RESEARCH PROPOSAL

RATE OF EROSION PROPERTIES OF ROCK AND CLAY

SUBMITTED TO:

FLORIDA DEPARTMENT OF TRANSPORTATION
RESEARCH OFFICE
TALLAHASSEE, FLORIDA

SUBMITTED BY:

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PROBLEM OR NEED STATEMENT

Erodable rock is found at a number of bridge sites throughout the State of Florida. The composition of these softer rock materials is one or more of the following: lime rock, consolidated sandstone, coquina or coral. Often the geotechnical properties of the rock materials are not sufficient for it to be considered as "unscourable" by the Federal Highway Administration (FHWA) as described in their Hydraulic Engineering Circular No. 18 (HEC-18) and thus are considered as cohesionless sediments for the purpose of estimating design bridge scour depths. In many cases this yields overly conservative scour depth estimates that translate into excessive costs in the construction of new bridges and/or the retrofitting of existing bridges. The Florida Department of Transportation (FDOT) State Drainage Engineer's Office has recommended that when the FDOT Districts encounter these materials, a special investigation, that includes the State Drainage Office, be made to determine the appropriate design scour depths for that site. It is recognized that there is significant variability from one site to the next and that if improved scour estimates are to be made each case must be considered individually. As part of this investigation the State Drainage Engineer's Office has recommended that cores from the site be tested for "Rate of Erosion" characteristics using apparatus developed at the University of Florida under contract with the FDOT Research Office in Tallahassee. These tests provide information on the rate at which these materials will erode as a function of the intensity of the water flow over them.

The University of Florida has developed two different apparatus for this purpose. The first apparatus which has been has been operational for approximately two years, is limited to testing sediments that can support their weight. That is, more rigid sediments that will not deform under their own weight. This apparatus [referred to here as the Rotating Erosion Test Apparatus (RETA)] is shown in Figures 1 and 2. A technical paper on the prototype version of this apparatus was presented at the International Symposium on Scour at Foundations in Melbourne, Australia on November 19, 2000 [Henderson, et al. (2000)]. A copy of this paper is attached to this proposal in Appendix A. The main advantages of the rotating apparatus (RETA) are that the applied shear stress can be measured directly and the attainable shear stresses are higher that those for the second apparatus. Four additional RETAs are under construction and should be operational by the end of January 2002. Having five RETAs will allow much faster turnaround when analyzing core samples for a particular site.

The second apparatus is a recirculating flume which is nearing completion. This devise has the advantage of being able to test a wider range of sediment types from silt to rock.

Once both apparatus are functional it will be necessary to test the same sediment sample in both apparatus in order to establish the relationship between the results from the two devises. This must be done for a range of sediment types including some of the more rigid clays to the harder limestone formations. The flume devise tests the rate of erosion on horizontal planes and thus is much closer to what actually happens in nature. The RETA measures the rate of erosion on vertical planes. There is reason to believe that these rates are larger than those for horizontal planes (and thus give more conservative estimates of scour depths) but this needs to be tested.

Problem Statement

There is a need to:

1. Test a number of sediment samples in both the flume apparatus and in RETA in order to establish the relationship between rate of erosion results produced by the two approaches and
2. Start a database on rate of erosion for softer clays and silts in the higher (design bed) shear stress range.
3. Establish guidelines for FDOT and consulting engineers regarding the conditions under which these test procedures should be used.

ISSUES ADDRESSED-OBJECTIVES

The issues addressed in the proposed work are:

1. A comparison of the two different approaches to the measurement of rate of erosion of rock and cohesive sediment samples will be made. Each apparatus has advantages and disadvantages and ranges of flows where they are applicable. Agreement in the results from the two apparatus for the overlapping conditions is sought in these tests.
2. The testing of sediment samples from a variety of locations around the State of Florida will be made to obtain information on the variability of rate of erosion properties for Florida sediments.
3. Based on the results of items 1 and 2 guidelines for FDOT and consultant engineers regarding the conditions under which rate of erosion tests should be performed will be established.

PORPOSED APPROACH

The proposed approach is summarized in the tasks below:

Task 1. Run approximately twenty sediment samples in the flume "rate of erosion" apparatus.
Task 2. Make any required modifications to the flume and/or procedures in order to achieve accurate and repeatable results.
Task 3. Run the same (or similar) sediment samples in the RETA.
Task 4. Analyze the results obtained in 1) and 2) and establish (where possible) the relationship between the rates obtained by the two methods.
Task 5. Run a minimum of 20 additional tests on silts and less rigid clays. Rates of erosion data exist for these types of sediments for low shear stresses. Some tests will be performed in the low shear stress range and the results compared with published data. Higher shear stresses will then be applied to the same samples to determine how they respond to design flow conditions.
Task 6. Attempt to establish relationships between rates of erosion and other properties of the sediment (blow counts, etc.). These relationships will be used in the development of guidelines for determining when rate of erosion testing should be conducted.
Task 7. Write preliminary guidelines for conditions under which rate of erosion test should be conducted.
Task 8. Write a preliminary report with all of the test results.
Task 9. Write a final report that includes FDOT reviewer comments.

SCHEDULE

MONTHS AFTER NTP[1] → / TASKS	1	2	3	4	5	6	7	8	9	10	11	12
1	xxxx	xxxx	xxxx	xxxx	xxx							
2	xx	xxxx										
3		xxxx	xxxx	xxxx	xxx							
4	xx	xxxx	xxxx	xxxx	xxxx	xxx						
5					xxxx	xxxx	xxxx	xxxx	xxxx			
6								xxxx	xxxx	xxxx		
7										xxxx	xxxx	
8								xxxx	xxxx	xxxx	xxxx	x
9												xxx

[1] Notice to proceed

BUDGET

$82,426 (see attached for details)

EQUIPMENT

No permanent equipment requested.

SIMILAR EFFORTS

There are similar flumes at Texas A&M and the University of California at Santa Barbara used to measure rate of erosion in cohesive soils. Neither have the flow capacity needed for rock scour of the flume under construction at the University of Florida.

IMPLEMENTATION PLAN

As soon as the flume apparatus has been completed and the comparison tests have been performed both systems (RETA and the flume apparatus) will be ready and available to test rock and/or cohesive sediment samples from FDOT bridge sites. The rate of erosion (as a function of applied shear stress) properties of the sediment obtained from the tests along with information about anticipated flows during the life of the structure will be used to establish design scour depths for the bridge piers.

IMPACT TO PRACTICE

As discussed in the problem statement above the FHWA requires that erodable rock and cohesive sediments be considered as cohesionless sediments (sand) when performing a design scour depth analysis for bridge piers. This often results in over conservative scour depths and unnecessarily large and deep pier foundations. The results of this work will greatly improve the

accuracy of scour depth prediction in erodable rock and cohesive sediments and in most cases reduce bridge foundation costs.

BENEFITS TO THE DEPARTMENT

The benefits to the department will be in safer and in most cases less expensive bridge foundations as a result of more accurate scour depth predictions.

OTHER

The proposed research will be conducted by:

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PROPOSED BUDGET **11-Apr-03**

CIVIL & COASTAL ENGINEERING **PRINCIPAL INVESTIGATOR: Dr. DM Sheppard**

SPONSOR: FDOT

CONTRACT/GRANT NO: **DATES: 12 months**
Est Start Date 8/1/03

TITLE: Rate of Erosion Properties of Rock and Clay

	Hourly Rate	# of Hours	Req. Amount
A. SALARIES:			
Academic (Name):			
DM Sheppard	$52.66	208.8	$10,995
C. Kohlhof	$25.12	720.36	$18,094
D. Bloomquist	$57.87	125.28	$7,249
USPS Personnel (Name):			
Secretary	$17.24	208.8	$3,600
Clerk	$14.37	208.8	$3,000
		TOTAL SALARIES	$42,938
B. OTHER PERSONNEL SERVICES (OPS):			
Graduate Student	$15.00	1044	$15,660
		TOTAL OPS	$15,660
C. FRINGE BENEFITS:			
18.73% ORP Retirement	$3,389		
17.65% DRP Retirement	$1,941		
14.06%% FRS Retirement	$1,947		
$2.92/per man hour insurance	$4,298		
0.24% Group Term Life	$86		
.55% Worker's Comp.	$86		
		TOTAL FRINGE BENEFITS	$11,747
		TOTAL SALARIES, OPS & FRINGE BENEFITS	$70,345
D. TOTAL PERMANENT EQUIPMENT:		OCO	$0
E. TOTAL OPERATING EXPENSES:		EXPENSES	$8,156
Materials	$500		
Travel	$561		
Reports	$350		
Computer Supplies	$200		
Fee Waiver*	$6,545		
F. TOTAL DIRECT COSTS:			$78,501
G. TOTAL INDIRECT COSTS:	5.0%	$78,501	$3,925
H. TOTAL BUDGET:			$82,426

*The remainder of the tuition will be provided by the College of Engineering