SECTION 6

MATERIALS

6.01 PAVEMENT ANALYSIS FOR DISTRESS

Existing pavement conditions are analyzed for distress. The proposed pavement type is selected and the required thickness is determined for the subbase, base course, and pavement surfacing.

A pavement analysis and an existing condition survey are done on all projects that have paving or resurfacing, with the exception of minor patching. A pavement analysis is performed by the Region Materials Engineer to determine the existing pavement condition and to determine the type of new pavement or resurfacing required on the project.

The principal factors in choosing pavement type or treatment are soil characteristics, traffic volume and types, climate, life cycle costs, and construction considerations.

The two types of pavements used are Portland cement concrete pavement (rigid) and hot mix asphalt (flexible). A life cycle cost analysis, supporting the pavement type selection will be prepared for all appropriate projects with more than $2 million in material cost for the pavement including any subbase and base course material. The analysis will compare concrete to asphalt pavements, compare alternative rehabilitation techniques, or both. Alternative pavement designs and life cycle costs are discussed in Section 6.05 of this manual.

The Resident Engineer must be in contact with the Materials Engineer at the inception of the project to allow sufficient time to perform a detailed pavement analysis. The Materials Engineer will prepare the pavement analysis, distress reports, and the pavement justification letter. The Region Materials Engineer reviews the analysis when it is prepared by a consultant.

After a proposed project involving pavements has been scoped, the Region Materials Engineer performs the following:

1. Field Condition Survey and Field Investigation
2. Selection of Pavement Design
3. Pavement Justification

The Region should retain a copy of the pavement justification in the project file.

Additional References:

1. CDOT *Pavement Design Manual*
2. CDOT *Roadway Design Guide*
3. CDOT Policy Directive 1400.0, *Surface Treatment Program*

6.02 PRELIMINARY SOIL SURVEY

The preliminary soil survey includes drilling soil samples for one or more of the following: proposed pavement rehabilitation, widening, new roadway alignment, or changes in grade cut and fill areas described in the CDOT Field Materials Manual. Additional information on the preliminary soil survey can be found in the Soil Survey section in Chapter 200 of the Field Materials Manual.

The investigations are needed to examine sites of proposed cut and fill areas, ground water problems, embankment failures, and soil problems related to pavement condition and structures such as CBCs, bridges, and retaining walls. These investigations provide information for pavement design.

The Region Materials Engineer (RME) or the Resident Engineer usually initiates the request to the Region Materials personnel for preliminary soil survey investigation and drilling soil samples for the proposed projects.

If the equipment available to Region personnel is not capable of drilling to the prescribed depth of a cut area or performing the needed drilling methods or procedures, the Geotechnical Program of the Materials and Geotechnical Branch or a commercial drilling contractor will be requested to provide drilling services.

Region Materials and Materials and Geotechnical Branch personnel perform a variety of field and laboratory tests and analyze data, CDOT Forms, and soil test reports. Region Materials will work with project personnel or consultants to ensure soil profile plan sheets are prepared.

Region Materials personnel will ensure the following actions are taken to collect and document information required for project design:

1. Research files for existing reports on proposed sites.
2. Examine sites of proposed projects and identify need for utility clearances.
3. Assign or perform drilling of proposed locations and collect samples of subsurface materials.
4. Assign or perform laboratory testing of samples.
5. Prepare reports and provide recommendation of pavement types, pavement rehabilitation, soil and base stabilization, etc.
6. Provide soil survey results and boring log information to the Resident Engineer; The Resident Engineer will assure incorporation of the information into the design plans.
7. Ensure that reports and plan sheets are submitted to the appropriate agency.

The Region Materials Engineer should coordinate with the Materials and Geotechnical Branch Soils Lab Manager at the inception of the project to allow sufficient time to perform the R-value test for pavement analysis and design. The Region Materials Engineer will review the analysis and design when it is prepared by a consultant.

The Region should retain a copy of the soil profile and test results in the project file.

During the design phase of the project, if it is determined that additional data or samples are needed, they will be obtained and a supplemental report submitted.

Additional References:

1. CDOT *Field Materials Manual* (Latest Edition)
2. CDOT *Pavement Design Manual* (Latest Edition)

6.03 FOUNDATION INVESTIGATION AND DRILLING

Geotechnical investigations include drilling for various structures and preparation of a final report with appropriate foundation recommendations.

Geotechnical investigations are needed to examine sites of proposed structures such as bridge foundations (piling, caissons, or spread footings), concrete box culverts, retaining walls, ground anchors, high-mast lighting, sound barriers, traffic signs, and highway related buildings.

The Materials and Geotechnical Branch provides assistance in areas such as foundation construction related problems during pile driving, caisson construction, and footing excavations.

The Project Structural Engineer will send a request for foundation investigation and drilling to the Resident Engineer, and will send a copy of the request to the Geotechnical Program Manager.

Requests for drilling and geotechnical studies should be submitted during the design phase together with site plan sheets and cross-sections as needed. Four to six weeks is usually required for completion of drilling, lab testing, and report preparation

The Staff Geotechnical Program performs and documents the following as requested:

1. Researches files for existing reports on proposed sites.
2. Examines sites of proposed structures and identifies any need for utility clearances.
3. Performs drilling at proposed locations and collects samples of subsurface materials.
4. Assigns laboratory testing of samples.
5. Prepares foundation report and specifies type and bearing capacity of recommended foundation.
6. Prepares the Engineering Geology Plan Sheets.
7. Submits report and plan sheet to the Resident Engineer and Project Structural Engineer.

Additional References:

1. CDOT *Bridge Design Manual*
2. CDOT *Roadway Design Guide*
3. CDOT *Field Materials Manual*
4. AASHTO *LRFD Bridge Design Specifications for Highway Bridges*

6.04 GEOTECHNICAL STUDIES

Suitable foundation systems should be designed for structures, and corrective or preventive measures taken for other geotechnical problems.

The Geotechnical group (Geotechnical Program and Soils/Foundation Program) of the Materials and Geotechnical Branch performs a variety of field and laboratory tests, analyzes data, and prepares engineering geology plan sheets and various types of geotechnical reports.

The Materials and Geotechnical Branch is involved in:

1. Foundations for bridges, culverts, retaining walls, ground anchoring, high-mast lighting.
2. Roadway embankment settlement studies.
3. Embankment and backslope failure.
4. Pavement subgrade stabilization.
5. Soil laboratory testing.
6. Environmental geologic problems, including wetland investigations.
7. Foundation construction related problems (such as pile driving, caisson misalignment, footing excavation).
8. Remote sensing for underground conditions such as bedrock and water table locations, buried tanks and utilities, buried foundations, stream scour, all using ground penetrating radar and other geophysical techniques.
9. Rockfall problems.
10. Ground water problems.
11. Low-altitude high-resolution aerial photography.
12. Space constraint identification such as limited right of way, steep terrain, wetlands and streams, existing high-value land uses, soft foundations, and contaminated soils.

During the design phase, when the need for drilling or a geotechnical study is required, the Project Structural Engineer should make a request to the Resident Engineer and Geotechnical Program Manager of the Materials and Geotechnical Branch in writing, and should include a set of plans showing approximate locations of required soundings for structures.

Typical requests are for foundation studies for bridges, culverts, and retaining walls. Requests should be done at the conceptual stages for inclusion in the Structure Selection Report prepared by the Bridge Design and Management Branch. The Resident Engineer and Design Engineer must review the geotechnical reports with the

Geotechnical Engineer and Project Structural Engineer to ensure that issues such as consolidation are accounted for in the design.

The Geotechnical group of the Materials and Geotechnical Branch conducts and prepares the following studies for bridges and other related structures:

1. Examines site and schedules a utility clearance, if needed.
2. Performs drilling and sampling operations and laboratory tests.
3. Determines required foundation type and prepares report stating the type and bearing capacity of foundation to be used.
4. Prepares and reviews engineering geology plan sheet and reports, and submits them to the Project Structural Engineer or Resident Engineer.

In addition to the usual foundation problems such as those with bridges or culverts, a project may involve a number of other features that may have foundation concerns or geologic hazards. The Materials and Geotechnical Branch personnel should be included in the Design Scoping Review to identify these types of problems and should participate in the follow-up and resolution of the problems identified.

The Resident Engineer should contact the Consultant Management section of the Materials and Geotechnical Branch when using a consultant.

Additional References:

1. CDOT *Bridge Design Manual*
2. CDOT *Roadway Design Guide*
3. CDOT Procedural Directive 512.1, *Project Scoping and the Design Scoping Review (DSR)*
4. CDOT *Standard Specification for Highway Bridges*

6.05 LIFE CYCLE COST ANALYSIS

Life cycle cost analysis of alternative pavement designs is an economic analysis performed to examine two or more pavement structures for new construction, reconstruction, or resurfacing of a project. Life cycle cost analysis is performed for all new construction and major reconstruction projects that have sufficient pavement quantity or thickness to justify considering alternatives. Various pavement designs can also be considered for restoration, resurfacing, and rehabilitation of existing pavement structure.

Life cycle cost analysis is prepared for all appropriate projects comparing concrete to asphalt pavements, comparing alternative rehabilitation techniques, or both. An economic analysis supporting the pavement type selection will be prepared for all appropriate projects with more than $2 million initial pavement cost including any base and sub-base material. A pavement structure will be designed for each option and life cycle costs will be studied. When comparing pavement designs, all alternatives being considered should be analyzed over the same period; i.e., compare a 40-year asphalt alternative to a 40-year concrete alternative. Alternative designs must also have the same levels of reliability and serviceability loss.

For new construction and reconstruction projects, the pavement structure will be designed for both asphalt and concrete to provide accurate quantities as a basis for the life cycle cost analysis. On resurfacing and rehabilitation projects, various methods to restore the roadway structure are considered. The Resident Engineer will provide accurate project limits, proposed typical section width, up-to-date traffic counts, and a project description with available budget to the Region Materials section. The Region Materials section will determine preliminary pavement type and thickness for each alternative prior to the Field Inspection Review (FIR). The Resident Engineer will develop preliminary quantities for the different pavement types.

Based on preliminary quantities, if one alternative is clearly more cost effective (comparison that yields a difference greater than 10 percent), a selection is made by the Region Materials Engineer. A comparison that yields results within 10 percent may be considered to indicate equivalent designs. When the alternatives have comparable life cycle costs or the type of project warrants further investigation, a Constructability Review and a complete Field Inspection Review design should be done for each alternative pavement. The life cycle costs for each alternative should be based on actual quantities.

In most cases, a final alternative is selected by the Region Materials Enigneer after the Field Inspection Review, and the project proceeds with the final design based on the selected pavement design. In some cases it may be appropriate to have the Pavement Type Selection Committee (PTSC) make the final materials type selection. However, PTSC pavement type selection may take up to two months to complete. In other cases it may be best to have bidders submit alternative bids for each pavement type.

Refer to the Pavement Design Manual for more details on the Life Cycle Cost Analysis (LCCA) and PTSC processes.

Additional References:

1. CDOT *Pavement Design Manual*
2. AASHTO *Policy Guide for Geometric Design of Highways and Streets*

6.06 PAVEMENT JUSTIFICATION REPORT

The Pavement Justification Report documents the analysis and procedure the Region used to arrive at its selection of pavement type or rehabilitation method.

The report should include the following:

1. An analysis supporting the pavement type selection or rehabilitation method.
5. Life cycle cost analysis of alternate designs.
6. Pavement distress survey of existing pavements.
7. Pavement thickness calculations of alternate designs.
8. Final recommendations for typical sections.
9. Surfacing plan.

Any additional information used to determine and justify the pavement type.

The Region Materials Engineer shall approve the Pavement Justification Report and submit the report to the appropriate Program Engineer, Resident Engineer and the Pavement Design Program Manager near the date of the FIR. The Pavement Justification Report shall be maintained in the Region's project records.

Additional References:

1. CDOT *Pavement Design Manual*