

**U.S. Department of Transportation
Research and Innovative Technology Administration
University Transportation Center Grant Agreement**

**Grant No. DTRT13-G-UTC38
DTRT13-G-UTC38, Mod 1, 2, & 3
Mountain-Plains Consortium, North Dakota State University
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April 30, 2018

DUNS: 803882299 and EIN: 45-6002439

**North Dakota State University
Upper Great Plains Transportation Institute
NDSU Dept. 2880, P.O. Box 6050, Fargo, ND 58108-6050**

Grant period: October 1, 2013 – September 30, 2018

**Reporting Period End Date: March 31, 2018
Semi-Annual PPPR#9**

Denver D. Tolliver



**Director, Mountain-Plains Consortium
North Dakota State University**

1. Accomplishments: What was done? What was learned?

a. What are the major goals of the program?

The overall objectives are to: (1) conduct basic and applied research, the products of which are judged by peers or other experts in the field of transportation to advance the body of knowledge in transportation; (2) offer an education program in transportation that includes multidisciplinary course work and participation in research; (3) conduct workforce development activities and programs to expand the workforce of transportation professionals; and (4) provide an ongoing program of technology transfer to make transportation research results available to potential users in a form that can be readily used. Other program goals are to select projects and activities using peer review principles and procedures and client input that: (1) address the Secretary's five strategic goals, and (2) leverage UTC funds with matching funds from state and local governments and private industry. The chief operational goals are to make important contributions to research and technology transfer in key areas related to the Secretary's goals of State of Good Repair, Safety, and Economic Competiveness, while addressing critical issues of the region and stakeholder groups.

b. What was accomplished under these goals?

i. Project Selection

Ninety research projects were selected from 2013 to present under this grant. Projects have been selected for the original grant, Modification 1, 2, and 3. The projects reflect substantial input and matching resources from state departments of transportation and MPOs in the region. Collectively, this set of projects addresses all five of the Secretary's strategic goals and several of USDOT's requested emphasis areas under State of Good Repair—e.g., (1) bridge condition monitoring, (2) locating critical infrastructure defects, (3) identifying tools to prevent and detect corrosion in transportation infrastructure, (4) analytical tools for infrastructure performance management, and (5) methods and criteria to measure performance of new materials and methods. Other research projects are related to the Secretary's strategic goals of Safety, Economic Competiveness, Livable Communities, and Environmental Sustainability. MPC projects selected under this grant include; MPC-371,409, MPC-446 to MPC-532.

Table 1: MPC Research Projects Most Directly Correlated with Safety

1. MPC-453: Speed Selection Behavior during Winter Road Conditions
2. MPC-454: Regional Implementation of Tribal Transportation Safety Program
3. MPC-455: Why Are Bike-Friendly Cities Safer for All Road Users?
4. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
5. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
6. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
7. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
8. MPC-467: Self-Regulation and Distraction
9. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
10. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
11. MPC-472: Developing an Optimization Model for Managing County Paved Roads
12. MPC-473: Bicycle and Pedestrian Design for Rural Communities
13. MPC-474: Highway Safety Manual Part D: Validation and Application in Wyoming
14. MPC-475: Analysis of the Relationship of Roadside Inspections on Large Truck Crashes
15. MPC-476: Highway-Rail Grade Crossing Traffic Hazard Forecasting Model
16. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
17. MPC-480: A Comprehensive Safety Assessment Methodology for Innovative Geometric Designs
18. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes

19. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
20. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
21. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
22. MPC-495: Safety Effects of Protected and Protected/Permitted Left-Turn Phases
23. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
24. MPC-503: Characterization of Crushed Bases in Wyoming
25. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
26. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
27. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging
28. MPC-508: Experimental Evaluation of a New Double Composite System for Steel Bridges
29. MPC-515: Redefining the Child Pedestrian Safety Paradigm
30. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
31. MPC-518: Tribal Crash Reporting in ND: Practices, Perceptions, and Systematic Implementation
32. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
33. MPC-520: Financial Benefits of Proposed Access Management Treatments
34. MPC-521: Evaluating Relationships between Perception-Reaction Times, Emergency Deceleration Rates, and Crash Outcomes using Naturalistic Driving Data
35. MPC-524: Development of Next Generation Liquefaction (NGL) Database for Liquefaction-Induced Lateral Spread
36. MPC-525: Does Cell Phone Use Impair Learning and Improvement in Driving Performance?
37. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement
38. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils
39. MPC-532: Further Validation of Safety Culture Measurement Tool for Improving Safety in Commuter Rail Operations

Table 2: MPC Research Projects Most Directly Correlated with State of Good Repair

1. MPC-446: A Modified Approach for Predicting Fracture of Steel Components under Combined Large Inelastic Axial and Shear Strain Cycles
2. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
3. MPC-448: Reducing Flood Vulnerability of Communities with Limited Road Access by Optimizing Bridge Elevation
4. MPC-449: Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management
5. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
6. MPC-452: Updating the Highway Safety Manual 2010 - Part C: Regional Consideration of the Rocky Mountains and Plain Regions
7. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
8. MPC-461: Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards
9. MPC-462: Implementation of Aerial LiDAR Technology to Update Highway Feature Inventory
10. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks

11. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
12. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
13. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
14. MPC-472: Developing an Optimization Model for Managing County Paved Roads
15. MPC-477: Characterizing the ductility of Portland cement stabilized soil
16. MPC-478: Long-Term Behavior of Precast Concrete Bridges
17. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
18. MPC-481: Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure
19. MPC-482: Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems
20. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
21. MPC-484: Effect of Service Temperature on Joint Removal in Steel Bridges
22. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness
23. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
24. MPC-492: Early-Age Fiber-Reinforced Concrete Properties for Overlays
25. MPC-493: Incorporating Maintenance Costs and Considerations into Highway Design Decisions
26. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
27. MPC-496: Prevention of Low Temperature Cracking of Pavements
28. MPC-497: Compaction Testing of Granular Materials
29. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
30. MPC-501: Development of an Alternative to the Double Tee Bridge System
31. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
32. MPC-503: Characterization of Crushed Bases in Wyoming
33. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
34. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
35. MPC-506: Reliable Prediction of Shear Strength of Swelling Clays
36. MPC-507: Automating Inspection and Damage Assessment of Transportation Infrastructure with Photographic Imaging
37. MPC-508: Experimental Evaluation of a New Double Composite System for Steel Bridges
38. MPC-511: Mechanical Bar Splices for Accelerated Bridge Construction of Columns
39. MPC-512: Pre-stress Losses and Development of Short-Term Data Acquisition System for Bridge Monitoring
40. MPC-516: Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica
41. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
42. MPC-522: Development of a Guideline for Selection of Tack Coats in South Dakota
43. MPC-523: Methodology for Load Rating Double-Tee Bridges
44. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement

45. MPC-528: Hotspot and Sampling Analysis for Effective Maintenance Management and Performance Monitoring
46. MPC-529: Alternative in-situ Water-Cement Meter Using a Parallel-Plate Capacitor Concept
47. MPC-530: Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches
48. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils

Table 3: MPC Research Projects Most Directly Correlated with Economic Competitiveness

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1. MPC-451: Assessing the Cost-Effectiveness of Wyoming's CMAQ Unpaved Road Dust Suppression Program
 2. MPC-463: Rehabilitation Project Selection and Scheduling in Transportation Networks
 3. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
 4. MPC-466: First and Last Mile Strategies for Transit Systems
 5. MPC-468: Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance)
 6. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
 7. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
 8. MPC-472: Developing an Optimization Model for Managing County Paved Roads
 9. MPC-479: Modeling Multi-class Truck Traffic Assignment Method with Different Traffic Restraint Constraints
 10. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
 11. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competitiveness
 12. MPC-494: Statistical Analysis and Sampling Standards for Maintenance Management Quality Assurance (MMQA)
 13. MPC-497: Compaction Testing of Granular Materials
 14. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
 15. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
 16. MPC-500: Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
 17. MPC-501: Development of an Alternative to the Double Tee Bridge System
 18. MPC-502: Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders
 19. MPC-503: Characterization of Crushed Bases in Wyoming
 20. MPC-504: Improved Element-Level Bridge Inspection Criteria for Better Bridge Management and Preservation
 21. MPC-505: An Intelligent Transportation Systems Approach to Railroad Infrastructure Performance Evaluation
 22. MPC-509: Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
 23. MPC-511: Mechanical Bar Splices for Accelerated Bridge Construction of Columns
 24. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
 25. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
 26. MPC-516: Innovative Strengthening for Deteriorated Concrete Bridges Using Embedded Composite Sheets Bonded with Polyester-silica
 27. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
 28. MPC-519: Operational and Safety Analysis with Mitigation Strategies for Freeway Truck Traffic in WY
 29. MPC-522: Development of a Guideline for Selection of Tack Coats in South Dakota

30. MPC-523: Methodology for Load Rating Double-Tee Bridges
31. MPC-528: Hotspot and Sampling Analysis for Effective Maintenance Management and Performance Monitoring
32. MPC-530: Screening of South Dakota Asphalt Mixes for Moisture Damage using Conventional and Innovative Approaches
33. MPC-531: Flood Hydrograph Generation for Predicting Bridge Scour in Cohesive Soils

Table 4: MPC Research Projects Most Directly Correlated with Livable Communities

1. MPC-454: Regional Implementation of Tribal Transportation Safety Program
2. MPC-455: Why Are Bike-Friendly Cities Safer for All Road Users?
3. MPC-465: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges
4. MPC-466: First and Last Mile Strategies for Transit Systems
5. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
6. MPC-473: Bicycle and Pedestrian Design for Rural Communities
7. MPC-483: Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes
8. MPC-489: The Unresolved Relationship between Street Trees and Road Safety
9. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
10. MPC-491: Self-Centering Buckling Restrained Braces for Curved Bridges
11. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
12. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
13. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
14. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
15. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
16. MPC-515: Redefining the Child Pedestrian Safety Paradigm
17. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
18. MPC-518: Tribal Crash Reporting in ND: Practices, Perceptions, and Systematic Implementation
19. MPC-520: Financial Benefits of Proposed Access Management Treatments
20. MPC-526: Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement
21. MPC-527: Strategic Planning and Design for Electric Bus Systems

Table 5: MPC Research Projects Most Directly Correlated with Environmental Sustainability

1. MPC-447: Post-Fire Ground Treatments for Protection of Critical Transportation Structures
2. MPC-458: Application of a Multi-Agent System with the Large-Scale Agent-Based Model for Freight Demand Modeling
3. MPC-469: Improving Efficiency and Reliability of Bus Rapid Transit
4. MPC-471: Enhancement of Mechanistic-Empirical Pavement Design Guide for Roadway Design, Construction and Rehabilitation
5. MPC-472: Developing an Optimization Model for Managing County Paved Roads
6. MPC-473: Bicycle and Pedestrian Design for Rural Communities
7. MPC-477: Characterizing the ductility of Portland cement stabilized soil
8. MPC-486: Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competitiveness
9. MPC-487: Investigation of Cross Laminated Timber Bridge Decks as a Sustainable Solution for Repair of Deficient Rural Wood Bridges
10. MPC-489: The Unresolved Relationship between Street Trees and Road Safety

11. MPC-490: Longevity of Air Pollution Mitigating Photo-Catalytic Coatings on Transportation Infrastructure
12. MPC-498: Development of Mixed Media Filtration for Stormwater Runoff Treatment
13. MPC-499: Reuse of Aqueous Waste Streams in Transportation-Related Applications
14. MPC-503: Characterization of Crushed Bases in Wyoming
15. MPC-509: Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment
16. MPC-510: Business and Commute Optimization System: Development and Denver-Based Case Study
17. MPC-513: Optimal Deployment of Wireless Charging Facilities for an Electric Bus System
18. MPC-514: Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior
19. MPC-517: Route Planning for Enhanced Transportation Network Utilization: A System Optimization Approach for Route Planning in Advanced Traveler Information Systems
20. MPC-524: Development of Next Generation Liquefaction (NGL) Database for Liquefaction-Induced Lateral Spread
21. MPC-527: Strategic Planning and Design for Electric Bus Systems

iii. Educational Accomplishments

The transportation and transportation-related courses offered during Fall 2017 and Spring 2018 are listed in Table 6, organized by major subject area. In some cases, courses with the same titles were offered at more than one MPC university. In these cases, the number of courses offered is shown in parenthesis.

Table 6: Transportation and Transportation-Related Courses Offered This Period

| Major Subject Area | Course Title |
|---------------------------------|--|
| Engineering & Design | 1. CIVE 507 Transportation Engineering |
| | 2. CIVE 508 Bridge Engineering |
| | 3. CEE 106 Elementary Surveying and Lab |
| | 4. CEE 411 Bituminous Materials and Lab |
| | 5. CEE 447/547 Foundation Engineering |
| | 6. CEE 456: Reinforced Concrete Theory and Design |
| | 7. CEE 458/558: Design of Timber Structures |
| | 8. CEE 492/592-S01: Highway Engineering |
| | 9. CEE 792-S01: Geosynthetics Design for Transportation Applications |
| | 10. EM 741: Finite Element Analysis |
| | 11. CEE 216-216L: Civil Engineering Materials and Lab |
| | 12. CEE 282: Civil Engineering Computer Aided Design |
| | 13. CEE 346-346L: Geotechnical Engineering and Lab |
| | 14. CEE 353: Structural Theory |
| | 15. CEE 363: Highway and Traffic Engineering |
| | 16. CEE 432: Hydraulic Engineering |
| | 17. CEE 452/552: Prestressed Concrete |
| | 18. CEE 455: Steel Design |
| | 19. CEE 692-S01: Pavement Stability |
| | 20. CEE 732: Advanced Foundation Engineering |
| | 21. CEE 754: Advanced Design of Steel Structures |
| | 22. CEE 792-S01: Advanced Highway and Roadway Design |
| | 23. CVEN 3602 Transportation Engineering |
| | 24. CVEN 5682 Pavement Design |
| | 25. CVEN 4602 Highway Engineering |

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|-----------------------------------|--|
| | 26. CVEN 5602 Advanced Street & Highway Design |
| | 27. URPL 3000 Planning the Built Environment |
| | 28. TRAN 4010 Introduction to Transportation Systems |
| | 29. TRAN 4330 Principles of Supply Chain: Management and Technologies |
| | 30. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 31. CVEEN 2010 Statics |
| | 32. CVEEN 2140 Strength of Materials |
| | 33. CVEEN 3210 Structural Loads and Analysis |
| | 34. CVEEN 4221 Concrete Design I |
| | 35. CVEEN 5230/6230 Steel Design II |
| | 36. CVEEN 5240/6240 Masonry/Timber Design |
| | 37. CVEEN 5305 Intro to Foundations |
| | 38. CVEEN 7225 Prestressed Concrete |
| | 39. CVEEN 5570/6570 Pavement Design |
| | 40. CVEEN 3510 Civil Engineering Materials |
| | 41. CVEEN 3310 Geotechnical Engineering I |
| | 42. CVEEN 6340 Advanced Geotech Testing |
| | 43. CVEEN 2010 Statics |
| | 44. CVEEN 2140 Strength of Materials |
| | 45. CVEEN 3210 Structural Loads and Analysis |
| | 46. CVEEN 4222 Steel Design I |
| | 47. CVEEN 5220/6220 Concrete Design II |
| | 48. CVEEN 5210/6210 Structural Analysis II |
| | 49. CVEEN 7250 Structural Earthquake Engineering |
| | 50. CVEEN 6310 Foundation Engineering |
| | 51. CVEEN 3520 Transportation Engineering |
| | 52. CVEEN 5510/6510 Highway Design |
| Freight & Logistics | 53. TRAN 4010 Introduction to Transportation Systems |
| | 54. TRAN 4330 Principles of Supply Chain: Management and Technologies |
| | 55. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 56. TRAN 4800 Analysis of Freight & Passenger Transportation Business Segments |
| | 57. TRAN 4430 Applied Micro Economics & Pricing |
| | 58. TRAN 4440 Marketing & Sales Management Strategies |
| | 59. TRAN 4450 Legal Studies: Contracts & Regulation |
| | 60. TRAN 4460 Financial & Managerial Accounting |
| | 61. TRAN 4470 Financial Analysis & Capital Structures |
| | 62. TRAN 4480 Capital Decision-making & Capital Markets |
| | 63. TRAN 4490 Global Trade & Economics |
| Planning & Environment | 64. CIVE 303 Infrastructure and transportation system |
| | 65. CVEN 5460 Introduction to Sustainable Urban Infrastructure |
| | 66. URPL 6399 Introduction to Sustainable Urban Infrastructure |
| | 67. URPL 6410 Social Justice in Planning |
| | 68. URPL 6600 Regional Planning |
| | 69. URPL 5050 Urban Development |
| | 70. URPL 6350 Form and Formation of Cities |
| | 71. URPL 6355 Urban Redevelopment Strategies |
| | 72. URPL 6365 Parks and Public Spaces |
| | 73. URPL 6400 Community Development |

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|---------------------------------|--|
| | 74. TRAN 4710 Transportation Finance |
| | 75. TRAN 4020 Transportation Economics |
| | 76. TRAN 4060 Transportation Marketing and Sales Tools |
| | 77. TRAN 4330 Principles of Supply Chain: Management and Technologies |
| | 78. TRAN 4320 Transportation Management, Leadership, and Values |
| | 79. CVEEN 1000 Intro to Environmental Engineering |
| | 80. CVEEN 3610 Environmental Engineering I |
| | 81. CVEEN 5500 Sustainable Materials |
| | 82. CVEEN 6560 Transportation Planning |
| | 83. CVEEN 6600 Solid Hazard Waste Engineering |
| | 84. CEE 5240 Urban/ Regional Transport |
| Public Transportation | 85. URPL 6560 Transit Planning |
| | 86. TRAN 4080 Transportation Law and Regulation: Domestic and International |
| | 87. TRAN 4860 Senior Management-Executives & Issues Seminar |
| | 88. TRAN 4870 Individual Leadership Development Project |
| | 89. TRAN 4880 Business Development & Productivity Impr movement Planning Project |
| | 90. TRAN 4890 International Transportation Travel Seminar |
| Traffic & Operations | 91. CVEN 5621 Traffic Impact Assessment |
| | 92. CVEN 3520 Transportation Engineering |
| | 93. CE 5700 Traffic Simulation |
| | 94. CE 5575 ITS |
| | 95. CEE 5220 Traffic Engineering |
| | 96. CEE 3210 Intro to Transportation Engineering |
| Transportation Safety | 97. CVEN 5611 Traffic and Safety Data Analysis |
| | 98. CE 5560 Traffic Safety |
| | 99. CEE 6250 Transport Data/ Safety |
| Transportation Systems | 100. URPL 6555 Transportation and Land Use |
| | 101. TRAN 4010 Introduction to Transportation Systems |
| | 102. TRAN 4050 Intermodal Transportation Systems |

Altogether, 102 transportation and transportation-related courses have been offered this reporting period, for a total of 666 total transportation courses offered this grant period. In addition to the courses listed in Table 6, foundational courses in engineering materials, mechanics, structural analysis, and geotechnical engineering were offered at most MPC universities.

iv. Workforce Development Accomplishments Training: A list of training events provided for transportation professionals during this reporting period is presented below.

- Autonomous, Connected Vehicles & Smart Highways - Tech & Policy Imp
- Backing Safety & Blind Spot Awareness
- Bridge 101 - on site - Bottineau County
- Bridge 101 - on site - Ellendale - Dickey County
- Chain Saw Operation & Safety
- Construction Site SWPPP Compliance, Tools, Tricks & Tips
- Corrugated Steel Pipe
- Enhanced Culvert Inspections Best Practices - MNDOT Guidebook
- High Strength Bolt Installation for Field Personnel

- Hosted NDLTAP Training with Bruce Drewes in Valley City & West Fargo
- Improving Gravel Roads - Understanding Design Criteria
- John Maxwell's 17 Indisputable Laws of Teamwork
- Legal Aspects of Traffic Control on Highway Work Zones (Tort Liability)
- Navigating the Landscape of Conflict
- ND Asphalt Conf Sponsorship letters mailed (90)
- Professional Communication in Today's Electronic Workplace
- Regional Local Roads Conference Rapid City
- Trenching Safety & Confined Spaces
- Truck Weight Education - on site – Jamestown
- Truck Weight Education Training - On-site – Casselton
- Truck Weight mailing to Ag Industry (30)
- UGPTI Annual Awards Banquet
- Uncovering Leadership Blind Spots
- Welding 101
- Winter Maintenance & Cold Weather Survival – Bowman
- Winter Maintenance & Cold Weather Survival - McLean County

v. Research Accomplishments

The following peer reviewed research reports were published during the rating period from grant DTRT13-G-UTC38.

| Project # | Title | Date | Report No. |
|-----------|--|----------|------------|
| 502 | Self-Consolidating Concrete for Prestressed Bridge Girders | Oct 2017 | MPC 17-334 |
| 411 | Re-Use of Mine Waste Materials Amended with Fly Ash in Transportation Earthworks Projects | Oct 2017 | MPC 17-332 |
| 400/352 | Evaluation of Ice Loads on Bridge Sub-Structures in South Dakota | Oct 2017 | MPC 17-335 |
| 315 | Analysis of Compound Channel Flow with Two-Dimensional Models | Oct 2017 | MPC 17-336 |
| 439 | Precast Bridge Girder Details for Improved Performance | Dec 2017 | MPC 17-340 |
| 306 | Optimization of Pavement Marking Performance | Dec 2017 | MPC 17-341 |
| 416 | Ipe: Evaluation of Orthotropic Elastic Properties and Its Application in Roadside Barriers | Dec 2017 | MPC 17-337 |
| 437 | Fiber-Reinforced Concrete for Structure Components | Dec 2017 | MPC 17-342 |
| 397 | Evaluation and Mitigation of Vehicle Impact Hazards for Overpasses | Dec 2017 | MPC 17-339 |
| 521 | Evaluating Relationships Between Perception-Reaction Times, Emergency Deceleration Rates, and Crash Outcomes Using Naturalistic Driving Data | Dec 2017 | MPC 17-338 |

c. How have the results been disseminated?

The results are being disseminated in a variety of ways, including: (1) workshops and conferences, (2) videoconferences, (3) online modules, (4) presentations at conferences, (5) publications, (6) webpage postings and displays, and (7) Internet-based dissemination media, including broadcast emails and webinars.

d. What do you plan to do during the next reporting period to accomplish the goals/objectives?

No changes are foreseen to the accepted plan and implementation schedule.

2. Products: What has the program produced?

a. Publications, conference papers, presentations

i. **Conferences and Workshops** can be found in Appendix A –

<https://www.mountain-plains.org/resources/progress/downloads/2018-mpc-pppr9-appendix-a.pdf>

ii. **Publications** can be found in Appendix B –

<https://www.mountain-plains.org/resources/progress/downloads/2018-mpc-pppr9-appendix-b.pdf>

iii. **Conference Papers** can be found in Appendix C –

<https://www.mountain-plains.org/resources/progress/downloads/2018-mpc-pppr9-appendix-c.pdf>

iv. **Presentations** can be found in Appendix D –

<https://www.mountain-plains.org/resources/progress/downloads/2018-mpc-pppr9-appendix-d.pdf>

v. Other Items Produced During this Period

Nothing to report at this time.

Due to space constraints all information under products can be found at the links provided above.

b. Books or other non-periodical, one-time publications

Nothing to report at this time.

c. Website(s) or other internet site(s)

The MPC website is fully operational at: <https://www.mountain-plains.org/>

The MPC Center Director can be found at: <https://www.mountain-plains.org/personnel/>

d. Technologies or Techniques

Nothing to report at this time.

e. Inventions, patent applications, and/or licenses?

Nothing to report at this time.

f. Other products

Nothing to report at this time.

3. Participants and Other Collaborating Organizations: Who has been involved?

a. What individuals have worked on the program?

The principal investigators, faculty, and administrators participating in MPC projects:

Ten principal investigators, faculty, and administrators participating in MPC projects at **Colorado State University** are: Christopher Bareither, Paul Heyliger, Rebecca Atadero, Mehmet Ozbek, Suren Chen, Jeffrey D. Niemann, Scott Glick Mahmoud Hussam, John w. Van de Lindt, Bolivar Senior and Joseph Scalia. In addition, nineteen students are working on MPC research projects at **Colorado State University**: Doctorate Students –Guangyang Hou, Mehrdad meman, Kaisen Yao, Kristen Peterson, Wen Huajie, Luke Chen, Chao Jiang and Masters Students – Almotasem Maamon, Kelsey Czyzyk, Taylor Ray, Kaula Muden, David Turner, Aliena Debelak, Karly Rager, Aura Lee Harper, Xin Huang, Chao Jiang, Zana Taner and Trai Nguyen.

Nine principal investigators, faculty, and administrators participating in MPC projects at **North Dakota State University** are: Eunsu Lee, Kimberly Vachal, Raj Bridgelall, Brenda Lantz, Pan Lu, Denver Tolliver, Zhibin Lin, Dinesh Katti, and Kalpana Katti. In addition, eight students are working on MPC projects at **North Dakota State University**: Bhavana Bakare, Leonard Chia, Ali Rahim Taleqani, Zijan

Zheng, Keshab Thapa HM Nasrulian Faisal, Wang Xingyu and Mingli Li.

Fourteen principal investigators, faculty, and administrators participating in MPC projects at **South Dakota State University** are: Allen L. Jones, Guanghui Hua, Christopher Schmit, Kyungnan Min, Nadim Wehbe, Mostafa Tazarv, Junwon Seo, Jonathan Wood, Rouzbeh Ghabchi, Michael Pawlovich, Vikash Gayah, Ilgin Guler Sheila Ohlsen and Francis Ting. In addition, twenty students are working in MPC research projects at **South Dakota State University**: Masters Students – Chamila Prashan Dharmarathna, Jason Weber, Samundra Thapa, Sandip Rimal, Ghaem Hooshyari, Peng Dai, Gregory Hansen, Lucas Bohn, Michael Mingo, Zachary Carnahan, Eduardo Torres, William Augustus Schaffer, Puskar Kumar Duhal, Thomas Cook, Shaohu Zhang, Chamika Prashan Dharmarathna, Buddhika Prasad, and Undergraduate Students - Brian Kidd and Sandip Rimal.

Eleven principal investigators, faculty, and administrators participating in MPC projects at the **University of Colorado Denver** are: Zohren Raghebi, Justin Shapiro, Wesley Marshall, Carolyn McAndrews, Bruce Janson, Jimmy Kim, Austin Troy, Moatasseem Abdallah, Matthew Cross, Mehmet Ozbek, Dan Piatkowski, and Krista Nordback. In addition, twelve students are working on MPC research projects at the **University of Colorado Denver**: Doctorate Students - Nick Ferenchak, Ibrahim Bumadian, Yaneev Golombek, Shahryar Monghasemi, Alejandro Henao, Abdullah Alajmi, Aaron Johnson, D. Akalp, Rob Fitzgerald; Masters Students –Ahmed Ibrahim, Nick Coppola, and Yifeo Chai.

One principal investigators, faculty, and administrators participating in MPC projects at the **University of Denver** is: Patrick Sherry. In addition, one student is working on MPC research projects at the **University of Denver**: Masters Student- Madden Bremer.

Fourteen principal investigators, faculty, and administrators participating in MPC projects at the **University of Utah** are: Tiffany Hortin, Richard J. Porter, Milan Zlatkovic, Kevin Franke, Ran Wei, Steven Bartlett, Cathy Liu, David Sanbonmatsu, David Strayer, Joel Cooper, Pedro Romero, Amanda Bordelon, Chris P. Pantelides, and Juan Medina. In addition, twenty-three students are working on MPC research projects at the **University of Utah**: Anurag Upadhyay, Anusha Musunuru, Bhaskar Kunwar, Donald Godfrey, Jamar Allah ham, Jeff Taylor, Jeffrey Oregon, Jem Locquaio, Kiavash Fayyaz, Kyle Strayer, M. Scott Shea, Martin Dinsmore, Massoud Hosseinali, McEntee Vanessa, Min Ook Kim, Ruoyang Wu, Sean Strayer, Shuanli Bao, Avinash Rishi, Mingde Lin, Taylor Adams, Zhenghui Yu and Zhuo Chen.

Eight principal investigators, faculty, and administrators participating in MPC projects at the **University of Wyoming** are: Khaled Ksaibati, Bart Evans, Mohamed Ahmed, Rhonda Young, Dennis Trusty, Kam Ng, Promotes Saha, and Milan Zlatkovic. In addition, seventeen students are working on MPC research projects at the **University of Wyoming**: Doctoral Students- Marwan Hafez, Waleed Mohammed Abd Allah Al Eadelat. Masters Students – Dawit Mebrahtom, Md Julfiker Hossain, Melake Brhanemeskel, Muhammad Tahmidul Haq, Nikolai Greer, Rameshwor Chalise, Sadia Sharmin, Sandeep Thapa, Sherif Gaweesh, Thomas Peel, Trena Terrell, Engineer, Andalib Shams and Sahima Nazneen. Undergraduate Student - Nicole Peterson.

Six principal investigators, faculty, and administrators participating in MPC projects at **Utah State University** are: Anthony Chen, Jim Bay, John Rice, Paul Barr, Marv Halling and Ziqi Song. In addition, eleven students are working on MPC research projects at **Utah State University**: Doctorate Students – Zhaocai Liu, Yi He, Hossein Nasr Isfaheni, Yu Song, Kiavash Fagyaz and Famararz Safazadeh. Masters Students - Phillip Powelson, Ethan Pickett, Justin Pace and Holly Llyod and Undergraduate Student- Jen Ostrowski.

b. What other organizations have been involved as partners?

The timing of match funding and the commitments of collaborators vary widely throughout the life of the grant. During this period, we have the following committed collaborators.

- AAA Foundation for Traffic Safety, Washington, DC
- Ajou University, Suwon, South Korea
- Bay Area Transportation Commission
- Berkeley, Berkeley, CA
- California State Fresno, Fresno, CA
- Campbell County Road and Bridge Department, Gillette, WY
- Campbell Scientific, Bridge Diagnostic Inc. (BDI), Logan, UT
- Campbell's Scientific, Logan, UT
- City of Watertown, Watertown, SD
- CMA-CGM Maritime, Inc.
- Colorado Department of Transportation, Denver, CO
- Converse County Road and Bridge Department, Douglas, WY
- Crook County Road and Bridge Department, Sundance, WY
- Digital Glove Foundation, Longmont, CO
- East Dakota Water Development District, Brookings, SD
- Fehr & Peers, Salt Lake City, UT
- Geneva Rock, Salt Lake City, UT
- Indian Highway Safety Program, BIA, Albuquerque, NM
- James River Water Development District, Huron, SD
- Keolis Commuter Services
- Lincoln County Road and Bridge Department, Kemmerer, WY
- Management Department, School of Business, New Jersey City University, Jersey City, NJ
- Management Quality Assurance (MMQA)
- Mandan Hidatsa Arikara Nation, Fort Berthold Reservation
- Mineta Transportation Institute
- Missouri Department of Transportation
- National Renewable Energy Laboratory, Golden, CO, Use of Facilities.
- NDDOT Safety Division, Bismarck, ND
- Nibley City, Nibley, UT
- North Carolina Pedestrian and Bicycle Information Center, Chapel Hill, NC
- Northern Plains TTAP (No longer active), Bismarck, ND
- Penn State University, University Park, PA
- Port of Oakland
- Sisseton Wahpeton Oyate Reservation, Agency Village, SD
- South Dakota Department of Environment and Natural Resources, Pierre, SD
- South Dakota Department of Transportation, Pierre, SD
- South Dakota State University, Brookings, SD
- Spirit Lake Nation, Fort Totten
- Standing Rock Sioux Tribe Indian Reservation, Fort Yates, ND
- StarSeismic LLC, Park City, UT
- Structural Special Assignment Engineering
- Teton County Road and Bridge Department, Jackson, WY
- The Colorado Department of Transportation
- University of California at Los Angeles, Los Angeles, CA
- University of Colorado Boulder, Boulder, CO

- University of Nebraska-Lincoln, Lincoln, NE
- Utah Department of Transportation
- Utah Transit Authority, Salt Lake City, UT
- Wisconsin Department of Transportation
- Wyoming Technology Transfer Center, Laramie, WY
- Yankton Sioux Tribe, Wagner, SD

c. Have other collaborators or contacts been involved?

The list of collaborating organizations in 3(b) is complete, as of this grant period.

4. Impact/ Expected Impacts

a. Impacts

North Dakota State University: Students supported by UTC funds here at North Dakota State University have gone onto very successful positions with fortune 500 companies, academia, federal, state, and local transportation agencies. Students continue to excel while building transportation skills that will enhance the transportation workforce now into the future. With the support of UTC funds, NDSU researchers have been able to focus on tribal needs throughout the state, infrastructure assessment, asset management, bridge strength analysis, and technology transfer. These efforts will continue to develop the skills and knowledge of the transportation workforce to face the challenges of the 21st century. NDSU researchers continue to move into sensor networks, smart city applications, and addressing the needs and challenges of public transportation in rural and metropolitan areas. Research findings are being disseminated through webinars, transportation learning network, newsletters, social media, and email blasts.

Wyoming: One of the projects concentrated on gravel roads management, the implementation of that study will help local governments in better managing their roads. In addition, it will provide them with the tool to identify needed funding levels for managing their gravel roads effectively. Another study concentrated on developing better designs for pedestrians and bicycle facilities. When completed, this study will enhance the safety and operation of such facilities.

Colorado State University: Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management, this project proposes a new way of planning bridge inspections. This work contributes to an ongoing area of debate in the bridge inspection/management community. It is fairly clear that biennial inspections are likely not the most effective use of management funds, but no single alternative strategy has been developed. Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards. The findings help on designing better bridges against earthquake. Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure. The STT method produced in this project overcomes key limitations of existing methods that estimate stream flow in response to specified rainfall (e.g., a design storm). In particular, it accounts for the nonlinearity in the relationship between basin runoff and stormflow at the basin outlet. In addition, it considers the channel network type that occurs in the basin (e.g., dendritic or parallel). The STT method is simple enough to be implemented in a spreadsheet by practicing engineers and could be implemented in modeling software such as HEC-HMS because it does not require hydrologic computations on a grid. We expect these methods to be adopted by hydrologists who work in transportation and other related fields. The new method is expected to produce more accurate estimates of streamflow, which should improve the safety bridges and culverts. Coupled Numerical Simulation of Debris Flow-

Soil-Structure Interactions for Flexible Barrier Mitigation Systems. The numerical model developed for this study was shown to yield more comparable predictions of deformations and loads in a flexible ring-net barrier for debris flows. This numerical model can be used to assess strength and deformation behavior of typical debris flow barriers constructed with a ring-net design. Thus, we anticipate the results of this report being beneficial to transportation professionals that are interested in modeling deformation and loads in a barrier. Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes. Help on understanding the seismic performance of bridges and moving traffic. Effect of Service Temperature on Joint Removal in Steel Bridges. Collect new data and establish new approaches for assessment of bridges under service temperature. Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness. Solidifies knowledge base for the use of fluid-based piping for snow clearance for common transportation foundations and slabs.

South Dakota State University: Engineers and researchers in Material Science may develop non-proprietary UHPC or non-shrink grout for longitudinal joints connecting precast bridge girders. Additionally, unified testing methods for mechanical bar splices in accelerated bridge construction.

University of Colorado Denver: The MPC projects are helping, for example, improve the way we consider and teach fundamental transportation engineering issues such as road safety as well as novel issues such as the impact of ride-hailing services. The results range from the development of innovative materials that will be used in bridge engineering to a reassessment of clear zone strategies in urban areas.

University of Utah: Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges. This research is contributing to the general body of knowledge on innovative intersection and interchange designs. It introduces several modules for operational and safety analysis for different modes: cars, transit, bicycles and pedestrians. The product is a user-friendly excel-based analysis tool that provides overall performance measures using basic inputs on design and traffic volumes. Self-Regulation and Distraction. The study provided an understanding of the cognitive underpinnings of attitudes toward fully automated vehicles. The findings are relevant to the field of transportation safety and the automotive industry because these attitudes will determine the willingness to adopt self-driving vehicles, and the support for the legal and physical infrastructure needed to put these vehicles on our roads. Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance). This project will result in better understanding of performance of surface treatments. Self-Centering Buckling Restrained Braces for Curved Bridges. The research has led to simplified methods for designing buckling restrained braces and energy dissipation braces for seismically deficient bridges. The research has also led to simplified design methods for retrofitting bridge columns that may have been damaged after a large earthquake. The analytical models developed for these retrofits are general and could also be applied to the seismic design and performance evaluation of new bridges. Early-Age Fiber-Reinforced Concrete Properties for Overlays. Age dependent properties of FRC as used in pavement design and pavement modeling. Incorporating Maintenance Costs and Considerations into Highway Design Decisions. Product development is still underway. This section will be updated as soon as a draft or final version of the products is finalized. Expected results from this research will provide a first look at the long term maintenance costs of roadway barrier systems, cross-sectional dimensions, as well as recommendations on innovative intersection design maintenance practices and successful drainage designs. Safety Effects of Protected and Protected/Permitted Left-Turn Phases. Results from this project are expected to provide a better understanding of the safety effects of different left-turn phasing indications. This project addresses current gaps in research and is expected to have wide impact. Practical

implications and guidance for state DOTs are also expected. Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement. The Utah DOT is interested in the retrofit measures since there are approximately 300 bridges constructed with concrete wall piers in Utah with similar details. Alternative in-situ Water-Cement Meter Using a Parallel-Plate Capacitor Concept device capable of measuring water or moisture content in cementitious materials

Utah State University: The principal discipline is Civil Engineering. Although our work with companies and cities has expanded it beyond just these areas. Workforce development and design continue to be primarily focus areas with increases in public transportation planning and safety.

b. Expected Impacts

North Dakota State University: NDSU transportation and logistics students will continue to infiltrate the transportation workforce bringing excellent data analysis and assessment skills to the organizations. Students continue to present and participate in industry workshops and conferences, and seek top level transportation positions around the world. NDSU researchers continue to disseminate the results of ongoing projects and research to transportation professionals around the state. Expected outcomes will continue to be shared through technology transfer opportunities, webinars, and social media.

Wyoming: The tribal safety study resulted with a tool kit which will help tribes in implementing a safety program. Such program will help in reducing crashes on tribal lands nationwide. A significant number of papers have been presented/published as a direct result of the MPC studies at the University of Wyoming.

Colorado State University: MPC-449 — Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management. This project helped to fund a M.S. student and provided the topic for their thesis. MPC-461 — Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards. Help train future bridge engineers. MPC-481 — Incorporating River Network Structure for Improved Hydrologic Design of Transportation Infrastructure. The project supported two Master of Science students who are expected to become active in the transportation workforce as hydrologists. MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems. Completion of this project and the MS of Aliena Debelak has led to the advanced training of a MS-level graduate student. Aliena is currently working as a consulting engineer. MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness. This could broaden the base of tools used to keep roadways and related systems clear of snow. MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment. Provided opportunity for research in transportation related disciplines.

South Dakota State University: The research projects covered in this report provided educational and research experience in transportation-related topics to 13 graduate and one undergraduate students.

University of Colorado Denver: The seven MPC projects have been instrumental in providing opportunities for at least a dozen graduate students. They are all gaining experience in research methods, paper writing, and presenting as well as developing new skills.

University of Utah: MPC-465 — Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges. Some aspects on design, operations and safety of innovative designs developed in this project were used in Highway Design, Introduction to Transportation Engineering and Traffic Simulation courses. The study provided partial scholarships for one MS and one PhD student. MPC-468 — Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance) MPC-491 — Self-Centering Buckling Restrained Braces for Curved Bridges The students working on this project have developed very high aptitude for research and teaching. They have lectured in regular courses and thus have benefited a large number of both graduate and undergraduate students from their research. MPC-526 — Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement. An ability to repair and retrofit reinforced concrete bridges with deficient structural details using new technologies such as carbon fiber rods, sheets and anchors. MPC-529 — Alternative in-situ Water-Cement Meter Using a Parallel-Plate Capacitor Concept ability to predict strength of concrete through accurate w/c content.

Utah State University: We have worked very hard to involve and support as many students as possible with these funds. It has been great opportunity to not only involve students directly but also motivate other potential students. It has been a good thing for the public as well.

c. What is the impact on the development of transportation workforce development?

Colorado State University

The projects supported two Master of Science students who are expected to become active in the transportation workforce as hydrologists. MPC-482 — Coupled Numerical Simulation of Debris Flow-Soil-Structure Interactions for Flexible Barrier Mitigation Systems. Completion of this project and the MS of Aliena Debelak has led to the advanced training of a MS-level graduate student. Aliena is currently working as a consulting engineer. MPC-486 — Sustainable Heated Pavements for Infrastructure Longevity, Safety and Economic Competiveness. This could broaden the base of tools used to keep roadways and related systems clear of snow. MPC-509 — Expansive Soil Mitigation for Transportation Earthworks by Polymer Amendment Provided opportunity for research in transportation related disciplines.

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University of Utah

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Utah State University

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d. What is the impact on physical, institutional, and information resources at the university or other partner institutions?

University of Utah

MPC-491 — Self-Centering Buckling Restrained Braces for Curved Bridges

The experiments carried out during this project have been instrumental in improving the physical capabilities of our structures laboratory. Moreover, one of the research assistants, has been giving weekly instructions on students who are trying to learn the structural analysis software Open Sees to other students in the department. MPC-492 — Early-Age Fiber-Reinforced Concrete Properties for Overlays. Physically built wedge-splitting test apparatus at University of Utah for fracture testing. Also physically built Ring Shrinkage concrete test apparatus at Utah Department of Transportation. MPC-526 — Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement. Development of new methods and procedures for seismic retrofit of concrete structures. MPC-529 — Alternative in-situ Water-Cement Meter Using a Parallel-Plate Capacitor Concept new device on market.

Utah State University

We use the TimeLab, SMASH lab and the Electric Vehicle Center as the three primary university resources. What is the impact on technology transfer?

South Dakota State University

Data of large-scale beams and full-scale double-tee girder bridges are electronically available and will be shared with researchers and public upon request. A digital brochure was prepared to disseminate the findings to DOTs, bridge engineers, local governments, and bridge owners. Data of more than 160 mechanical bar splices are electronically available and will be shared with researchers and public upon request. The South Dakota DOT has adopted the new design for longitudinal joints between double tee bridge girders.

University of Colorado Denver

The results of these MPC projects have already been published in well-regarded peer review journals and highlighted at numerous conferences. We have also developed several project websites based on this work.

University of Denver

The development of the Safety Culture instrument has been of great value in terms of technology transfer. The instrument has been used in both state DOT's as well as in freight and shipping operations.

University of Utah

MPC-465 — Development of Performance Matrices for Evaluating Innovative Intersections and

Interchanges. The results and tools developed in this research were shared with UDOT for testing and implementation in the field. MPC-468 — Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance). MPC-491 — Self-Centering Buckling Restrained Braces for Curved Bridges. The Utah DOT is very much aware of the retrofit strategies developed in this project. They have shown interest in the experiments and analytical techniques developed in this research.

Utah State University

Technology transfer has been in terms of publications, although smaller at this stage, and conference participation. We have not had much activity in terms of commercialization. We hope that the research will result in new design practices.

e. What is the impact on society beyond science and technology?

South Dakota State University

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders:

The outcome of the project save millions of tax-payers' dollar since the proposed rehabilitation method only costs 30% of the double-tee girder replacement cost. Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders: The outcome of the project save millions of tax-payers' dollar since the proposed rehabilitation method only costs 30% of the double-tee girder replacement cost. Mechanical Bar Splices for Accelerated Bridge Construction of Columns: Bridge codes may be relaxed to allow mechanical bar splices for accelerated construction of bridge columns. Experimental and Computational Study of Self-Consolidating Concrete for Prestressed Bridge Girders: The recommendations for SCC mixture design that achieves desired performance for use in prestressed SCC girders for WisDOT will be widely accepted across Wisconsin and utilized for ensuring public and construction safety. Development of a Guideline for Selection of Tack Coats in South Dakota: This project's outcomes after implementation is expected to improve state of practice and construction resulting in safer pavements which require less maintenance. This will benefit the community by saving money and time. Development of a Guideline for Selection of Tack Coats in South Dakota: This project's outcomes after implementation is expected to improve state of practice and construction resulting in safer pavements which require less maintenance. This will benefit the community by saving money and time.

University of Colorado Denver

The bigger picture goals are to help makes our transportation system safer as well as extend the longevity of our infrastructure investments. These results will help do so.

University of Utah

MPC-465 — Development of Performance Matrices for Evaluating Innovative Intersections and Interchanges The research can help the general public better understand innovative intersection design and adopt their driving behavior. MPC-468 — Performance Evaluation of Highway Surface Treatments (Phase I: Short-Term Performance). MPC-491 — Self-Centering Buckling Restrained Braces for Curved Bridges. Improvement of safety of bridges before a large earthquake and pre-earthquake retrofit to minimize downtime after a large earthquake. MPC-493 — Incorporating Maintenance Costs and Considerations into Highway Design Decisions. Potential improvement of long-term resource and tax dollar investment on maintenance-related needs, primarily by State DOTs. MPC-526 — Seismic Repair of Concrete Wall Piers Using CFRP Active Confinement Safer bridges when large earthquakes occur.

Utah State University

We have had good interaction with the public and some lawmakers on the Electric Vehicle and bridge instrumentation. These opportunities are good for people outside the direct program to gain a better understanding of the value of the program.

5. Changes/Problems

No changes or problems at this time.

5a. Additional Information Regarding Products and Impacts

Nothing to report at this time.

PROGRAM OUTPUTS: Nothing to report at this time.

PROGRAM OUTCOMES: Nothing to report at this time.

PROGRAM IMPACTS: Nothing to report at this time.

6. SPECIAL REPORTING REQUIREMENTS: None