**DRAFT AASHTO LRFD Geotechnical Roadmap**
June 2, 2004

The following provides a suggested listing of Geotechnical Engineering needs as related to the scope of the AASHTO LRFD Bridge Design and Construction Specifications. This extensive listing would provide the United States bridge community a complete reference for all mainstreamed technologies as related to structural foundations and earth retaining structures. The DRAFT Roadmap was prepared by a working group of technical committee T-15 under the leadership of Chair Mr. Jawdat Siddiqi of Ohio DOT. The extensive listing of needs is due largely in part to the recent entry of Geotechnical Engineering guidance within the AASHTO specifications (both ASD and LRFD). Prior to 1989 the specifications were generally silent on geotechnical related topics. This DRAFT Roadmap may be viewed a long-range plan and should be considered as a living document as new technologies and refinements to proven technologies is an on going developmental process. ***It is imperative for the reader to recognize that this comprehensive listing does not mean that LRFD for Geotechnical Engineering Features can't be implemented currently.***

The roadmap is presented under three headings: Priority for Calibration Studies, Design and Construction Topics Requiring Specification Development or Refinement, and Suggested Database and Calibration Process. The first heading presents the work group views on the timing and sequence of reliability based calibrations and performance of such calibration studies. The topics presented provide a complete listing of needs based on the current (3rd Edition) specification. The topics are NOT presented in an order of priority, several individually listed needs may be combined to form a larger study and the needs vary in financial scope from smaller studies (1-person month) to extensive research and development efforts (several person-years). The third heading provides a suggested approach for database and calibration activities.

The Roadmap work group strongly encourages that work completed to satisfy the suggested needs be very closely coordinated with the T-15 Committee membership to the significant the direct impact which the study results will have on future versions of the specifications. The traditional NCHRP practice of naming a liaison representative is viewed as being inadequate for this purpose. Joint meetings between project panel and T-15 and milestone report reviews by the T-15 membership are recommended.

Although the needed topics largely have a design focus many newer or undocumented, within AASHTO) technologies (micropiles) require the development of materials and means and methods specifications for construction.

**Priority of Calibration Studies**
A key long-term objective of any LRFD specification is to determine all the load and resistance factors using reliability theory. The completion of such calibrations truly permits an optimization of an LRFD approach. However prior to conducting such reliability based calibration it is important to evaluate the current LRFD specifications

(3rd Edition) to identify those areas that are in serious need of updating, or are simply absent and need to be developed. It would be a counter productive to perform a detailed statistical calibration on an outdated design or construction section, or on a technology or design procedure that is new to the AASHTO specifications, still under development, and subject to significant change.

A suggested approach for future calibration studies related to the Geotechnical Features addressed by the specifications follows:

a. First, update the design and construction specification section in question, and then perform the statistical calibration using reliability theory.
b. It may be possible to gather and document the appropriate limit states data needed to eventually perform the calibration while the updated or new specification is being developed, provided that the data gathered, including measured results and measured input data needed for estimating the nominal value (resistance or load), will be usable regardless of the final details of the design procedure/methodology.

   Nominal (predicted) resistances or loads and the resulting statistics should not be determined, however, until the design procedures that will ultimately be selected for inclusion in the LRFD design specifications have been essentially finalized.
c. Unless the subject investigated is very limited in scope (and well defined), it is recommended to not combine design specification development with calibration by reliability theory. These activities should be two separate and sequential efforts. If new resistance or load factors are needed to complete the new or revised design specification, calibration by fitting to allowable stress design (ASD) should be used to develop "place holder" load and resistance factors, if applicable existing load or resistance factors are not already available, until the more detailed reliability analysis can be completed.

**Design and Construction Topics Requiring Specification Development or Refinement**

Subject areas where the AASHTO LRFD design and construction specifications need to be developed are as follows:

*a*. Footing, shaft, and pile foundation design (Section 10), and downdrag loads (Section 3) and their consideration in foundation design – *note that this is now nearly completed through FHWA study.*
b. Lateral load design and analysis for deep foundations, and use of lateral soil resistance values to determine the distribution of loads between the substructure and superstructure components for strength, service and extreme event limit states.
c. Development of single pile settlement analysis specifications
d. Develop design specifications on the *minimum* number and *types* of test results per geologic unit of a given aerial extent needed to determine design and constructability parameters, and to quantity the effect the

number of measurements have on the load and resistance factors needed (this has been partially address by NCHRP 12-55)

e. Micropile design and construction.
f. Soil nail wall design and construction (NCHRP study on this technology is well underway already)
g. Seismic design of structural foundations and walls
    1. For walls, this is already partially addressed through an NCHRP study, though seismic design of certain types of walls, such as modular block faced walls and geosynthetic walls in general, may not be covered in that study.
    2. For structural foundations, development work is needed to update Standard Specification material to an LRFD format, as well as to update the design approach guidance regarding liquefaction design, lateral spreading, residual strength of liquefied soil for bearing resistance, lateral resistance, and overall stability, liquefaction settlement and downdrag, and vertical springs for footings and deep foundations. Note that this work should be performed subsequent to currently proposed work through NCHRP 20-07 and the LRFD Oversight committee to provide a new LRFD seismic specification to replace the agenda item that failed in 2002 (i.e., NCHRP 12-49).
h. Reinforced slope design and construction – FHWA has published comprehensive technical guidance.
i. Integral abutment design and construction.
j. Design methodology improvements for MSE walls in Section 11 (i.e., the K-Stiffness Method of design) – note: as this work has progressed, appropriate load and resistance factors are being developed as part of the overall development of this methodology
k. Extend design specifications for MSE wall K-Stiffness and Simplified Methods to poorer quality backfill materials (i.e., high silt content soils)
l. Auger cast pile design and construction– An FHWA technical document is currently under development.
m. Deadman anchored wall design
n. Design specifications for Osterberg load cell and Statnamic deep foundation load test methods (this will require the development of test standards by others).

**Suggested Database and Calibration Process**

As each specification topics listed above is essentially finalized, the following database development and calibration work should be accomplished:

a. Perform a follow-up activity to NCHRP 12-55 to develop revised load factors for earth loads, make any adjustments needed to affected resistance factors, and how to adjust load and resistance factors for lack of data or for extra data. This is urgent, and should be done before performing other calibration work that could be affected by the revised load factors.

b. Evaluate effect of combined dead, live, and earth pressure load on the resistance factors needed for deep foundations.
c. Gather spread footing bearing resistance data, and update calibration using reliability theory to be consistent with the revised Section 10.
d. Update calibration of drilled shaft foundation bearing resistance performed through NCHRP 24-17 using the updated design methodology provided in the rewrite of Section 10.
e. Update pile and drilled shaft resistance factor calibration as additional load test data becomes available.
f. Augment data gathered as part of current NCHRP study on soil nail walls, and develop resistance factors for soil nail walls using reliability theory.
g. Gather micropile resistance data (both measured resistance and soil/rock property data needed as input for estimating the nominal resistance), develop statistics, and determine appropriate strength limit state resistance factors using reliability theory.
h. Develop LRFD design methodology for reinforced and unreinforced slopes, gathering the full-scale data needed to develop strength limit state resistance factors using reliability theory, if possible.
i. Perform any follow-up studies to NCHRP 12-66 needed to provide a complete set of resistance factors for the service limit state for foundations (and as applicable, to walls).
j. Develop resistance factors for single pile settlement.
k. Develop resistance factors for downdrag design (strength and extreme event limit states).
l. Development of an Osterberg load cell and Statnamic deep foundation load test database, and the development of appropriate strength limit state resistance factors for their use using reliability theory.
m. Develop database, and using reliability theory, strength limit state resistance factors for auger cast piles – development of this is currently way down the road.
n. Develop database and, using reliability theory, strength limit state resistance factors for deadman anchored walls.
o. Extend MSE wall K-Stiffness and Simplified Methods to poorer quality backfill materials (i.e., high silt content soils) regarding load and resistance factors needed.