**Task 1 – Literature Review**

The first task in the research program is a thorough review of relevant literature. The literature review will focus on ASR prevention, mitigation, and repair. The literature review will also investigate test methods used in assessing ASR potential in various aggregates and cements. An early search of the literature has shown that there are three standardized tests that are generally recommended for ASR testing. Two, ASTM C1260 *Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)* and ASTM C1567 *Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)* , are accelerated mortar bar tests. These two tests measure the amount of expansion that occurs in mortar bars immersed in an alkaline solution for 16 days. The third test, ASTM C1293 *Determination of Length Change of Concrete Due to Alkali-Silica Reaction (Concrete Prism Test)*, measures the expansion of concrete prisms at 12 months and beyond. Sodium hydroxide is added to the concrete mix water to increase the amount of available alkalis. In addition to these tests, there have been several tests that have been developed and recommended by researchers, but there is little consensus on the accuracy of the tests when compared to field conditions. The literature review will continue throughout the duration of the project, but the major emphasis will be concentrated in the beginning of the project. A search of all relevant journal articles, books, and technical reports will be conducted.

**Task 2 – Defining the Problem in Arkansas**

ASR damage in concrete pavements is difficult to identify. Often, ASR damage is misidentified as some other type of problem, such as poor quality in design, poor materials and/or poor construction. With assistance from AHTD's research section, an examination of concrete pavements in Arkansas Highways will be conducted to determine if other ASR damage is possible in other areas around the state. The results from Task 2 will be used to determine which aggregates and their associated mixes will be studied in Task 3.

**Task 3 – Laboratory Study**

There are two objectives in the laboratory study. Identifying potential reactive aggregates in Arkansas is the first objective. With assistance AHTD, coarse aggregates sources from areas suspected to produce ASR issues will be tested using the accelerated mortar bar test (ASCM C1260). The coarse aggregates used these mixtures will include aggregates that have produced ASR suspect mixes identified in Task 2. River sand will be the fine aggregate used for tests. Mortars using these aggregates will be subjected to ASTM C1260. Aggregate combinations that show ASR potential will then be subjected to ASTM C1293. As previously mentioned, ASTM C1293 examines the expansion of concrete mixtures over the course of at least one year. The concrete mixtures used in the test will meet AHTD Standard Specifications.

The second objective in the laboratory study is to develop guidelines for using supplementary cementitious materials (SCMs) to prevent ASR. Concrete mixtures containing Class C fly ash, Class F fly ash, or slag cement will be batched and tested using ASTM C1567 and ASTM C 1293. Concrete mixtures containing 20, 30, and 40 percent SCM will be examined using the two tests (ASTM C1567 and ASTM C1293). Coarse aggregates included in this portion study will include those identified in Task 2. A single source of Type I cement and washed river sand will be used in all mixtures.

**Task 4 – Monitor I-540 Wall**

Large sections of the concrete barrier wall along I-540 between Exit 45 and the Bobby Hopper Tunnel are experiencing significant deterioration due to ASR and corrosion of the reinforcing steel. Segments of the wall will be in need repair in the near future while other segments of the wall appear to be unaffected by ASR. As a part of Task 4, the construction records for the wall will be examined to determine if there were changes in the concrete mixture proportion or casting sequence for the barrier. A change in materials could be the cause for the affected and unaffected segments.

In Task 4, six segments of the wall will be instrumented to monitor wall movement. Two good segments (showing little distress), two segments showing some distress, and two poor segments will be instrumented to monitor wall movement. The results from Task 4 will allow researchers to determine if the good and moderate segments can be repaired or coated to prevent further deterioration.

Figure 1. Good and Poor Sections of the I-540 Wall.

Due to the proximity of the wall to traffic, a wireless data acquisition system will be used instead of manually measuring crack widths using mechanical strain gages. Although the wireless system is more expensive, the mechanical gages would require frequent trips to each wall segment which are in close proximity to traffic. The six wall segments will be instrumented with two, string (or wire) pots (one on the west side of the wall and one on the east side of the wall). The string pots are capable of measuring 12 in. of movement over a 10 ft length. The string pots will be anchored to the sides of the wall and covered for protection from the elements and drivers.

**Task 5 – Wall Repair**

The findings of Task 4 will determine if some segments of the wall can be repaired. The research team will examine methods that have been previously used to repair or prevent further deterioration due to ASR. Once the sections are repaired, the monitoring system will then be used to monitor movement in the repaired sections.

**Task 6 – Pavement Monitoring**

The same constituent materials used in the I-540 Wall were also used to cast the pavement. The pavement is beginning to show signs of distress, but it is not as advanced as that of the wall. This is most likely due to the absence of reinforcing steel in the pavement. Researchers will monitor the pavement for one year by measuring crack widths and joint widths at selected locations in the pavement. The expansion of the pavements can then be compared to that of the I-540 Wall. By the knowing the rate of expansion, the researchers may be able to estimate when the pavement will need rehabilitating.

As part of Task 6, researchers will also investigate methods that have been used to prevent ASR, to mitigate ASR damage, or to stop ASR reaction in concrete pavements. This will involve a thorough literature search along with contacting and interviewing State DOTs where the methods have been employed. These methods may include topical treatments such as sealers or fiber reinforced polymers (FRP). Researchers will also determine the effectiveness of overlays that have been placed on ASR damaged payments.

| **Supplies:** | Unit | Total |
|---|---|---|
| 3, 1 in. by 1 in. by 11.5 in. molds for ASTM C1260 & C1567 | $120 | $360 |
| 3, 3 in. by 3 in. by 11.5 in. molds for ASTM C1293 | $162 | $486 |
| Miscellaneous supplies for ASR tests (containers, NaOH, heater, etc) | $1000 | $1000 |
| Cement – 2 pallets | $400 | $800 |
| Fly ash (Class C and Class F) – 1000 lbs of each | $500 | $1000 |
| Aggregates (sandstone, limestone, etc) | $250 | $1000 |
| String pots to measure wall movement (12 total) | $200 | $2400 |
| **Travel** | | |
| Travel in AR to acquire aggregates | $2000 | $2000 |
| **Equipment** | | |
| Data acquisition system | $7500 | $7500 |

| Fiscal Year 13 (July 2012 - June 2013) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A. Direct Costs** | | | | | | | | | |
| | | Academic Year | | | Summer | | | | Totals |
| **1. Salaries and Wages** | | PM | % | Amount | PM | % | Amount | | |
| Principal Investigator W. Micah Hale | | 0 | 0.00 | 0 | 1.5 | 66.66 | 14250 | | 14,250 |
| Co-Principal Investigator K. Grimmelsman | | 0 | 0.00 | 0 | 0.5 | 33.33 | 4250 | | 4,250 |
| Research Assistants | | | | | | | | | |
| PhD Research Assistant (Andy Tackett) | | 9 | 1.00 | 13500 | 3.0 | 1.00 | 4500 | | 18,000 |
| PhD Research Assistant (TBA) | | 0 | 0.00 | 0 | 0.0 | 0.00 | 0 | | 0 |
| Laboratory Technician | | 0 | 0.00 | 0 | 0 | 0.00 | 0 | | 0 |
| **Total Salaries and Wages** | | | | | | | | | **$36,500.00** |
| **2. Fringes and Benefits** | | | | | | | | | |
| Faculty Salaries (AY) = | 28.90 | | | | | | | | $0 |
| Faculty Salaries (SY) = | 16.90 | | | | | | | | $2,408 |
| Employee Salaries = | 28.90 | | | | | | | | $0 |
| RA Salaries = | 3.20 | | | | | | | | $576 |
| Student Hourly = | 0.10 | | | | | | | | $0 |
| **Total Fringe Benefits** | | | | | | | | | **$2,984.25** |
| **3. Supplies and Services** | | | | | | | | | |
| supplies (cylinder molds, lab supplies, epoxy, etc) | | | | | | | | | $6,000 |
| cement, aggregate, SCM | | | | | | | | | $1,000 |
| **Total Supplies and Services** | | | | | | | | | **$7,000.00** |
| **4. Travel** | | | | | | | | | |
| Travel in Arkansas | | | | | | | | | $1,500 |
| Travel to Fall 2012 ACI Conference | | | | | | | | | $0 |
| **Total Travel** | | | | | | | | | **$1,500.00** |
| **Modified Total Direct Costs** | | | | | | | | | **$47,984.25** |
| **B. Indirect Costs (15% of MTDC)** | | | | | | | | | **$7,197.64** |
| **C. Graduate Student Tuition** | | | | | | | | | |
| Andy Tackett - 21 hours of tuition - 9/9/3 | | | | | | 369 | $/hr | | $7,749.00 |
| Student TBA - 21 hours of tuition - 9/9/3 | | | | | | 0 | $/hr | | $0.00 |
| **Total Tuition** | | | | | | | | | **$7,749.00** |
| **D. Subcontract** | | | | | | | | | |
| None | | | | | | | | | **$0** |
| **E. Equipment** | | | | | | | | | |
| Data acquisition system | | | | | | | | | **$7,500.00** |
| **Total Project Costs (FY 13)** | | | | | | | | | **$70,430.89** |

| Fiscal Year 14 (July 2013 - December 2013) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A. Direct Costs** | | | | | | | | | |
| | | Academic Year | | | Summer | | | | Totals |
| **1. Salaries and Wages** | | PM | % | Amount | PM | % | Amount | | |
| Principal Investigator W. Micah Hale | | 0 | 0.00 | 0 | 1 | 66.66 | 9500 | | 9,500 |
| Co-Principal Investigator K. Grimmelsman | | 0 | 0.00 | 0 | 0 | 33.33 | 0 | | 0 |
| Research Assistants | | | | | | | | | |
| PhD Research Assistant (Andy Tackett) | | 4.5 | 1.00 | 6750 | 1.5 | 0.50 | 2250 | | 9,000 |
| PhD Research Assistant (TBA) | | 0 | 1.00 | 0 | 0.0 | 1.00 | 0 | | 0 |
| Laboratory Technician | | 0 | 0.00 | 0 | 0 | 0.00 | 0 | | 0 |
| | | | | | | | | | |
| **Total Salaries and Wages** | | | | | | | | | **$18,500.00** |
| | | | | | | | | | |
| **2. Fringes and Benefits** | | | | | | | | | |
| Faculty Salaries (AY) = | 28.90 | | | | | | | | $0 |
| Faculty Salaries (SY) = | 16.90 | | | | | | | | $1,606 |
| Employee Salaries = | 28.90 | | | | | | | | $0 |
| RA Salaries = | 3.20 | | | | | | | | $288 |
| Student Hourly = | 0.10 | | | | | | | | $0 |
| **Total Fringe Benefits** | | | | | | | | | **$1,893.50** |
| | | | | | | | | | |
| **3. Supplies and Services** | | | | | | | | | |
| supplies (cylinder molds, lab supplies, epoxy, etc) | | | | | | | | | $500 |
| cement, aggregate, SCM | | | | | | | | | $500 |
| **Total Supplies and Services** | | | | | | | | | **$1,000.00** |
| | | | | | | | | | |
| **4. Travel** | | | | | | | | | |
| Travel in Arkansas | | | | | | | | | $500 |
| Travel to Fall 2005 ACI Conference (Graduate student) | | | | | | | | | $0 |
| **Total Travel** | | | | | | | | | **$500.00** |
| | | | | | | | | | |
| **Modified Total Direct Costs** | | | | | | | | | **$21,893.50** |
| | | | | | | | | | |
| **B. Indirect Costs (15% of MTDC)** | | | | | | | | | **$3,284.03** |
| | | | | | | | | | |
| **C. Graduate Student Tuition** | | | | | | | | | |
| Andy Tackett - 12 hours of tuition - 3/9 | | | | 369 | $/hr | | | | $4,428.00 |
| Student TBA - 12 hours of tuition - 3/9 | | | | 0 | $/hr | | | | $0.00 |
| **Total Tuition** | | | | | | | | | **$4,428.00** |
| | | | | | | | | | |
| **D. Subcontract** | | | | | | | | | |
| None | | | | | | | | | **$0.00** |
| | | | | | | | | | |
| **E. Equipment** | | | | | | | | | |
| None | | | | | | | | | **$0** |
| | | | | | | | | | |
| **Total Contractor Costs FY 06** | | | | | | | | | **$29,605.53** |

| Fiscal Years 13 & 14 (July 2012 - December 2013) | | | |
|---|---|---|---|
| **A. Direct Costs** | | | |
| | | | Totals |
| **1. Salaries and Wages** | | | |
| Principal Investigator W. Micah Hale | | | 23,750 |
| Co- PI K. Grimmelsman | | | 4,250 |
| Research Assistants | | | |
| PhD Research Assistant (Andy Tackett) | | | 27,000 |
| PhD Research Assistant (TBA) | | | 0 |
| Laboratory Technician | | | |
| Technician | | | 0 |
| **Total Salaries and Wages** | | | **$55,000.00** |
| | | | |
| **2. Fringes and Benefits** | | | |
| Faculty Salaries (AY) = | 28.90 | | $0 |
| Faculty Salaries (SY) = | 16.90 | | $4,014 |
| Employee Salaries = | 28.90 | | $0 |
| RA Salaries = | 3.20 | | $864 |
| Student Hourly = | 0.10 | | $0 |
| **Total Fringe Benefits** | | | **$4,877.75** |
| | | | |
| **3. Supplies and Services** | | | |
| supplies (cylinder molds, lab supplies, epoxy, etc) | | | $6,500 |
| cement, aggregate, SCM | | | $1,500 |
| **Total Supplies and Services** | | | **$8,000.00** |
| | | | |
| **4. Travel** | | | |
| Travel in Arkansas | | | $2,000 |
| Travel to ACI Conference (Grad students) | | | $0 |
| **Total Travel** | | | **$2,000.00** |
| | | | |
| **Modified Total Direct Costs** | | | **$69,877.75** |
| | | | |
| **B. Indirect Costs (15% of MTDC)** | | | **$10,481.66** |
| | | | |
| **C. Graduate Student Tuition** | | | **$12,177.00** |
| | | | |
| **D. Subcontract** | | | |
| None | | | **$0.00** |
| | | | |
| **E. Equipment** | | | |
| **Data Acquistion System** | | | **$7,500.00** |
| | | | |
| **Total Contractor Costs FY 13 & 14** | | | **$100,036.41** |