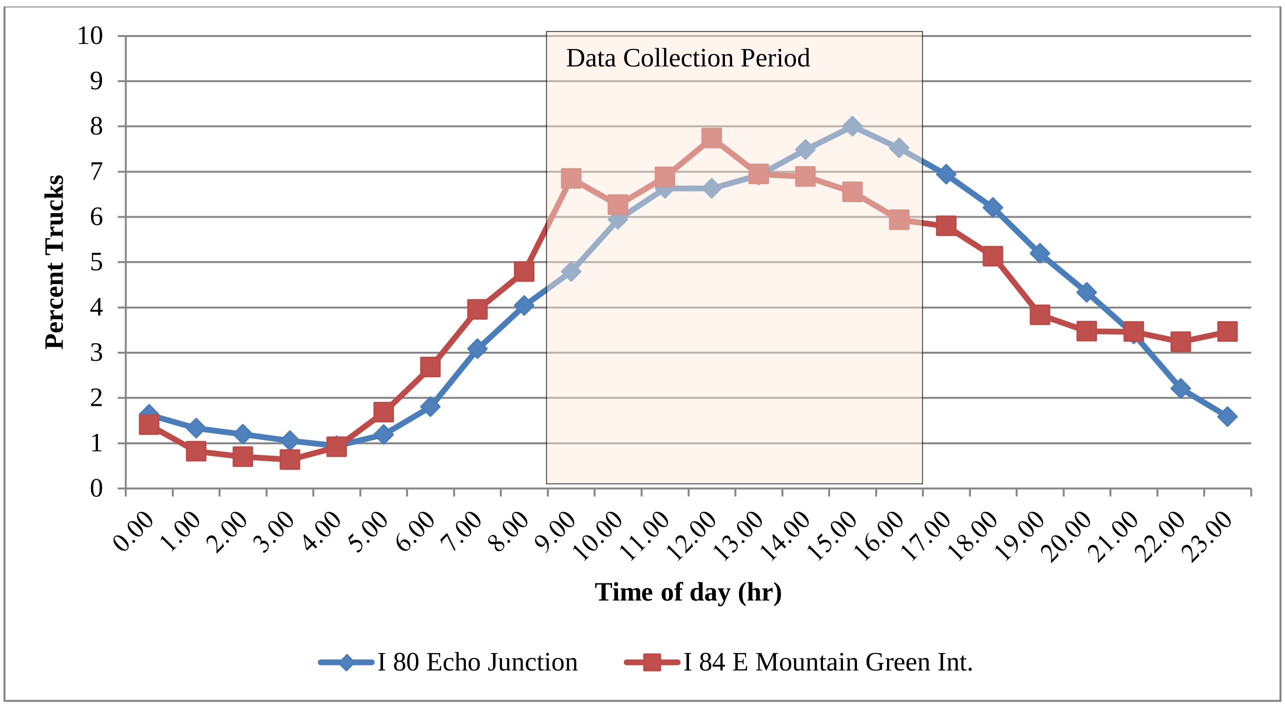



Figure 58. Graph. Hourly traffic on I-80.

Figure 59 through 61 present the travel time data collection routes used in this study.

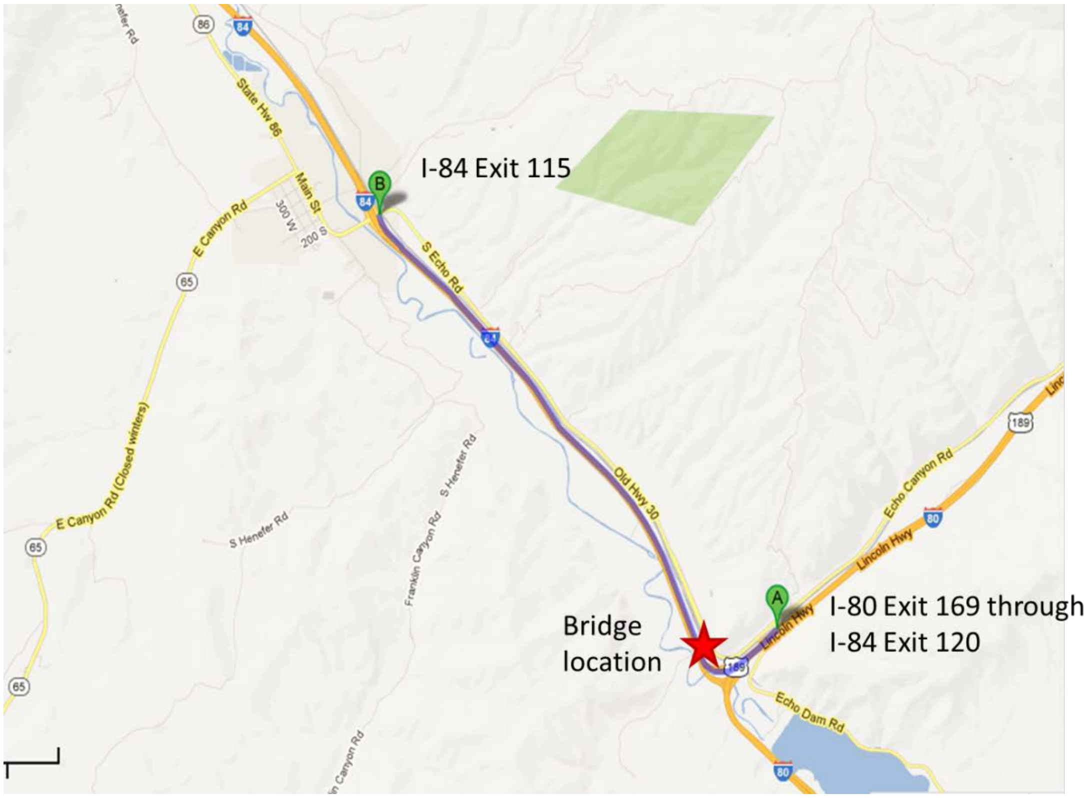


Figure 59. Map. Destination and origination points for trip time data collection.

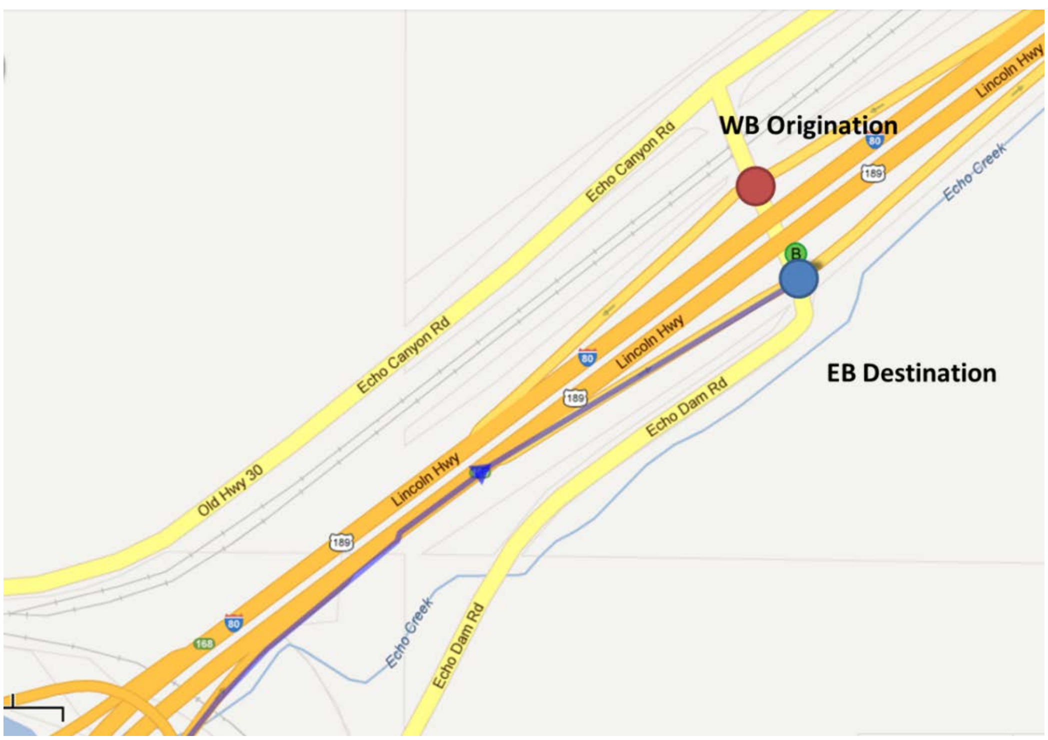


Figure 60. Map. I-80 exit 169 (nearest eastbound exit).

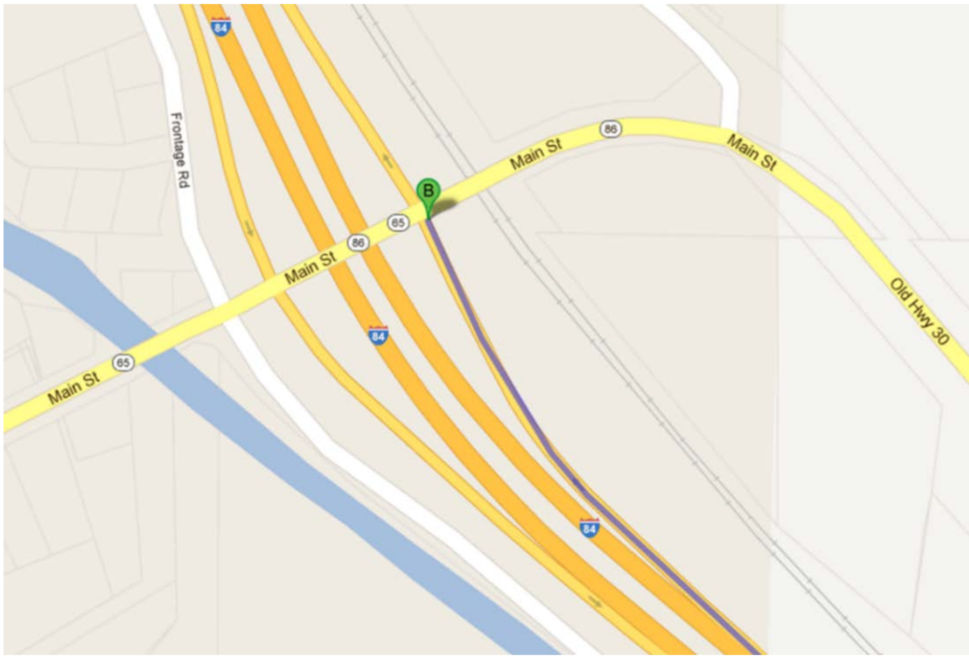


Figure 61. Map. I-84 exit 115 (nearest westbound exit).

The travel time data were collected both before and during the construction period. The preconstruction and postconstruction travel time data are reported in tables 9 and 10, respectively. Travel time data were also collected on the designated detour route, and those travel times are provided in table 11.

Table 9. Preconstruction travel time data.

| MP 115 to Exit 169 | | Exit 169 to MP 115 | |
|---|---|---|---|
| **I-84 Eastbound** | [sec] | **I 84 Westbound** | [sec] |
| Run 1 | 283.55 | Run 1 | 307.68 |
| Run 2 | 279.39 | Run 2 | 306.34 |
| Run 3 | 280.15 | Run 3 | 308.23 |
| Run 4 | 282.23 | Run 4 | 307.56 |
| Run 5 | 278.58 | Run 5 | 307.07 |
| **Average** | **280.78** | **Average** | **307.376** |

Table 10. During construction travel time data.

| MP 115 to Exit 169 | | Exit 169 to MP 115 | |
|---|---|---|---|
| **I-84 Eastbound** | [sec] | **I 84 Westbound** | [sec] |
| Run 1 | 307.16 | Run 1 | 310.58 |
| Run 2 | 302.81 | Run 2 | 309.14 |
| Run 3 | 305.9 | Run 3 | 309.05 |
| Run 4 | 299.51 | Run 4 | 309.86 |
| Run 5 | 301.76 | Run 5 | 306.12 |
| **Average** | **303.428** | **Average** | **308.95** |

Table 11. During construction travel time data (detour).

| MP 115 to Exit 169 (Through US 30 Old Hwy) | |
|---|---|
| **Eastbound** | [sec] |
| Run 1 | 377.77 |
| Run 2 | 365.67 |
| Run 3 | 364.23 |
| **Average** | **369.22** |

A difference of around 23 seconds can be observed between the preconstruction and during construction trip times for I-84 eastbound. This difference can be attributed to the deceleration and subsequent speed reduction among the vehicles approaching the I-84 eastbound work zone area. The posted speed limit on I-84 eastbound was 70 mph, while the speed limit for work zone area was 45 mph. However, for the I-84 westbound route, there was no additional time due to speed reduction observed during construction. One of the reasons for this occurrence could be that the work zone was proximate to I-84 westbound entry ramps with a speed limit of 50 mph, thereby eliminating the need for deceleration of vehicles.

Overall, it can be noted that there was hardly any variation in the average travel times before and during construction. Thus, it can be safely assumed that there was little or no delay during the construction period. In other words, the project met the HfL goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions.

## QUALITY

### Sound and Smoothness

The research team decided against collecting sound and smoothness data for this project. It was understood that the bridges were too short (less than 100 feet) for meaningful data.

### Precast Beams Pavement Test Site

For the precast beams used in this project, the UDOT Concrete Division followed the standard UDOT quality management plan for the precast/pre-stressed concrete elements.

## USER SATISFACTION

The HfL requirement for user satisfaction includes a performance goal of 4 or more on a Likert scale from 1 to 7 (in other words, 57 percent or more participants showing favorable response) for the following two questions:

- How satisfied is the user with the new facility compared with its previous condition?
- How satisfied is the user with the approach (ABC) used to construct the new facility in terms of minimizing disruption?

A post-construction survey of UDOT's I-84 bridge project was carried out on October 30, 2013. Fifty-nine truck drivers who reported traveling on I-84 during and after construction were interviewed at the Echo Port of Entry on the Utah/Wyoming border. As an alternative to the HfL questions, UDOT posed five questions to roadway users, asking them to rate their responses:

1. How often do you travel on I-84 between I-80 and I-15?
2. Please rate your satisfaction level with traveling on I-84 during construction.
3. Please rate your satisfaction level with safety on I-84 during construction.
4. Please rate how the improved road has contributed to your ability to transport goods and services on I-84 since the completion of the I-84 Echo bridge project.
5. Please rate the quality of I-84 since the completion of the I-84 Echo bridge project.

Table 12 shows the results from the user satisfaction survey. Around 68 percent of the survey participants indicated that they traveled frequently on I-84 between I-80 and I-15. On the travel satisfaction, safety, roadway improvement, and quality criteria, a majority of responders gave a performance rating of 7 for the new I-84 facility.

Table 12. User satisfaction survey results.

| **Question** | **Majority Response** | **Majority Number** | **Average** |
|---|---|---|---|
| How often do you travel on I-84 between I-80 and I-15? | Frequently | 40 | 67.8% |
| On a scale of 1 – 7, please rate your satisfaction level with traveling on I-84 during construction *(1 meaning not satisfied and 7 meaning very satisfied).* | 7 | 34 | 57.63% |
| On a scale of 1 – 7, please rate your satisfaction level with safety on I-84 during construction *(1 meaning not satisfied and 7 meaning very satisfied).* | 7 | 41 | 69.49% |
| On a scale of 1 – 7, please rate how the improved road has contributed to your ability to transport goods and services on I-84 since the completion of the I-84 Echo bridge project *(1 meaning slightly improved and 7 meaning very improved).* | 7 | 32 | 54.24% |
| On a scale of 1 – 7, please rate the quality of I-84 since the completion of the I-84 Echo bridge project *(1 meaning unacceptable and 7 meaning acceptable).* | 7 | 37 | 62.71% |

Overall, the responses to the questions were favorable and met or exceeded the HfL performance goal. The complete results of the survey are presented in the appendix.

# ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This involves comparing the benefits and costs associated with the innovative project delivery approach adopted on an HfL project with those from a more traditional delivery approach on a project of similar size and scope. The latter type of project is referred to as a baseline case and is an important component of the economic analysis.

For this economic analysis, UDOT supplied the cost figures for the as-built project and baseline construction. Traditional methods would have involved the use of cast-in-place construction coupled with periods of curing that would have prolonged the time motorists would have been impacted to 194 days.

## CONSTRUCTION TIME

The baseline scenario would have been design bid-build project with cast-in-place construction. UDOT estimates that the MOT plans for the traditional construction scenario would have involved the use of a detour or a crossover with a single lane for each direction. The detour option has been considered in the baseline scenario because a crossover would be improbable given the width between the existing bridges. In the baseline scenario, the construction time would have been 194 days and would have involved a complete closure during that period. The use of GRS method reduced the project construction time to 125 days and the closure duration to 34 hours. Thus, the HfL goal of a 50 percent reduction in the time traffic is impacted compared to traditional construction methods was met.

## CONSTRUCTION COSTS

The agency costs presented in table 13 are based on UDOT estimates. The as-built cost information was obtained through the UDOT website. [3] In addition, the contractor was awarded an incentive of $20,000 for the bridge slide. There was also a disincentive on HMA item for asphalt binder content, aggregate gradation, and compaction issues. However, since this disincentive was not directly associated with the innovations on this project, it was not considered for further analysis.

The traditional bridge replacement costs were calculated based on UDOT estimates of $250/sq. ft for the construction area.  The additional construction costs incurred due to MOT, sign structures, and other items, were considered same for both the baseline and the as-built scenarios.

The preliminary engineering and construction management costs for the baseline scenario were calculated as a percentage of construction costs. UDOT estimates the preliminary engineering and construction management costs for traditional construction to be 8 to 9 percent and 6 to 7 percent of the construction costs, respectively. For calculation purposes, the preliminary engineering and construction management costs were estimated at 9 and 7 percent, respectively, of the total estimated construction costs for the traditional alternative.

Table 13. Agency cost comparison for as-built and baseline scenarios

| | As-Built | Baseline |
|---|---|---|
| Construction Costs | $ 3,223,874 | $ 3,818,874 |
| Construction Management Costs | $ 504,924 | $ 267,321 |
| Preliminary Engineering Costs | $ 471,011 | $ 24,059 |
| I/D | $ 20,000 | $ 0 |
| **Total Costs** | **$ 4,219,809** | **$ 4,110,254** |

### USER COSTS

Generally, the three categories of user costs used in an economic/life cycle cost analysis are vehicle operating costs (VOC), delay costs, and safety-related costs/crash costs. The cost differentials in delay costs and safety costs were considered for comparative analysis of cost differences between the baseline and as-built alternatives. Table 14 presents the AADT and percent truck values used in user costs calculation.

Table 14. I-84 traffic statistics.

| Traffic Data | Value |
|---|---|
| AADT (Year 2012) | 8100 |
| Passenger cars | 56% |
| Single-unit trucks | 4% |
| Combination trucks and trailers | 40% |

### VOC

Since the detour route (4.6 miles) was shorter than the actual route (4.9 miles), no VOCs were applicable for either the as-built scenario or the baseline scenario.

### Delay Costs

The average delay was calculated based on the difference in travel time during construction between I-84 eastbound and the detour route. The hourly value of passenger car delay of $32 was computed based on Utah's median household income (4) of $57,049 for personal intercity travel (with an assumed average vehicle occupancy of 1.67) and total employer's cost of employee compensation (5) of $31.00 (in June 2013) for business intercity travel. The hourly value for truck delay ($21.52 for single-unit trucks and $27.52 for combination trucks) was calculated based on Utah's prevailing wages (6) and benefits.

The traffic impacts for the as-built and baseline scenarios were for 34 hours and 194 days, respectively. The travel time data and related information has already been presented in tables 9 through 11. For the as-built scenario, the delay costs were computed for two cases:

- Average delay of 23 seconds due to speed reduction on EB lanes only (see table 15)
- Average delay of 60 seconds due to detour on both EB and WB lanes (see table 16)

Table 15. Delay costs due to speed reduction on EB lanes only.

| Description | As-Built | Baseline |
|---|---|---|
| Days Impacted | 59.5 | 0 |
| Delay cost (Autos) | $ 27,589 | $ 0 |
| Delay cost (Single Trucks) | $ 1,325 | $ 0 |
| Delay cost (Combo Trucks) | $ 16,948 | $ 0 |
| **Delay cost due to speed reduction in EB lanes only** | **$ 45,862** | **$ 0** |

Table 16. Delay costs due to detour on both EB and WB lanes.

| Description | As-Built | Baseline |
|---|---|---|
| Days Impacted | 34 hours | 194 |
| Delay cost (Autos) | $ 1,885 | $ 258,129 |
| Delay cost (Single Trucks) | $ 91 | $ 12,399 |
| Delay cost (Combo Trucks) | $ 1,158 | $ 158,565 |
| Delay Costs due to detour | $ 3,133 | $ 429,093 |
| **Total Delay costs (detour + speed reduction)** | **$ 48,995** | **$ 429,093** |

**Safety Costs**

There were no work zone related crashes during construction for the as-built scenario. For the traditional alternative, the crash costs were computed based on the preconstruction crash rates presented in table 7 for project limits during the period 2008-2011. Table 17 presents the estimated number of crashes expected during construction for the traditional alternative.

Table 17. Expected crashes during construction for traditional alternative.

| Description | Value |
|---|---|
| Days of Coverage | 194 |
| Average ADT (vpd) | 8100 |
| MVMT | 0.884 |
| Work Zone Fatalities | 0 |
| Work Zone Injuries | 0.398 |
| Work Zone PDO | 1.062 |

Table 18 presents the 2013 values of mean human and mean comprehensive costs.

Table 18. Mean human and mean comprehensive costs.

| Cost type | Mean Human Cost per Crash [a] | Mean Comprehensive Cost per Crash [b] |
|---|---|---|
| PDO costs in 2001 dollars | $ 5,193.00 | $ 6,386.00 |
| Injury costs in 2001 dollars | $ 32,737.00 | $ 62,752.00 |
| PDO costs in 2013 dollars | $ 6,857.84 | $ 8,542.89 |
| Injury costs in 2013 dollars | $ 43,232.25 | $ 85,626.91 |

Notes:
[a] human costs of crashes were converted from 2001 to 2013 dollars using Consumer Price Index (CPI) adjustment factor of 1.321
[b] the differential amount between comprehensive and human costs of crashes were converted from 2001 to 2013 dollars using Employment Cost Index (ECI) adjustment factor of 1.412

Table 19 presents the summary of estimated crash-related costs for both traditional and as-built scenarios.

Table 19. Comparison of crash costs.

| Cost type | As-built | Traditional |
|---|---|---|
| Injury Costs | $ 0 | $ 34,110 |
| PDO Costs | $ 0 | $ 9,075 |
| **Total Crash Costs** | $ 0 | **$ 43,185** |

### COST SUMMARY

Table 20 presents the cost summary for both the as-built and baseline scenarios. The total costs were calculated by adding the agency costs and user costs for both scenarios. Though UDOT's direct costs for constructing the bridge increased by approximately 2.7 percent, there was significant savings in user costs. Using the GRS-IBS and bridge slide approach for construction saved an estimated $ 313,728 (6.9 percent) cost benefits over traditional methods.

Table 20. Final cost summary.

| Cost type | As-built | Baseline | % Difference |
|---|---|---|---|
| Agency costs | $ 4,219,809 | $ 3,861,983 | 2.67% |
| User costs | $ 48,995 | $ 472,278 | -89.63% |
| Total costs | $ 4,268,804 | $ 4,582,532 | -6.85% |
| **Difference** | **$ 313,728** | | |

# TECHNOLOGY TRANSFER

To promote the innovation of PBES, GRS-IBS, and lateral bridge slide, UDOT and FHWA organized a site visit and a workshop for the Utah I-84 Echo Frontage Road bridge replacement project. The project site visit included a viewing of the bridge demolition and lateral slide on Saturday, August 17, 2013. Figure 62 shows the participants during the field visit on this project.


Figure 62. Photo. Participants during the field visit.

The field visit was followed by the workshop on project and technologies on Sunday, August 18. The workshop was attended by 73 participants, including representatives from various State DOTs, FHWA, construction industry, and local agencies.

During the workshop, Shane Marshall, UDOT Deputy Director, provided the introduction and opening remarks. He provided a brief overview of the current challenges faced by UDOT and the strategic goals adopted to take advantage of innovation to accomplish UDOT’s goals. Arlene Kocher and Gloria Shepherd welcomed the participants and provided the FHWA perspective on the innovations.

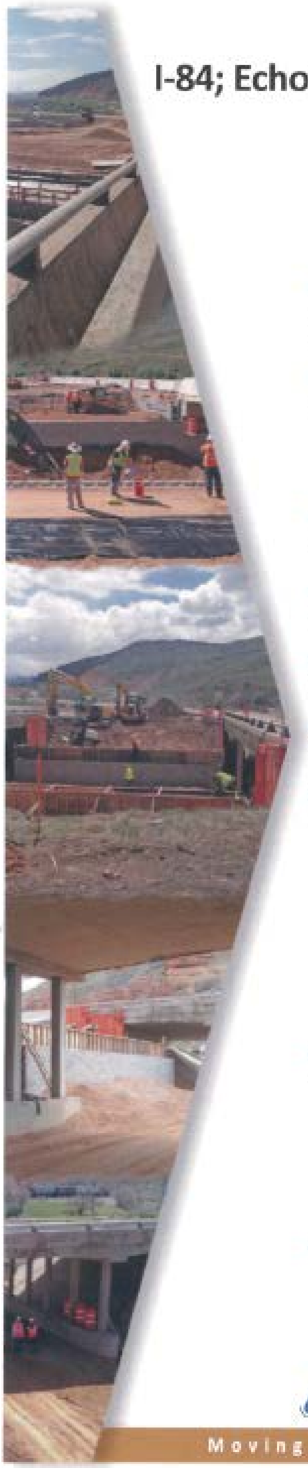
Victoria Peters from FHWA provided the ABC national perspective to the audience, covering topics such as slide-in bridge construction and the FHWA Every Day Counts summits. The GRS-IBS national perspective was provided by Daniel Alzamora, FHWA, who presented insights on the GRS-IBS technology with the help of some past GRS-IBS projects.

This was followed by a talk from Carmen Swanwick on UDOT’s ABC perspective, describing the vision UDOT has for building high-quality bridges efficiently and quickly, and the deployment strategies and tools adopted. Jason Davis, UDOT, highlighted UDOT’s approach in ensuring worker and motorist safety, improving confidence in the public through trust, support, communication, and innovation, and reducing user and community impacts. Matt Zundel from UDOT shared the owner’s perspective on the I-84 Echo Frontage Road project by presenting the goals, overview, closure limitations, schedule, and partnering techniques adopted for the project. The designer perspective for this project was presented by Donath Picardo, UDOT, who provided information on the existing structure, bridge description, ABC process and selection, design plan, construction sequence, lateral slide considerations, and the risk assessment done for the project.

Jim Higbee, UDOT, discussed the GRS-IBS research, geotechnical investigation, geotechnical design, instrumentation program, construction aspects, and challenges of the project. Bryce Wadsworth and Jason Klophaus detailed the contractor's role and efforts during the project planning, construction, and bridge slide.

The presentations were followed by a project panel discussion wherein questions and comments were invited from the participants. Matt Zundel, Daniel Alzamora, Donath Picardo, Jim Higbee, Bryce Wadsworth, and Jason Klophaus, led the project panel discussion (see figure 63).

Figure 63. Photo. Workshop panel discussion (courtesy: UDOT).



# I-84; Echo Frontage Road, Bridge Replacement
## UDOT/FHWA Showcase

ECHO

## Workshop Agenda

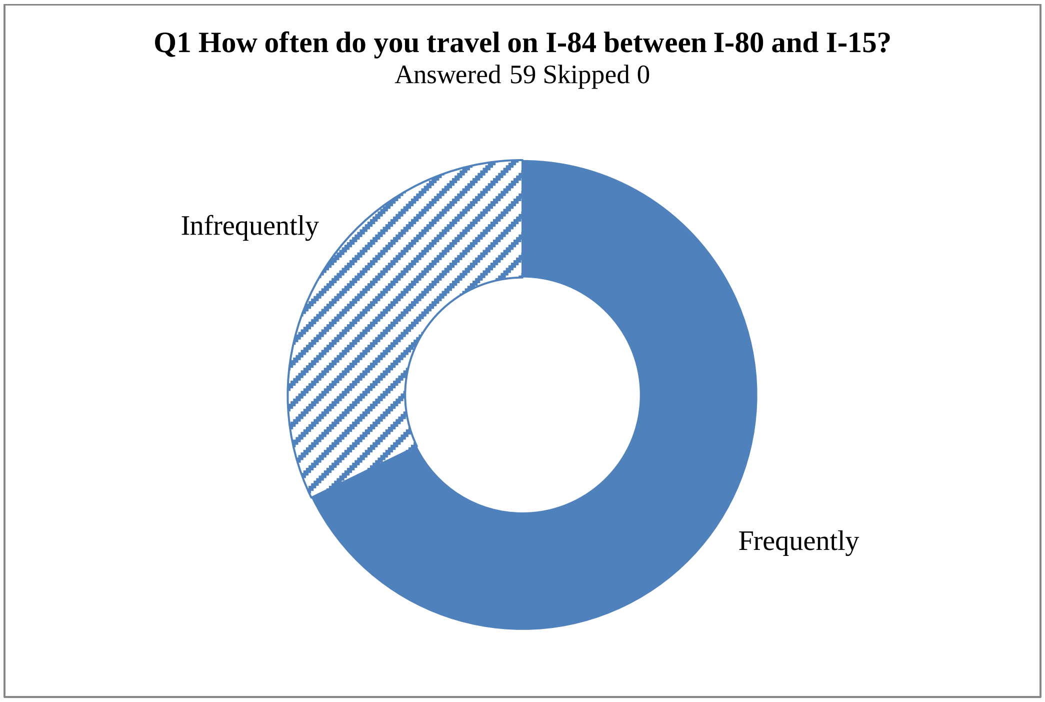
| | |
|---|---|
| Date<br>Time<br>Venue | **Sunday, August 18, 2013**<br>**10:00 a.m. – 3:00 p.m.**<br>**Marriott; Park City, Utah** |
| 10:00 - 10:30 a.m. | **Welcome**<br>Shane Marshall, UDOT Deputy Director<br>Arlene Kocher, FHWA Utah Assistant Division Administrator<br>Gloria Shepherd, FHWA Associate Administrator for the Office of Planning, Environment and Realty |
| 10:30 – 10:50 a.m. | **ABC National Perspective**<br>Victoria Peters, FHWA Director of Innovation and Technology |
| 10:50 – 11:10 a.m. | **GRS-IBS National Perspective**<br>Daniel Alzamora, FHWA Resource Center |
| 11:10 - 11:30 a.m. | **Utah's ABC Practice**<br>Carmen Swanwick, UDOT Chief Structural Engineer |
| 11:30 a.m. - 12:30 p.m. | **Working Lunch and UDOT Region Two Overview**<br>Jason Davis, UDOT Region Two Director |
| 12:30 - 2:30 p.m. | **I-84; Echo Frontage Road, Bridge Replacement Project Presentation**<br>**Owner Perspective**<br>Matt Zundel, UDOT Resident Engineer<br>**Design and Construction Perspective**<br>**Designer;** Donath Picardo, UDOT Design Engineer<br>**GRS-IBS;** Jim Higbee, UDOT Geotechnical Engineer<br>**Contractor;** Bryce Wadsworth, Dry Creek Structures<br>Jason Klophaus, Klophaus & Associates |
| 2:30 - 3:00 p.m. | **Project Panel Discussion**<br>Daniel Alzamora, FHWA<br>Matt Zundel, UDOT<br>Donath Picardo, UDOT<br>Jim Higbee, UDOT<br>Bryce Wadsworth, Dry Creek Structures<br>Jason Klophaus, Klophaus & Associates |

UDOT U.S. Department of Transportation Federal Highway Administration HIGHWAYS FOR LIFE

Moving Innovation Ahead | Echo, Utah Showcase Event

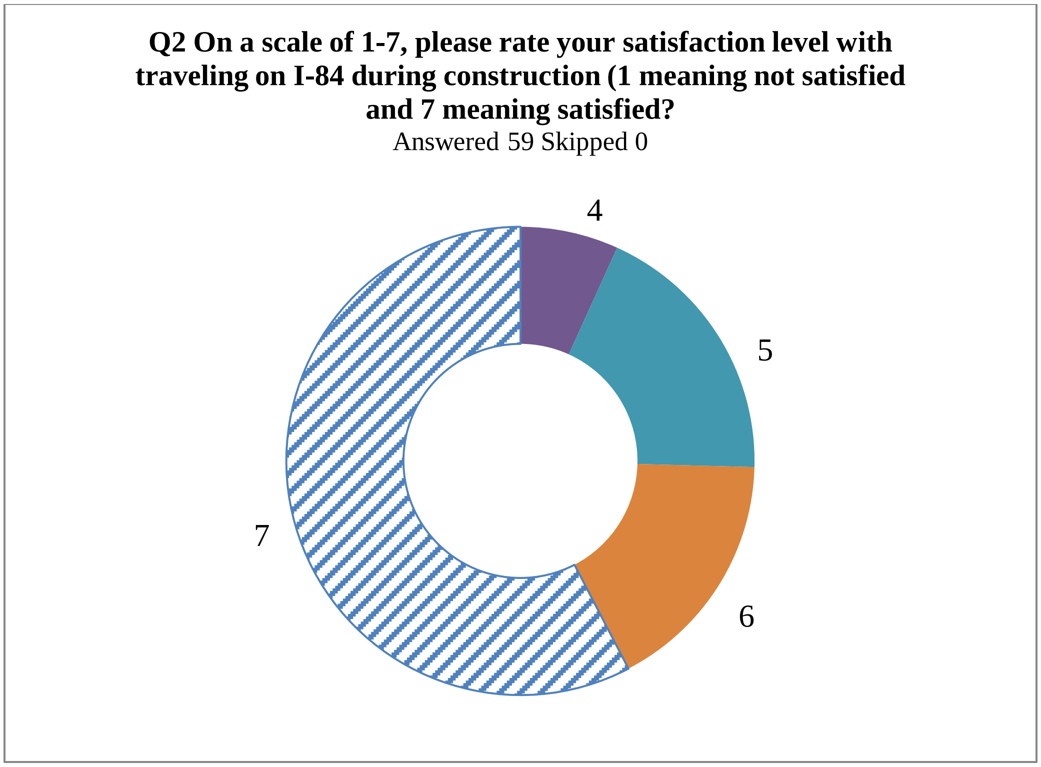
Figure 64. Showcase agenda for I-84 Echo project

# APPENDIX: USER SATISFACTION SURVEY RESULTS



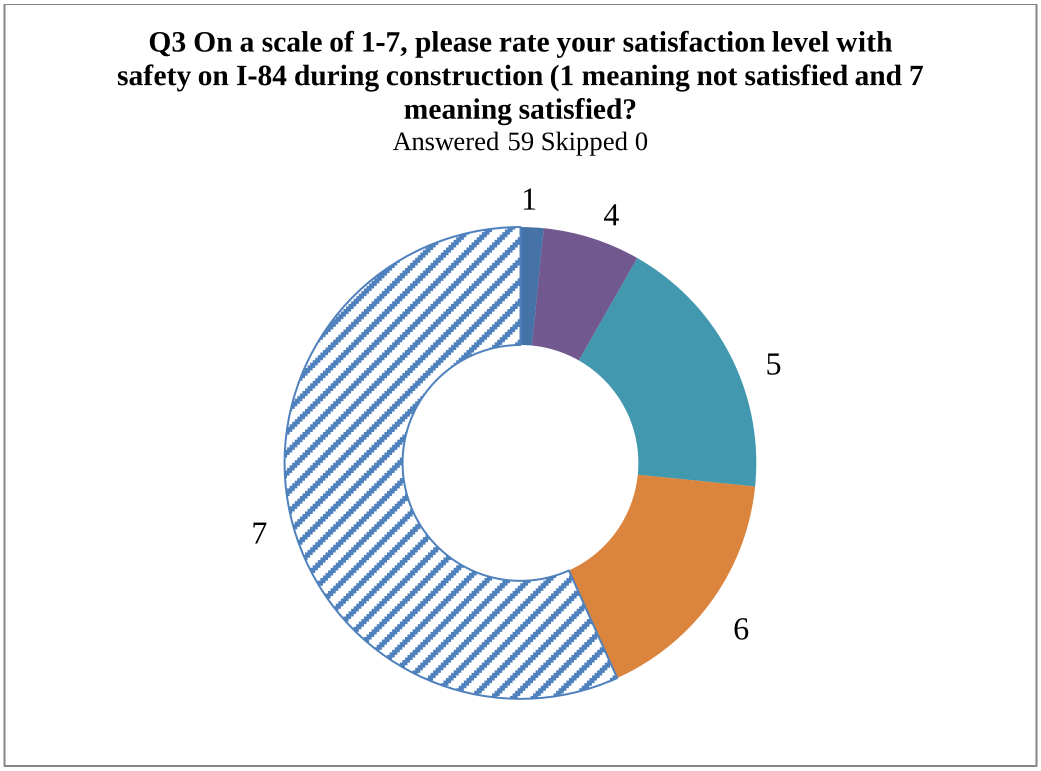

| Answer Choices | Responses | |
|---|---|---|
| | Number | Percent |
| Frequently | 40 | 67.80% |
| Infrequently | 19 | 32.20% |
| Total | 59 | |

Figure 65. Chart. Results showing frequency of user travel on the facility (I-84 between I-80 and I-15)



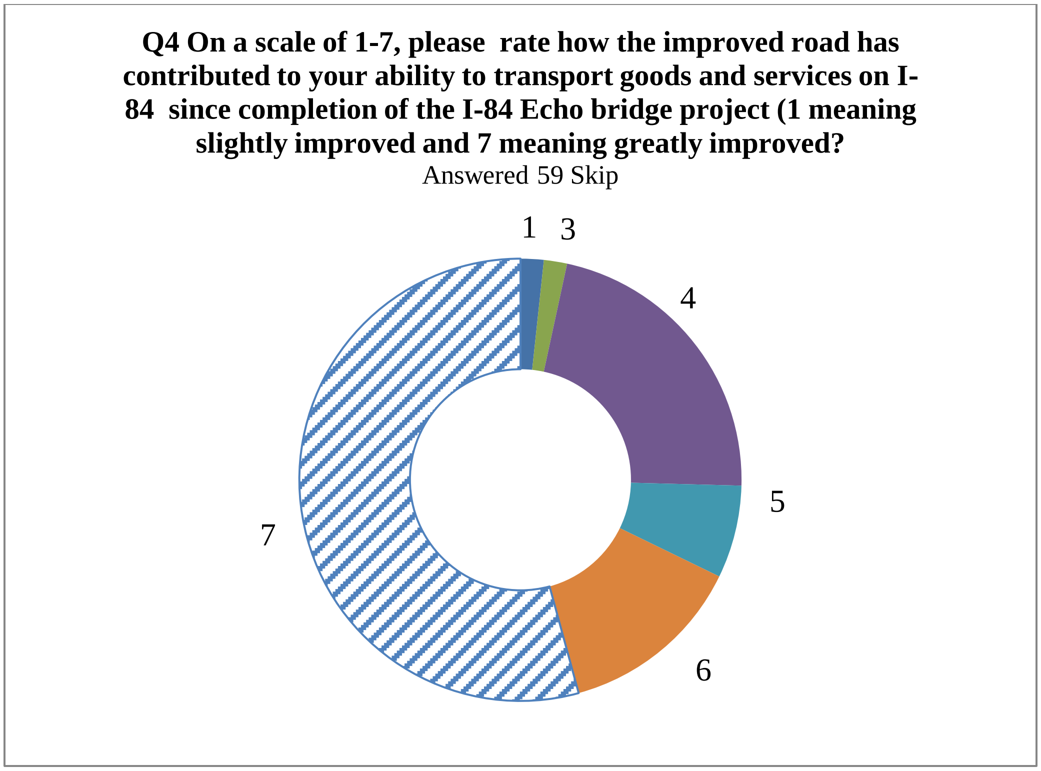

| Answer Choices | Responses | |
|---|---|---|
| | Number | Percent |
| 1 | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 0 | 0% |
| 4 | 4 | 6.78% |
| 5 | 11 | 18.64% |
| 6 | 10 | 16.95% |
| 7 | 34 | 57.63% |
| Total | 59 | |

Figure 66. Chart. Results showing user satisfaction level on facility travel



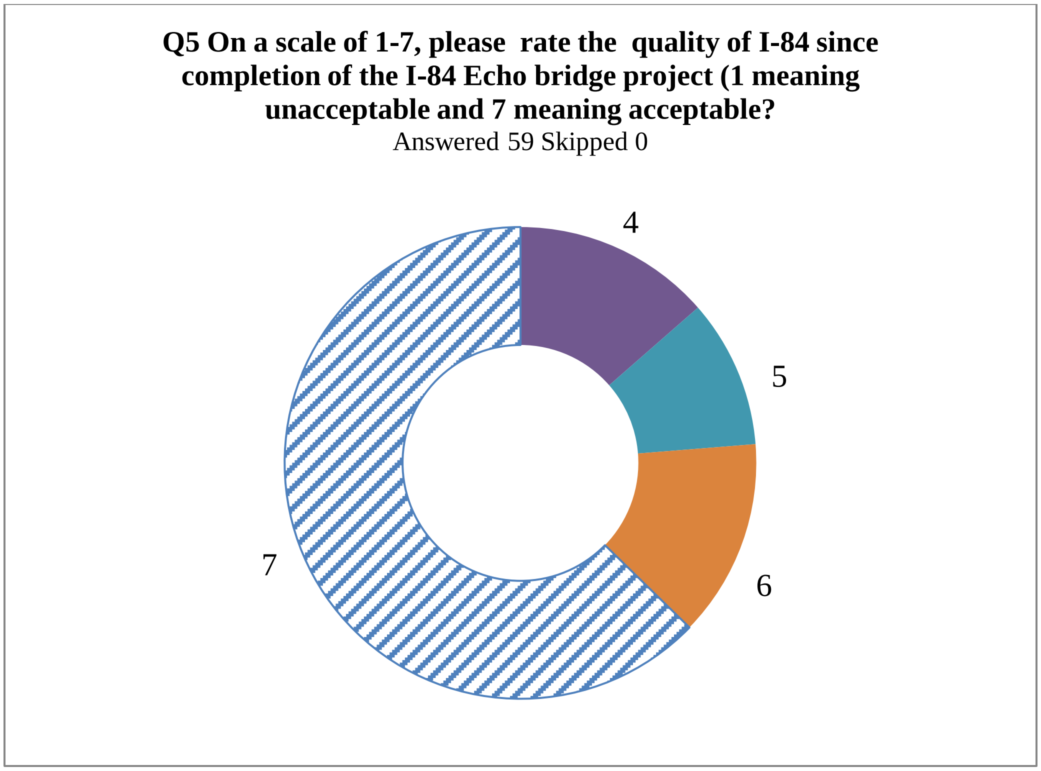

| Answer Choices | Responses | |
|---|---|---|
| | Number | Percent |
| 1 | 0 | 1.60% |
| 2 | 0 | 0.00% |
| 3 | 0 | 0.00% |
| 4 | 4 | 6.78% |
| 5 | 11 | 18.64% |
| 6 | 10 | 16.95% |
| 7 | 34 | 57.63% |
| Total | 59 | |

Figure 67. Chart. Results showing user satisfaction level on facility safety




| Answer Choices | Responses | |
|---|---|---|
| | Number | Percent |
| 1 | 1 | 1.69% |
| 2 | 0 | 0.00% |
| 3 | 1 | 1.69% |
| 4 | 13 | 22.03% |
| 5 | 4 | 6.78% |
| 6 | 8 | 13.56% |
| 7 | 32 | 54.24% |
| Total | 59 | |

Figure 68. Chart. Results showing user satisfaction level on facility improvement




| Answer Choices | Responses | |
|---|---|---|
| | Number | Percent |
| 1 | 0 | 0.00% |
| 2 | 0 | 0.00% |
| 3 | 0 | 0.00% |
| 4 | 8 | 13.56% |
| 5 | 6 | 10.17% |
| 6 | 8 | 13.56% |
| 7 | 37 | 62.71% |
| Total | 59 | |

Figure 69. Chart. Results showing user satisfaction level on facility quality

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