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5.01 PAVEMENT ANALYSIS / DISTRESS

Prior to restoration and resurfacing, the existing pavement conditions are analyzed for distress. Following that, the pavement type is selected and the required thickness is determined for the subbase, base, and pavement surfacing.

A pavement analysis and 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/or 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 (rigid) and hot bituminous pavements (flexible). An economic analysis, including life cycle cost, supporting the pavement type selection will be prepared for all appropriate projects with more than $1 million initial cost. The analysis will compare concrete to asphalt pavements, and/or compare alternative rehabilitation techniques. Alternative pavement design and life cycle costs are discussed in Section 5.07 of this manual.

The Resident Engineer should 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 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 Design Guide*
3. *CDOT Policy Directive 1002.0, Surface Treatment Program*

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5.02 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 Resident Engineer and/or the Project Structural Engineer usually initiate the request to the Geology Program Manager for a foundation site investigation and drilling for proposed structures.

The Staff Geology unit performs and documents the following as requested:

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

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

Additional References:

1. *CDOT Bridge Design Manual*
2. *CDOT Design Guide*
3. *CDOT Field Materials Manual*
4. *AASHTO Standard Specification for Highway Bridges*

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5.03 GEOTECHNICAL STUDIES

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

The Geotechnical group (Geology 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 tank/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/ 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 Resident Engineer or Project Structural Engineer, should make a request to the Geology Program of the Materials and Geotechnical Branch in writing and should include with the memo plans with cross-sections of the location requested.

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 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.

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2. Performs drilling/sampling operations and laboratory tests.
3. Determines foundation type and prepares report indicating type and bearing capacity of foundation to use.
4. Prepares and reviews engineering geology plan sheet and reports, and submits to appropriate agencies (Bridge Branch or Region).

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

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5.04 PIT OPTION

The pit option provides the contractor with available sources for aggregate and embankment. This available or designated source of materials is described in the Plans, Specifications and Estimate package.

The pit option provides information to the bidders about available material sources. When a pit option is not provided, the Contractor may require extra time to locate materials sources and obtain required materials mining permits. The Plans, Specification and Estimate show locations that may be used by the contractor as a source of material; these locations are known as "available sources." When the use of these sources of materials by the contractor is mandatory in the Plans, Specification and Estimate, the pit source is referred to as a "designated pit."

If the Region determines that the bidders need to be informed of an available or mandatory pit source prior to the project advertisement date, a pre-bid notice should be publicly advertised at least four weeks prior to advertising for bids. This pre-bid notice should be published in the same manner as a project advertisement and should contain the following information: project number, project description, project limits, project locations, available pit information, and the pit location related to a milepost on a highway or distance from a city or town. The pre-bid notice should specify all permits that CDOT has obtained; the remaining permits are the responsibility of the Contractor. The approximate quantity of materials should be specified along with the approximate month of project advertisement. Details of the pre-bid notice for pit status should be worked out with the Region Materials Engineer.

The Region Materials Engineer is responsible for identifying potential sources of gravel or borrow material available for a highway project within the vicinity of the project. The Region Materials Engineer should be familiar with nearby commercial and private aggregate sources. The Region Materials Engineer will determine if CDOT will obtain permits for material pits that will be made available to the Contractor based on the amount of material needed, distance to commercial or private sources and the ability of CDOT to obtain these permits.

When obtaining material sources:

1. All material used shall meet specification requirements indicated in the contract.
2. An agreement with the property owner will be required by the Department to remove material from the pit.
3. City/county zoning clearances and permits are required from the Colorado Mined Land Reclamation Division. If the Department does not obtain these clearances/permits, the Plans, Specification and Estimate shall designate it to be the responsibility of the Contractor.

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4. Unless a mandatory use (designated) source is indicated, the contractor may select his own source, when approved by the Region Materials Engineer.
5. The Contractor shall obtain all permits and agreements necessary to remove material from the Contractor's source.

The *Region Materials Guide Manual* details the responsibilities for obtaining a Mined Land Reclamation permit required for mining activity, including aggregate, in the State of Colorado. In general, when CDOT obtains the permits, the Region Materials section performs the following activities and documentation for obtaining gravel and borrow materials from pits:

1. Investigates sample sources and existing vegetation.
2. Obtains field boundary survey, topography and cross-sections surveys.
3. Obtains option/lease agreements, wildlife evaluation, and permits.
4. Formulates a reclamation plan and obtains the State Mined Land Permit (see Section 5.05).
5. Submits samples of material to the Materials Laboratory and provides material analysis information to the Resident Engineer.
6. Obtains the environmental clearances.

If a pit option (available or designated) is provided to the contractor, the Resident Engineer will include the following in the plans:

1. Pit sketch or map.
2. Location and description of test holes.
3. Quantities available, including stripping to be removed and replaced.
4. Slope grading, revegetation requirements, and structure relocation when required.

The Plans, Specification and Estimate package will contain a statement reading that the Contractor must restrict operations to the area as designated and staked by the Engineer within the Office of Mined Land Reclamation permitted area.

When a determination is made that CDOT should provide a material source due to lack of developed resources, the Region Materials Engineer will locate and map the pit. The Resident Engineer is responsible for ensuring that all necessary pit information options and reclamation are in the Plans, Specification and Estimate. When the Contractor obtains the borrow sources, it is its responsibility to procure all permits and agreements, and to furnish the Region Materials section with a written list of all permits for proper completion of the contract prior to beginning work.

Additional References:

1. *CDOT Standard Specifications*
2. *CDOT Region Materials Guide Manual*

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5.05 PIT RECLAMATION REQUIREMENTS

A pit reclamation plan provides the details to achieve subsequent beneficial use of reclaimed pit area. Material pit permit applications shall be submitted to the Mined Land Reclamation Board in ample time to ensure approval prior to award of the project contract. The pit application will include a description of the pit area and a statement of the final pit reclamation proposal.

The Region Materials Engineer is required to file for a pit reclamation permit based on the following:

1. Regular Permit -- 90 days prior to monthly board meetings preceding anticipated award date.
2. Limited Impact Permit -- 30 days prior to monthly board meetings preceding anticipated award date.
3. Special Permit -- Limited to emergencies or if a regular or limited impact permit cannot be obtained prior to contract award.

The Region Materials Engineer is responsible for obtaining pit reclamation permits from the State Reclamation Board. When the Contractor obtains materials from its own source, it is responsible for meeting all state and county reclamation permit requirements.

The requirements in Section 5.04, Pit Option, need to be followed. The Resident Engineer ensures that all necessary pit reclamation requirements are complete and in the plans package.

Additional References:

1. Colorado Mined Land Reclamation Act
2. *CDOT Region Materials Guide Manual*

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5.06 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.

At a minimum, the report should include the following:

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

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The Region Materials Engineer shall approve the Pavement Justification Report and maintain it in the Region.

Additional References:

1. *CDOT Pavement Design Manual*

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5.07 ALTERNATE PAVEMENT DESIGN (LIFE CYCLE COST ANALYSIS)

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

The alternate pavement design is prepared for all appropriate projects comparing concrete to asphalt pavements, and/or comparing alternative rehabilitation techniques. An economic analysis supporting the pavement type selection will be prepared for all appropriate projects with more than $1 million initial cost. 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 evaluated over the same period; i.e., compare a 30-year asphalt design to a 30-year concrete design. Alternate 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 Region will provide the designer with accurate project limits, proposed typical section width, up-to-date traffic counts, and project description with available budget. The designer will work with the Region Materials section to determine pavement and related quantities for each potential alternative prior to the Field Inspection Review.

A comparison that yields results within 10 percent may be considered to have equivalent designs. A comparison that yields results within 5 percent would certainly be considered to have equivalent designs. Based on preliminary quantities, if one alternative is clearly cost effective, a selection is made. When the alternatives have comparable life cycle costs or the type of project warrants further investigation, a complete Field Inspection Review design may be done for each alternate pavement together with life cycle costs for each based on actual quantities. In most cases, a final alternate is selected after the Field Inspection Review, and the project proceeds with the final design based on the selected pavement design. When life cycle costs are similar for two alternates, the Region Preconstruction Engineer may decide to proceed with a separate design for each alternate and request the contractors bid for each alternative design individually. The selection can then be based on actual bid prices.

NOTE: Each Region needs to document the analysis in the pavement justification report. The reports should be maintained in the Region.

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The documentation and procedures for a life cycle cost analysis for an alternate design can be found in the *CDOT Pavement Design Manual* in section 5.3.2.B. A synopsis of the procedures is as follows:

The analysis period for pavement costs is 30 years.
Actual maintenance costs should be used, if they are available. If the actual costs cannot be provided, the following default values may be used:

$1,300/lane mile for asphalt pavements
$150/lane mile for Portland cement concrete pavements.
$750/lane mile for composite pavements (asphalt on concrete)

The salvage value of pavements is considered to be equivalent after 30 years. Thus, the salvage value of a pavement will not be taken into account in the analysis.
The present worth economic analysis will be used. All future costs are adjusted, according to a discount rate of 4 percent, to a present worth.

Direct costs, such as grading costs or traffic control, associated with each pavement alternative must be considered.

If a clear advantage is not found for one of the feasible alternatives, secondary factors should be used to help in the selection process (refer to Figure 5-3 of the *Pavement Design Manual)*.

The choice of pavement type is usually based on lowest life cycle costs (annual costs). Conditions can warrant extra initial expenditure for a particular pavement type; for example, a roadway with high truck traffic may favor concrete pavement but swelling soil conditions may favor asphalt.

Additional References:
1. *CDOT Design Guide*
2. *AASHTO Policy Guide for Geometric Design of Highways and Streets*

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