Feasibility of Reclaimed Asphalt Pavement as Aggregate in Portland Cement Concrete Pavements

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PROBLEM STATEMENT

Each year, the highway construction industry in the United States produces over 100 million tons of reclaimed asphalt pavement (RAP) through standard rehabilitation and construction of our nation's roads. Although this reusable material has been put to use in some applications (usually in the form of asphalt paving), a large portion of this material remains unused and is either stockpiled or land filled. Therefore, alternative uses for this material are needed. One possible use for this material is the replacement of conventional aggregates in Portland cement concrete pavement (PCCP). The environmental impact of using RAP as aggregate replacement in PCCP goes beyond an alternate use for RAP, it reduces the need for conventional aggregates and the environmental impacts associated with their creation and transportation. Preliminary research has demonstrated the feasibility of using RAP in this application; however, these research efforts are limited and have focused primarily on short-term mechanical characteristics of the material and have not addressed long-term durability characteristics such as alkali silica reactivity (ASR) or freeze–thaw resistance. Therefore, the proposed research will focus on further characterizing RAP in Portland cement concrete (including durability), a necessary step in validating its use in transportation applications (e.g., pavements, sidewalks, medians).

The proposed research effort will begin by developing mix designs with similar strengths, set-times, and workability to standard Portland cement concrete mixtures. Once these mix designs are developed, the resulting concretes will be evaluated with a suite of mechanical and durability tests. These results will then be analyzed and documented. Depending on the outcome of this feasibility study, recommendations will be made for a Phase II pilot project in which this material is used in place of traditional concrete in a transportation application.

BACKGROUND SUMMARY

Previous research has demonstrated the feasibility of using RAP as aggregate replacement in PCCP; however, these preliminary research efforts have been focused on short-term mechanical properties of the material and have not addressed the issue of durability, an essential component of designing and constructing a sustainable infrastructure. A brief summary of the results of these research efforts is provided below.

Previous researchers have demonstrated that the fundamental mechanical properties (e.g., compressive strength, elastic modulus) of concrete containing RAP as aggregate replacement decrease with increasing replacement rate (Delwar et al., 1997, Hossiney, 2008; Huang et al., 2005). This effect is likely due to the residual asphalt within the RAP and the associated deleterious effects on the bond between the aggregates and cement matrix. The effect on mechanical properties is significant, and decreases in strengths of around 75 percent have been reported for mixes with 100 percent replacement (Huang et al., 2005; Delwar et al., 1997). However, despite having strengths significantly less than those of control mixes, concretes suitable for transportation applications (compression strengths around 3 ksi) have been produced using replacement rates around 40–50 percent (Hossiney, 2008; Huang et al., 2005).

The effects of using RAP as aggregate replacement are not always negative; Huang et al. (2005) and Delwar et al. (1997) both noted increases in ductility and toughness as the replacement rate was increased. These increases may prove beneficial with respect to crack control, an essential component in transportation-related applications. Additionally, Hossiney (2008) reported a decrease in drying shrinkage as the rate of replacement increased. The increase in toughness and decrease in shrinkage cracks are most likely related to the adhesive properties of the residual asphalt. Hossiney also noted that the effect of RAP on the coefficient of thermal expansion was negligible, and demonstrated (via a finite element analysis) that the reduced stiffness of RAP concretes resulted in less demand on concrete pavements; therefore, the decreased compressive strength may not be as detrimental as it first appears. In fact, they observed that the ratio of demand to capacity decreased with increasing replacement rates.

It should be noted that the concrete mixtures in these research efforts did not include chemical or mineral admixtures to enhance performance of the concrete mixtures. Huang et al. (2006) performed a follow-up study on their initial work to investigate the effects of using high range water reducers and silica fume in concrete mixtures containing RAP. They determined that the use of high range water reducers did indeed improve performance, but the use of silica fume did not.

OBJECTIVES

The primary goal of this project is to develop and characterize an environmentally friendly concrete suitable for transportation-related applications in which a portion of the conventional aggregate has been replaced with reclaimed asphalt pavement. This concrete has the potential to reduce the myriad of environmental impacts associated with the production of traditional concrete, as well as reduce the volume of solid waste stockpiled or disposed in landfills.

The research proposed herein will investigate the effects of RAP on several mechanical properties along with key durability characteristics (an important aspect overlooked in previous research efforts). Additionally, the proposed research will utilize both mineral and chemical admixtures to enhance concrete performance. Class C fly ash will be used to replace 15 percent of the Portland cement in the concrete mixtures, which will further reduce the environmental impact of this material and possibly increase the performance. High range water reducers will be used to improve workability ideally without negatively impacting strength or durability.

BENEFITS

The benefits to society and the state of Montana as a result of the proposed research are obvious and at least twofold: the reduced environmental impact of producing and transporting traditional aggregates, and the reduced need for stockpiling or land filling a significant waste stream.

In addition to the obvious environmental advantages of these materials, other benefits include (1) increased lifecycle of concrete pavement in comparison to flexible pavements, and (2) the potential for reduced costs—as a byproduct, using onsite RAP may be less expensive than using traditional aggregates that must be quarried and transported to the jobsite.

RESEARCH PLAN

The research program described in this proposal will deliver a comprehensive characterization of the mechanical and durability properties of Portland cement concretes containing RAP as aggregate replacement. The project will begin with a literature review on the topic (Task 1). Task 2 will consist of creating mix designs and validating several key mechanical properties of eight concrete mixtures containing various RAP and air contents. Two of the most promising mix designs from Task 2 will then be evaluated further with a full suite of mechanical and durability tests (Task 3). Finally all test results will be fully analyzed (Task 4) and a final report will then be produced documenting all work performed, results obtained, and suggested further work (Task 5).

Task 0: Project Management

The Principal Investigator on this project will be Dr. Mike Berry. He will serve as the primary point of contact between the Montana State University (MSU) research team and the Montana Department of Transportation (MDT) Project Manager. Quarterly progress reports will be prepared and submitted to MDT for review. These reports will include a summary of progress, significant findings, and problems encountered over the past quarter, as well as a description of worked planned for the next quarter. A summary of expenditures to date will also be included.

Task 1: Literature Review

As this research moves ahead, it is essential to be aware and take advantage of any work completed to date by other investigators. Researchers at MSU and MDT recently conducted a literature review on this subject, and this review will be revisited and expanded as part of the proposed project.

Task 2: Mix Designs and Validation of Key Properties

In this task, eight different mix designs containing various RAP and air contents will be investigated. Four different replacement rates of RAP (between 25 and 100 percent) will be investigated as part of this research effort. The exact replacement rates will be determined after initial trial mixes are performed to determine the quality of concrete attainable with the proposed materials. The factors that may affect the quality of the concrete are: (1) the specific RAP used and its percentage of residual asphalt, (2) the characteristics of the local aggregates, (3) the effects of using 15 percent fly ash replacement, (4) the use of admixtures such as high range water reducers, and (5) various other aspects of the mix design (e.g., water to cementitious material (w/cm) ratio, paste ratio, air content). The results of the initial trial mixes will be shared with MDT, and the research team and MDT will work together to identify suitable replacement rates. Parallel mixtures with and without air will be investigated to study the effects of air entrainment.

Once the replacement rates to be studied are identified, mix designs will be prepared and additional trial mixes will be performed to ensure workability, air content, and set times consistent with MDT specifications. As noted earlier, to further the environmental benefits of this material, 15 percent of the Portland cement in the proposed mix designs will be replaced with Class C fly ash (a byproduct of coal-fired power plants). The w/cm ratios and paste contents will be held constant for each mix design, and water reducers will be used as necessary

to achieve proper workability. Once proper mix designs are determined for these concretes, the materials will be tested to determine key mechanical and durability properties—namely, compressive strength, flexural tensile strength, and freeze–thaw resistance (see following section for description of tests). The results of these tests, along with workability and set times, will be used to screen proposed mixtures and identify two promising mixes for further testing.

Based on physical similarities to conventional aggregates, the proposed concrete mixtures are expected to share many of the well-established attributes of conventional concrete. That being said, the residual asphalt binder will affect how the aggregate bonds to the cement matrix. This difference is expected to significantly affect the mechanical and durability characteristics of these materials. In addressing the various concerns identified above, the state of the art in concrete science is not sufficiently advanced to definitely predict how this new concrete will perform based on the material properties of its constitutive ingredients. While the existing knowledge base and preliminary work completed to-date consistently point toward its potential to perform well in construction applications, tests must be conducted on the concrete itself to definitively evaluate this performance. Empirically derived equations are available to estimate some of these properties for conventional Portland cement concretes based on the unconfined compressive strength of the material. The appropriateness of these equations for estimating the same properties of fly ash concrete based on their compressive strength will be evaluated.

The various sampling and testing in this program will be conducted as possible and appropriate in accordance with the American Society for Testing and Materials Standards (ASTM, 2007). While considerable information is available on tests for evaluating the properties of Portland-cement-based concrete with traditional aggregates, little is available on evaluating the properties of RAP replacement concretes.

Task 3: Comprehensive Determination of Material Properties

Two promising concrete mixtures will be identified for further testing based on the results of Task 2. These mixtures will be tested with a comprehensive suite of mechanical and durability property tests. It should be noted that three duplicate specimens will be tested for each test method and time period to ensure reliable results, and where applicable control specimens made with traditional aggregates will also be tested to provide a comparative basis for performance. The tests that will be performed are described below, and are summarized in Table 1.

Mechanical Properties

The mechanical properties of these new concretes are key indicators of how well they will perform with respect to strength and durability and are essential in predicting the response of structural elements. The mechanical properties to be tested are discussed below.

Compressive Strength: The simplest property to obtain and possibly the single most informative property for concrete is the compressive strength. For the proposed project, the compressive strength of 4-by-8-inch cylinders will be determined according to ASTM C39 (Test Method for Compressive Strength of Cylindrical Concrete Specimens).

Elastic Modulus: Stiffness is another important property of concrete. The stiffness of the material is characterized by the ratio of stress to strain in the elastic range, often referred to as the elastic modulus or Young's modulus. The elastic modulus will be determined from load-deformation measurements made on 4-by-8-inch concrete cylinders tested in uniaxial

compression (ASTM C469, Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression).

Tensile Strength: The tensile capacity of concrete is significantly less than its compressive strength; therefore most applications of concrete include reinforcing steel to carry tensile loads. However, the tensile capacity is very important with respect to cracking, shear capacity, anchorage capacity, and durability. Splitting tensile strengths will be obtained from tests on 6-by-12-inch concrete specimens conducted according to ASTM C496 (Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens). The tensile strengths of the materials will also be investigated by testing rupture beams according to ASTM C78 (Test Method for Flexural Strength of Concrete).

Shrinkage: Concrete tends to shrink over time due to chemical and moisture changes, which often leads to significant cracking. The tendency for the concrete to shrink will be tested according to ASTM C490-00a (Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete).

Creep: Concrete has an inherent tendency to deform or creep over time under sustained load. This phenomenon is particularly important in structural elements with high dead loads. The tendency for the mix designs to creep will be evaluated according to ASTM C512 (Standard Test Method for Creep of Concrete in Compression).

Table 1: Schedule of Mechanical and Durability Tests

Property	ASTM Test Method	Days to be Tested
Compressive Strength	C39	systematically over one year
Elastic Modulus	C469	systematically over one year
Tensile Strength	C496/78	systematically over one year
Shrinkage	C490-00a	systematically over one year
Creep	ASTM C512	systematically over one year
Alkali Silica Reactivity	C1260	systematically over 28 days
Alkali Silica Reactivity	C1293	systematically over one year
Absorption	C642	systematically over one year
Abrasion	C944	systematically over one year
Chloride Permeability	NA	90 days
Freeze-Thaw	C666	systematically for 300 cycles
Scaling	C672	systematically over 50 days

Durability Properties

The durability of the concrete is especially important with regard to constructing sustainable infrastructure. The durability tests to be conducted are described below and are summarized in Table 1.

Alkali Silica Reactivity: The susceptibility of the concrete to deleterious ASR will be investigated following the protocols of ASTM C1260, Potential Alkali Reactivity of Aggregates (Mortar Bar Method). Several methods are available to investigate ASR; ASTM C1260 is one of the more rapid and conservative of these methods. Additionally, ASTM C1293 will be performed on the test specimens to compare with results of ASTM C1260.

Absorption: Absorption capacity often is a broad indicator of a concrete's resistance to degradation from various environmental exposures, as much of this degradation is associated

with the ingress of moisture into the hardened concrete. Absorption properties of the various concretes will be determined using the test methods outlined in ASTM C642. This test involves submerging dry test specimens in water and monitoring their weight change, which corresponds to the weight of the water absorbed over time.

Abrasion: The abrasion resistance of concrete is especially important for concrete pavements, hydraulic structures, and bridge decks. This property is closely related to compressive strength of the concrete; however, the hardness of the aggregate within the concrete can have a significant effect as well. The RAP concrete will be tested for abrasion resistance according to ASTM C944 (Standard Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method).

Chloride Permeability: A concrete's ability to resist chloride penetration is especially important in reinforced concrete elements exposed to deicers and salt water because of the deleterious effects the chloride can have on the reinforcing steel. A Rapid Chloride Permeability Test (RCPT) is designated in AASHTO T277 and ASTM C1202 as a standard test method to evaluate Portland cement concrete's ability to resist chloride penetration. However, the electrical charge passed in the test is related to all ions in the pore solution, not just chloride ions (Stanish et al., 1997). In addition, RCPT is not suitable to evaluate the chloride permeability of concrete with supplementary cementing materials (Shi et al., 1998), and the results may be significantly biased due to the change in the chemical composition of the pore solution (Savas, 1999 and Wee et al., 2000). Therefore, the modified RCPT procedure proposed by He and Shi (2008) will be used in the proposed research.

Freeze–Thaw Resistance: A primary mechanism of physical degradation of exposed concrete is prolonged exposure to cycles of freezing and thawing in a saturated state. This damage, which can occur at both a microscopic and macroscopic level, accumulates over time, eventually contributing to failure of the concrete. The freeze–thaw resistance of the RAP concrete will be tested according to ASTM C666 (Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing). Three specimens from each mix design will be tested. The degradation of the specimens will be monitored via their mass loss and changes in their resonant frequencies of vibration. The fundamental transverse frequency will be measured according to ASTM C215 (Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens).

Scaling: The scaling resistance of concrete is especially important with respect to transportation-related applications such as concrete pavements and bridge decks. The scaling resistance of the concrete mixes will be evaluated according to ASTM C672 (Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals).

Task 4: Analysis of Results

The results of the research program will be thoroughly analyzed in this task. Comparisons will be made between the different replacement rates, air contents, and control specimens.

Task 5: Final Report and Dissemination of Results

The dissemination of results will be achieved through several avenues. First, the research team will prepare a final report documenting the findings of this investigation. Additionally, the team will prepare journal publications and several key engineering conferences will also be targeted as

outlets for dissemination via conference papers and presentations. Such conferences include the Transportation Research Board's Annual Meeting, American Society of Civil Engineers and Structural Engineering Institute's (ASCE/SEI) Structures Congress, and the American Concrete Institute's (ACI) semiannual conventions. The PI will also seek opportunities with MDT to educate staff and encourage the use of this material in construction projects.

PRODUCTS

The following products will be produced as a result of the proposed research:

1. Quarterly progress reports.
2. Final report.
3. Project summary report.
4. Peer reviewed journal articles.
5. Conference presentations.

IMPLEMENTATION

Depending on the outcome of this research phase, MDT may elect to further investigate this material in a full-scale pilot project in which a transportation element is constructed with concrete containing RAP aggregate replacement. Upon completion of a successful pilot project, MDT will have a new "green" concrete available for use in road construction. The mixture proportions, batching procedures, and material properties will be documented in the final report for the project. This information can be used as appropriate to develop standard specifications for the material, and/or to identify additional work that must be done to move this material forward for such standard use.

TIME SCHEDULE

This project is will take approximately 18 months to complete. The anticipated project schedule by task is presented in Table 2. The anticipated start date is January 4, 2010, with an estimated completion date of June 30, 2011.

Table 2: Schedule of Tasks

Task/Milestone	Quarter (after start of work)					
	1	2	3	4	5	6
Task 0: Project Management	x	x	x	x	x	x
Task 1: Literature Review	x					
Task 2: Mix Designs and Validation of Key Properties	x	x	x	x	x	
Task 3: Comprehensive Determination of Material Properties				x	x	
Task 4: Analysis of Results				x	x	
Task 5: Final Report and Dissemination of Results					x	x
MDT Review of Final Report						x

STAFFING

The primary research team is composed of two faculty members from the MSU Department of Civil Engineering, a Project Manager from the Western Transportation Institute (WTI), a lab technician from WTI, and undergraduate and graduate student researchers. Collectively, the research team has extensive research experience in reinforced concrete structures and alternative construction materials. With respect to alternative construction materials, the team's work has focused on concrete materials made with byproducts. This work has ranged from manufacturing bricks from mine tailings to the production of lightweight aggregate for concrete blocks using fly ash, to more recent work on fly-ash-based concrete for general construction applications. This work has all been characterized by an interest in green materials, an interest in better understanding the fundamental material science of these materials, and an interest in seeing these materials move out of the laboratory and into practice.

Michael Berry will serve as a PI on this project. Dr. Berry has a research background in reinforced concrete structures and the behavior of these structures subjected to earthquake excitations. More recently his work has focused on alternative materials and their use in structural elements. He currently serves on the Transportation Research Board Committee on Basic Research and Emerging Technologies Related to Concrete.

Jerry Stephens will serve as a Co-PI on this project. Dr. Stephens has worked with alternative materials for nearly two decades and has pioneered (with Doug Cross) research on 100 percent fly ash concrete. His research interest in concrete began with the investigation and development of innovative high-strength and fiber-reinforced concretes for military structures. With this background, he has been researching the use of alternate materials in civil engineering construction since joining MSU in 1989. He is a full professor in the Department of Civil Engineering and is the Research Director at WTI.

Doug Cross is a Project Manager for WTI and will serve as a Co-PI on this project. After working several years in the construction industry, Mr. Cross has returned to the academic environment and has been a key investigator in MSU's alternative concrete research efforts, while pursuing his engineering degree at MSU. In addition to working and attending school at MSU, Mr. Cross was affiliated with Headwaters Composites in Three Forks, MT, a private firm that manufactured specialty products made with innovative concrete materials.

In their work on alternate materials over the years, the project team has collaborated with a variety of partners with a stake in the development of such materials, from material suppliers to final end users. These partners include PPL Montana (power company producing fly ash), Headwaters Resources, Inc. (major fly ash marketer), and the Montana Department of Environmental Quality (one of whose tasks is to promote the use of recycled materials).

The project will also employ graduate and undergraduate students to assist in sampling and testing the concrete, analyzing the test results, and documenting the fieldwork.

The projected level of effort by project personnel is summarized in Table 3. These personnel can commit the time necessary to complete this work in a timely and deliberate manner. Professional members of the research team will not be changed without written consent of MDT.

Table 3: Schedule of Staffing

Name of Principal, Professional, Employee, or Support Classification	Role in Study	Task 0	1	2	3	4	5	Total
Mike Berry	Principal Investigator	60	8	60	60	100	58	346
Jerry Stephens	Co-Principal Investigator	20	4	15	15	60	6	120
Doug Cross	Co-Principal Investigator	60	0	145	145	60	16	426
Keith Fortune	Specimen construction, testing, and data analysis	0	0	300	350	100	0	750
Graduate Research Assistant	Specimen construction, testing, and data analysis	0	40	500	500	144	200	1384
Undergraduate Student	Specimen construction and testing	0	0	250	250	0	0	500
Administrative Staff	Administrative Support	8	0	0	0	0	0	8
Clerical Staff	Report Preparation	8	0	0	0	0	16	24
Total		156	52	1270	1320	464	296	3558

FACILITIES

With respect to the validation of the mechanical properties and durability of the concrete to be studied in this project, a majority of the required equipment is already available in the Civil Engineering Department at MSU and at WTI. The pieces of equipment that must be acquired to conduct this research will be purchased with matching funds from MSU. The dollar amounts of these purchases are identified in the budget.

MDT INVOLVEMENT

MDT will be involved in the selection of suitable replacement rates to be investigated based on initial trial pours as indicated in Task 2 of the Research Plan. Additionally, MDT will be responsible for collecting and delivering the RAP to MSU at the commencement of this project. The RAP could be delivered to MSU (Bozeman) via a standard dump truck, and MSU would be responsible for packaging and grading this material after delivery. It is estimated that we will need approximately 14-15 tons of RAP aggregate. This quantity is rough approximation because the percentages of RAP replacements have not yet been determined. Furthermore, important mix design characteristics (e.g., paste content and aggregate gradation) have also not yet been determined. Finally, MDT will be asked to review and comment on quarterly reports and the final report.

BUDGET

This project is being supported by $33,793 in funding from the WTI University Transportation Center program, matched by $103,892 in MDT funding, as shown in Table 4. The pay rates and benefit rates of the investigators is provided in Table 5. A detailed breakdown of supplies and equipment is included in Table 6. Projected expenditures by task are shown in Table 7. Total and MDT projected expenditures by state and federal fiscal years are shown in Table 8 and Table 9, respectively.

Table 4: Project Budget by Item

Item	MSU	MDT Match	Total
Salaries	$11,626	$58,517	$70,142
Benefits	$1,163	$15,810	$16,972
In-State Travel	$0	$200	$200
Out-of-State Travel	$0	$0	$0
Expendable Supplies and Minor Equipment	$6,500	$12,050	$18,550
Participant Costs	$6,500	$0	$6,500
Total Direct Costs	$25,788	$86,576	$112,365
Overhead (41.5% MSU, 20% MDT)	$8,005	$17,315	$25,320
Total Project Cost	$33,793	$103,892	**$137,684**

Table 5: Pay Rate and Benefits

Employee	Hourly Rate	Benefit Rate
Berry	$36.50	30%
Stephens	$52.55	30%
Cross	$26.00	33%
Fortune	$19.73	33%
Graduate Student	$14.00	10%
Undergraduate Student	$10.00	10%
Business Manager	$41.77	33%
Admin Staff	$26.00	33%

Table 6: Detailed Budget (Expendable Supplies and Minor Equipment)

Item	MSU	MDT	Total
Concrete Formwork and Molding			
3 - ASR 1260 molds	$0	$600	$600
8 - ASR 1293 molds	$0	$1,500	$1,500
8 - Scaling molds	$0	$80	$80
20 - Abrasion molds	$0	$200	$200
15 - Steel 4"x8" cylinder molds	$0	$1,500	$1,500
12 - Steel 6"x12" cylinder molds	$0	$1,620	$1,620
Total	**$0**	**$5,500**	**$5,500**
Materials, Handling, and Disposal			
Portland Cement	$0	$1,000	$1,000
Conventional Aggregate	$0	$500	$500
Misc chemicals for testing	$0	$500	$500
Disposal of discarded specimens	$0	$500	$500
Freeze-Thaw Machine Fee	$0	$2,500	$2,500
Total	**$0**	**$5,000**	**$5,000**
Testing Equipment			
Creep Testing Frame and Hydraulics	$4,500	$0	$4,500
Abrasion Test Setup	$0	$300	$300
Data Acquisition	$2,000	$0	$2,000
Total	**$6,500**	**$300**	**$6,800**
Misc Supplies	$0	**$1,250**	**$1,250**
Total	**$6,500**	**$12,050**	**$18,550**

Table 7: Project Budget by Task

Task	Budget
0 - Project Management	8,531
1 - Literature Review	1,602
2 - Mix Design and Validation of Key Properties	38,343
3- Comprehensive Determination of Material Properties	51,477
4- Analysis of Results	28,396
3-Final Report	9,336
Total	**$137,684**

Table 8: Total Project Budget by Fiscal Year

	State Fiscal Year		Federal Fiscal Year	
Item	2010	2011	2010	2011
Salaries	$27,277	$42,865	$38,968	$31,174
Benefits	$6,600	$10,372	$9,429	$7,543
In-State Travel	$78	$122	$111	$89
Out-of-State Travel	$0	$0	$0	$0
Expendable Supplies and Minor Equipment	$7,214	$11,336	$10,306	$8,244
Participant Costs	$2,528	$3,972	$3,611	$2,889
Total Direct Costs	$43,697	$68,667	$62,425	$49,940
Overhead	$9,847	$15,473	$14,067	$11,253
Total Project Cost	$53,544	$84,140	$76,491	$61,193

Table 9: MDT Project Budget by Fiscal Year

	State Fiscal Year		Federal Fiscal Year	
Item	2010	2011	2010	2011
Salaries	$22,756	$35,760	$32,509	$26,007
Benefits	$6,148	$9,662	$8,783	$7,027
In-State Travel	$78	$122	$111	$89
Out-of-State Travel	$0	$0	$0	$0
Expendable Supplies and Minor Equipment	$4,686	$7,364	$6,694	$5,356
Participant Costs	$0	$0	$0	$0
Total Direct Costs	$33,669	$52,908	$48,098	$38,478
Overhead	$6,734	$10,582	$9,620	$7,696
Total Project Cost	$40,402	$63,489	$57,718	$46,174

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