



**DAM SAFETY PROGRAM**  
**TECHNICAL NOTE 8**  
**SPECIFICATIONS REQUIREMENTS FOR DAMS**

Prepared for:

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**DAM SAFETY PROGRAM**  
**TECHNICAL NOTE 8 (TN8)**  
**SPECIFICATIONS REQUIREMENTS FOR DAMS**

**Overview**

Technical Note 8 (TN8) is provided to assist and guide engineers and professionals in preparing construction specifications for Montana high hazard dams. The Dam Safety Program intends TN8 to provide consistent guidelines to adequately define the construction requirements needed to complete a project in conformance with the design intent

TN8 contains a discussion of construction documents as it applies to general civil engineering projects followed by more specific considerations that commonly apply to Montana dam construction.

The preparation of Technical Specifications for construction or repair of High Hazard Dams needs to be performed by a Professional Engineer that is competent in the area of practice. It is the responsibility of this professional to apply sound engineering judgment when using technical references. This publication is intended solely for use by professional personnel who are competent to evaluate the significance and limitations of the information provided herein, and who accept total responsibility for the application of this information. Anyone making use of this information assumes all liability from such use.



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**1.0 INTRODUCTION**

This technical note is intended to provide practical technical guidance to design professionals engaged in the preparation of construction documents for high hazard dams in Montana. Our goal is to provide information, references and procedures relevant to the dam safety rules for Montana for preparation of construction specifications that contribute to a construction process that provides a finished product in conformance with the design intent.

This document was prepared by DOWL HKM, under contract to the Montana Department of Natural Resources and Conservation (DNRC) Dam Safety Program. The DOWL HKM work was directed by Jason H. Thom, P.E. Users of this document are encouraged to provide feedback and recommendations on its contents. Please send your comments to:

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The Montana Dam Safety Program operates within the DNRC Water Resources Division's Water Operations Bureau. Funding for the preparation of this document was provided through the Federal Emergency Management Agency (FEMA) National Dam Safety Program.

TN8 will be revised and updated as new technical references are made available.

**1.1 PURPOSE**

The purpose of TN8 is to assist and provide guidance to engineers and professionals for preparation of specifications that adequately define the construction requirements needed to

complete a project in conformance with the design intent. TN8 is not a regulatory document and the references and procedures provided can be modified to suit the needs of the user. The Dam Safety Program intends for TN8 to provide guidance for consistent specifications but recognizes that professionals may use other technical resources, accompanied with relevant reasons for their use. Other agencies and funding sources may also have specific requirements that need to be included to meet the specific needs of particular projects.

Additional detail about preparation and organization of construction documents is available from a number of sources. The Construction Specifications Institute (CSI) is an organization dedicated to "...improving specification practices in the construction and allied industries." CSI publishes numerous guidance documents and provides training and certification in specification writing. A number of their documents are listed in the references section of TN8 and their web site is at [www.csinet.org](http://www.csinet.org). Standard construction documents and forms are available from the Engineers Joint Contract Documents Committee (EJCDC) which is a joint organization of the National Society of Professional Engineers (NSPE), American Council of Engineering Companies (ACEC), American Society of Civil Engineers (ASCE), and the Associated General Contractors of America (AGC). These standard documents are endorsed by CSI. Use of EJCDC standard documents is preferred by the Montana Dam Safety Program.

The terms *Project Manual*, *Specifications* (or Technical Specifications), *Construction Documents*, *Contract Documents* and *Drawings* will be utilized within TN8. The meanings of these terms are summarized below:

*Project Manual* represents the written construction documents including the introductory information, procurement requirements, contracting requirements and the specifications. Often additional information, such as geotechnical data reports, is included as supplemental appendices within the Project Manual. In practice, the Project Manual is frequently referred to as the specifications but the Project Manual includes other materials beyond the specifications. The sections of the project



manual are usually bound together to provide a comprehensive book with the various documents organized in a standardized format and order.

*Specifications* refer to the written description of the work to be performed. This section of the Project manual covers the technical requirements and the term *technical specifications* may also be used. The specifications are a part of the *contract documents* but generally do not deal with the contract terms, general requirements and administration aspects of the construction requirements. The specifications are intended to describe the work to be performed and define products, materials and workmanship requirements of the construction.

*Construction Documents* are the comprehensive written and graphic documents prepared or assembled by the design professional (Engineer) to communicate the design for construction and administering the construction contract. This includes the Project Manual and the construction drawings.

*Contract Documents* are the portions of the construction documents directly identified in the construction contract as pertaining to that contract. These typically include the contracting requirements, the specifications and the contract drawings.

*Drawings* are the graphic representations of the project to communicate the design and construction requirements. Drawings are often also referred to as the plans. In general, the term Drawings (or Plans) refer to the documents prepared by the Engineer in advance of construction. However, supplemental drawings produced during the construction stage, such as shop drawings, are also an important part of the graphic communication included in the term Drawings.

## **1.2 TARGET AUDIENCE**

TN8 is for use by engineers and professionals experienced in design and rehabilitation of dams and appurtenant structures. Professional judgment is required in the preparation of specifications for construction of high hazard dams, regardless of guidance provided by TN8.

Users of TN8 are expected to be familiar with the design and construction of dams and competent in applying that knowledge to the unique aspects of each project. DOWL HKM, DNRC and the Dam Safety Program are not responsible for the use and interpretation of TN8 contents.

## **2.0 IMPORTANCE OF SPECIFICATIONS FOR PROJECT SUCCESS**

The primary purpose of the construction documents is to adequately define and communicate the construction requirements needed to complete a project in conformance with the design intent. The concept of **adequate communication** is a key issue in regards to organization, format and content of the specifications. Misunderstanding or confusion on the part of the builder will most likely result in construction of a project that does not meet the design intent with potential for costly or even catastrophic consequences. Clear and concise information that is appropriate for the project, provides ready reference and that is consistent and complete are necessary aspects. Proper definition of the roles, responsibilities and authority of the various members of the construction team is also needed.

### **2.1 APPROPRIATE FOR PROJECT**

Producing specifications that are appropriate for the nature of the project is an essential aspect of adequate communication to the construction team. The specifications should address the specific needs of the project and should not include extraneous information that is not relevant.

Information in the specifications should have the appropriate level of detail and complexity for the project. A simple minor repair should be quite brief when compared to a project that includes a complex combination of zoned fills, drains, a concrete spillway and outlet works. Extra information that is not relevant could create “clutter” that obscures the important relevant information.

Consideration should be given to the normal practices of likely bidders and suppliers for the project. Smaller dam repairs located in remote areas of Montana often are constructed by local contractors and local suppliers. For example, utilizing a concrete mix that includes special features that are readily available in urban areas may not be readily available in remote rural areas.

Whether it is appropriate to use standardized specifications should be carefully evaluated. Some projects may require the use of a given standard – for example a grant or loan used to

fund the construction may require using the standard specification of an agency such as the NRCS or Bureau of Reclamation. If a standard specification is required, it should be carefully reviewed by the designer to ensure that the specific aspects of the project are included and appropriately defined in the specifications. The organization and presentation of standard specifications requires special attention to be sure they clearly communicate the aspects that apply to the project. Standard specifications typically include a broad range of components that cover aspects that are not applicable to the project and this can contribute to confusion and mistakes by the construction team.

Some standard specifications such as the Montana Public Works (MPW) or Montana Department of Transportation (MDT) standard specifications are generally not appropriate for use in dam construction projects. These specifications were developed for road and utilities projects without consideration to special requirements often included in construction associated with dams. The typical Project Manual based on standard specifications, such as MPW or MDT, consists of a small project manual that references the standard specifications and identifies specific deviations from the standard for the project. The standard specifications are a separate published reference book that is obtained from the agency responsible for producing and publishing the standard – in many cases the standard is copyrighted material. The construction team is expected to have the separately published standard specifications in-hand and to be familiar with their application. This concept is very useful for the cities and agencies that developed the standards as it provides consistency that becomes very familiar to the construction team as they perform multiple projects following the standards. However, most dam construction projects in Montana do not benefit from the standardized specifications because of the unique characteristics of each dam and the need for two separate references (Project Manual and Standard Specification) which may cause confusion and errors during construction. Besides, the standard specifications, such as MDT or MPW, often include some aspects that are not acceptable for construction of a dam.

Many design firms utilize master guideline specifications to efficiently develop project specifications. These master guidelines allow the specification writer to produce the specifications by editing pre-written text. The firm may have developed in-house master

guidelines or there are commercially available master guideline specifications, such as MASTERSPEC, SPECTEXT and SpecLink. Guideline specifications for specific products developed by product manufacturers are also available. When using guideline specifications it is imperative that the designer carefully review and edit the specifications to make them appropriate for the project.

## **2.2 REFERENCE DURING CONSTRUCTION**

In order to effectively communicate the detailed requirements for construction, it is important that the specifications are organized and formatted to serve as a useful reference to the construction team. Concise and well-organized specifications provide ready answers to specific questions that arise during construction.

The specifications should be organized in a logical and consistent order that is useful for the construction team. It is important that the information is presented concisely and completely in the appropriate location. It is also important to avoid duplication of information in various locations – this will lead to potential contradictions and ambiguities within the specifications. The format of each specification section and of the pages should be consistent throughout. Following CSI guidelines for uniform subject location, section numbering, section format and page format is recommended. Further discussion regarding organization and format of the Project Manual is provided in Section 4 of this Technical Note.

## **2.3 CONSISTENT**

The construction documents need to be consistent in the use of terms and writing style. Words should be carefully selected and used for precise meaning. Once a term is selected (i.e. *Drain Gravel*, *Zone 1 Embankment*, etc.) it should be consistently used throughout the documents – including the Drawings. Interchangeably using different names for the same material (such as core zone, clay fill, zone 1) in the specifications and drawings will lead to confusion. The use of capitalization of certain words should also be consistent. Capitalization of the first letter of certain specific nouns can be utilized to indicate a precise

meaning that is defined in the documents, while lack of the capitalization then implies a *general* meaning of the word.

The writing style and sentence structure should also be consistent throughout the documents. Short and concise sentences written in the declarative or imperative mood avoids ambiguity. Avoid complicated sentences by using multiple simple sentences that eliminate ambiguity.

## **2.4 COMPLETE**

The construction documents need to completely define the requirements of the work. Ambiguous terms or missing information can result in construction deviating from the design intent. Clear definition of the required materials characteristics, quality and tolerances provides a basis to require correction of items not meeting the requirements.

## **2.5 COORDINATION**

The roles and responsibilities of the various parties involved in the construction of the project need to be defined and clearly identified. Along with an understanding of the authority and responsibility for each party, an effective plan for communication between the parties should be established.

### **3.0 METHODS OF SPECIFYING**

Four methods for specifying construction are performance, descriptive, reference standard and proprietary. Project specifications often use more than one of these methods and each method may have advantages for a specific item. However, care should be taken to ensure that combining methods does not result in a conflicting requirement that is not easily resolved.

#### **3.1 DESCRIPTIVE SPECIFICATIONS**

Descriptive specifications involve a detailed description of the product, workmanship and installation. This method describes the process that is required and the contractor would not be responsible for results so long as the process is followed. Using a purely descriptive method for specifications becomes very complex and involved. It removes the opportunity for the contractor to develop innovative approaches. However, the descriptive method may be preferred for some aspects of the construction. For example, the compaction of clay core zone material should be performed with tamping feet compactors that have characteristics suitable to ensure complete kneading of the clay and elimination of lift lines. Requirements for scarifying a clay lift surface before placing an overlying lift would be another example of a descriptively specified construction requirement.

Descriptive specifications run a risk of the designer establishing control over means and methods of construction that should be the responsibility of the contractor.

#### **3.2 PERFORMANCE SPECIFICATIONS**

Performance specifications describe the desired end result, rather than the means to that end. A requirement of concrete compressive strength of 4,000 psi at 28-days is a performance specification. Some features of performance are very hard to define or measure in the completed product, so it is very common that specifications include a combination of descriptive and performance. *“Concrete shall have a minimum cement content of 564 pounds per cubic yard; a maximum w/c ratio of 0.45; and a 28-day compressive strength of 4,000*

*psi.*” Performance specifications leave more latitude up to the contractor for alternative methods and innovative approaches.

### **3.3 REFERENCE STANDARD SPECIFICATIONS**

Reference standard specifications take advantage of broadly established standards that are accepted in the industry. The standards may be published by trade associations, professional societies, government agencies and institutional organizations. The reference standards are incorporated into the specifications by reference and become a part of the specifications just as if the entire text had been included. Examples of reference standards include ASTM (American Society for Testing and Materials), ACI (American Concrete Institute International) and ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers).

It is the responsibility of the designer to be familiar with the reference standard and to use it appropriately in the specifications. Other specification requirements must be compatible with the standards or include appropriate language to clarify the modifications to the standards. There may also be conflicts between standards if two or more standards are referenced for a given product. Some standards include workmanship and quality control requirements that contradict with other requirements of the specifications. Many standards contain options or classes to select. For example, the wall strength class for a concrete pipe needs to be incorporated in the reference to the standard. If the designer does not specify the option, the decision is given to the contractor who should be expected to select the lowest cost option.

### **3.4 PROPRIETARY SPECIFICATIONS**

Proprietary specifications designate a specific product from a given manufacturer brand, model and other unique characteristics. Designating specific requirements that can only be met by one product, without naming the company or product, could also be considered a proprietary specification. Proprietary specifications offer the advantage of close control over the selection of a product and developing the design based on the precise details of that product. Proprietary specifications may also be desired when there is a specific product that



offers distinct advantages to the project goals. The disadvantage of proprietary specifications is that they reduce or eliminate competition. Most government funding sources will require that the specifications allow alternative products to promote competition.

Proprietary specifications are often written with a provision for substitution of an “or equal” product. A description of the criteria to establish whether a substitution is equal should be included to provide a pre-established basis for acceptance or rejection. Including a legitimate “or-equal” alternative will generally overcome the non-exclusive requirements and promote competition.



## 4.0 PROJECT MANUAL

The Project Manual contains the written documents for procuring, contracting and performing the construction of the project. It is important that the Project Manual be organized and formatted in a logic and consistent manner to ensure effective communication. A consistent, standardized approach to the location of information simplifies the retrieval of the information and reduces the possibility of errors.

### 4.1 RECOMMENDED ORGANIZATION SYSTEM

MasterFormat is a registered trademark of the Construction Specifications Institute (CSI) is the most widely used system in North America for organizing the information in a Project Manual. This system provides a master list of numbers and titles for the procurement and contract requirements as well as the specification sections to produce a standardized Project Manual. This system divides the Project Manual into two groups, the *Procurement and Contracting Requirements Group* and the *Specifications Group*. The groups are broken into *Sub-groups*, the sub-groups are broken into *Divisions* and the divisions consist of groups of *Sections*. This standardized organization structure allows information to be placed in a pre-determined location within the document which makes use of the documents much easier.

Prior to 2004 the CSI MasterFormat system consisted of Division 0, which contained the Procurement and Contracting Requirements, and 16 specifications Divisions as shown in Table 4-1. The MasterFormat system underwent a major revision in 2004 to expand the system to better serve a broader range of the construction industry as the original system was developed for building construction. The expanded system re-organized the specifications divisions as shown in Table 4-2. At this time, the design and construction industry in Montana is in early stages of transition from the original system. While the expanded system is preferred, the original system is still in common use.

**TABLE 4-1 MASTERSPEC DIVISIONS (PRE-2004 VERSION)**

<b>Division</b>	<b>Title</b>
00	Bidding & Contract Documents
01	General Requirements
02	Site Work
03	Concrete
04	Masonry
05	Metals
06	Wood & Plastics
07	Thermal & Moisture Protection
08	Doors & Windows
09	Finishes
10	Specialties
11	Equipment
12	Furnishings
13	Special Construction
14	Conveying Systems
15	Mechanical
16	Electrical

**TABLE 4-2 MASTERSPEC DIVISIONS (2011 VERSION)**

<b>Division</b>	<b>Title</b>
00	Procurement & Contract Requirements
01	General Requirements
02	Existing Conditions
03	Concrete
04	Masonry
05	Metals
06	Wood, Plastics & composites
07	Thermal & Moisture Protection
08	Openings
09	Finishes
10	Specialties
11	Equipment
12	Furnishings
13	Special Construction
14	Conveying Equipment
15-20	<i>Reserved for future expansion</i>
21	Fire Suppression
22	Plumbing
23	Heating, Ventilating & Air Conditioning (HVAC)
24	<i>Reserved for future expansion</i>
25	Integrated Automation
26	Electrical
27	Communications
28	Electronic Safety & Security
29-30	<i>Reserved for future expansion</i>
31	Earthwork
32	Exterior Improvements
33	Utilities
34	Transportation
35	Waterway & Marine Construction
36-39	<i>Reserved for future expansion</i>
40	Process Integration
41	Material Processing & Handling Equipment
42	Process Heating, Cooling & Drying Equipment
43	Process Gas & Liquid Handling, Purification & Storage Equipment
44	Pollution & Waste Control Equipment
45	Industry-Specific Manufacturing Equipment
46	Water & Wastewater Equipment
47	<i>Reserved for future expansion</i>
48	Electrical Power Generation
49	<i>Reserved for future expansion</i>

Additional guidance on uniform location of information for construction documents has been developed by the American Institute of Architects (AIA) and the Engineers' Joint Contract Documents Committee (EJCDC) and is presented in EJCDC Document 1910-16.

#### **4.2 SPECIFICATION FORMAT**

A consistent and standardized format for organizing information within a section also aids in simplifying retrieval of information and provides clarity of communication. The CSI three-part *SectionFormat* and page layout (*PageFormat*) are a format that is recommended. This format is summarized in Appendix A. CSI explains the three parts in the publication "SectionFormat ©1997" as follows:

- *PART 1 GENERAL: Describes administrative, procedural, and temporary requirements unique to the section. PART 1 is an extension of subjects covered in Division 1 and amplifies information unique to the section.*
- *PART 2 PRODUCTS: Describes materials, products, equipment, fabrication, mixes, systems and assemblies that are required for incorporation in the project. Materials and products are included with the quality level required.*
- *PART 3 EXECUTION: Describes installation or application, including preparatory actions and post-installation cleaning and protection. Site-built assemblies and site-manufactured products and systems are included.*

#### **4.3 PROCUREMENT AND CONTRACTING REQUIREMENTS (DIVISION 00)**

The procurement and contracting requirements division should contain the information on the terms for soliciting and establishing pricing for the work, contract forms and the conditions of the contract. These documents have important legal consequences that should be carefully reviewed by the owner with adequate legal counsel. Public owners and funding agencies may have specific legal requirements that need to be incorporated in these documents. The use of standardized forms and conditions, such as those developed by EJCDC is encouraged. Where modifications and supplemental requirements are needed to

the standardized forms, it is important to ensure that a modification of the language does not create ambiguity or assign unintended legal obligations to the parties involved.

The procurement requirements for bidding typically include an advertisement and/or invitation to bid, instructions to bidders, the bid form, bid security and additional certifications that may be required of bidders. The procurement requirements are not part of the contract documents but are the basis for establishing agreement between the owner and contractor.

The contracting requirements typically include the agreement form, project forms (performance bond, payment bond, certifications), and the conditions of the contract. The agreement form is the basic document that identifies the project, parties to the contract, contract documents, scope of work, time requirements, cost and payment terms, and signatures of the parties to the contract. Project forms include the performance bond, materials and labor payment bond, and other certifications that may be required. The conditions of the contract define the basic rights, responsibilities, and relationships of the parties involved in the performance. Conditions of the contract often include standardized *General Conditions* and project-specific *Supplementary Conditions*.





## 5.0 RECOMMENDED PROJECT MANUAL COMPONENTS

Each project is unique and the development of a Project manual should reflect the unique requirements of that project. However, there are a number of items that are typical to most projects that should be included to provide a clear understanding of the project requirements and the roles and responsibilities of the parties involved.

### 5.1 INTRODUCTORY INFORMATION

The project manual should have a cover that clearly identifies the project. An inside cover with the project name, project location, name and address of owner, name and address of engineer, date and other relevant information. The introductory information should also include space for certifications and seals of those responsible for the contents of the Project manual. A table of contents that identifies the sections of the document is needed. In addition to the table of contents, a list of the drawings and other documents bound separately should be provided.

### 5.2 BIDDING/PROCUREMENT INFORMATION

Invitation to Bid	The legal advertisement that is published to comply with public bidding notice requirements.
Pre-bid Conference	Indicate time and location; whether attendance is mandatory.
Instructions to Bidders	Important legal document that defines the terms and conditions of bids. Ensure that the basis for award is clearly defined. A standard set of instructions with a separate section that indicates supplemental, project-specific instructions is acceptable.
Bid Form	Defines the project, acceptance of the terms, acknowledgement of addendums, establishes price and includes binding signature of contractor. Bid form may include multiple schedules with potential to award individual or combinations of schedules.
Bid Bond	Form for Bid Security and terms for enforcement/collection of the security.
Other Bid Certifications	As needed.

### 5.3 CONTRACT REQUIREMENTS & GENERAL CONDITIONS

Agreement Form	Defines the Work, The Project, parties to the contract, contract time, liquidated damages, contract price, payment terms and identifies contract documents. Also includes signatures and corporate seals of the contracting parties.
Performance and Payment Bonds	Montana Dam Safety Regulations require a Performance Bond be obtained by the contractor in an amount of at least 100% of the cost of the project. A Payment Bond is typically required for public works projects and most private owners.
Other Certifications	As needed
General Conditions of the Contract	Standardized terms that define the basic rights, responsibilities, and relationships of the parties. Typically standardized documents such as EJCDC are utilized.
Supplemental Conditions	Project-specific conditions to the contract to modify and expand the general conditions. Insurance, wage rates, retainage and alternative dispute resolution clauses are examples of potential items in the supplemental conditions.
Project Forms	Some preparers include the project forms that will be utilized for administration of the contract. These may include items such as transmittal forms, progress pay estimate forms, change order forms, and close-out forms.

### 5.4 GENERAL REQUIREMENTS (DIVISION 1)

Summary of Work	Overview of the work and general requirements that may not warrant a separate specification section.
Measurement & Payment	Provide a clear definition of each payment item and the methods for measurement of work.
Construction Surveying	Define roles and responsibilities for construction surveying and records.
Scheduling Requirements	Some projects may include special coordination and scheduling requirements. Clearly define requirements, roles and responsibilities of the parties.

Submittal Procedures	Responsibilities and procedures for submittal and review of work-related submittals are critically important. A formal process to ensure clear communication and approval is required. Submittals provide added specific detail of actual procedures, materials and equipment beyond the drawings and specifications. Further discussion is provided in Section 8 below.
Quality Assurance/Quality Control	Define roles and responsibilities for quality assurance (QA) and Quality Control (QC). Who is performing testing, reporting requirements, etc.
Temporary Facilities	Items such as field offices, erosion control during construction, traffic control, and temporary utilities may need roles and responsibilities defined.
Closeout Procedures	Details of the process, responsibilities, and documentation of the project completion.

## 5.5 SITE WORK (DIVISION 2)

Earthwork	Earthwork could be many sections for various aspects of a complex project or a single section for a simple project. Typical items covered could include clearing, stripping, excavation, dewatering, foundation considerations, fill materials, compaction requirements, slope protection and testing requirements.
Drains	Drains are a key feature in the design and performance of dams. Special attention should be given to materials requirements, installation, inspection and protection of internal drainage features.
Roadways & Surfacing	As needed
Fencing	As needed
Reclamation & Restoration	Requirements for topsoil, vegetation restoration and erosion control need to be defined. Define responsibilities for maintenance and re-seeding while permanent vegetation is being re-established.

### 5.6 CONCRETE (DIVISION 3)

Concrete Forming	Define acceptable formwork materials, accessories, tolerances, etc. Forming, accessories and reinforcement may be incorporated into one concrete section for simple projects.
Concrete Accessories	Define materials such as anchors, inserts, waterstops, joint filler, etc.
Concrete Reinforcing	
Cast-in-Place Concrete	Requirements for concrete mixes, delivery, placement, testing, protection, curing, tolerances, and repairs.
PreCast Concrete	As needed.

### 5.7 OTHER DIVISIONS

Division 5 - Metals	Structural steel, gratings, handrails, etc..
Division 11 - Equipment	Water Control Gates and other manufactured equipment.
Division 16 - Electrical	As needed.

## **6.0 SPECIAL CONSIDERATIONS FOR DAMS**

There are some aspects of construction for dams that are critical for proper performance of the completed project or that may otherwise require special attention. Some common issues are discussed below.

### **6.1 COFFERDAMS & STREAM DIVERSION**

Control and diversion of water during construction and repairs of dams can be a significant aspect of achieving successful completion. The site must be adequately protected for surface water inflows to allow for construction activities. Diversion of streamflow past the work can be a challenging issue. The work needs to be protected against damage from floods and considerations to maintain safety from dam failure during construction are necessary. Specifications should establish the requirements that need to be attained and clearly assign responsibilities to the appropriate parties for compliance with the requirements. Considerations for diversions and water control may have significant impacts on the scheduling and sequencing of the work.

### **6.2 DEWATERING**

In addition to control of surface water at the construction site, considerations to dewater the work and foundation also need to be included for most projects. Water collecting in the work area can prevent the ability to properly place materials as well as potential to saturate and damage foundation conditions. Proper control of groundwater around and under excavations is necessary to prevent potential instability and softening of foundations. The dewatering plan should be planned and reviewed well in advance of implementation. Roles and responsibilities for design, implementation and monitoring should be clearly defined in the specifications.

### **6.3 FOUNDATION INSPECTION, PROTECTION & TREATMENT**

Special considerations for foundation inspections, protection and foundation treatments are another important aspect of dam construction. It is essential that the designer verifies that the actual foundation conditions that are encountered are appropriate for the design assumptions.

The saying that “*the geotechnical investigation is not complete until construction has been completed*” is an important concept to remember. Foundation treatments that match the actual conditions encountered and that are properly constructed are necessary. The specifications must include adequate measures with provisions to allow adjustments during construction to ensure that appropriate foundation protection and treatment is attained.

#### **6.4 IMPERVIOUS FILL AT STRUCTURES & ABUTMENTS**

An area that is typically difficult to attain desired results relates to the placement and compaction of impervious material adjacent to structures (such as outlet conduits) and rock abutments. These areas typically preclude access by large equipment that is utilized in more open areas of the embankment fill. The presence of a hard concrete structure or hard bedrock adjacent to clay fill can lead to “bridging” of overburden stresses to the hard features and reduced confining stress of the clay fill. The reduced stress may lead to increased seepage and potential piping along the contact between the hard surface and the clay. It can even lead to a very dangerous “hydraulic fracture” situation in which hydraulic forces within the clay become greater than the confining stresses on the clay causing sudden development of a seepage crack through the clay zone.

Specifying higher moisture content in the clay that is placed in special compaction areas is a common requirement to increase the plasticity and reduce potential for seepage and cracking. Special compaction requirements using hand operated tampers and pneumatic wheel-rolling should be specified for these areas. Special compaction areas should also receive extra observation and testing efforts.

#### **6.5 EMBANKMENT LIFT SURFACES**

Compaction and traffic on lift surfaces within the embankment can lead to smooth surfaces and unbounded lifts that may have significantly higher permeability in the horizontal direction. Proper compaction equipment and treatment of lift surfaces should be specified for embankment core zone materials. Smooth drum compaction is generally not acceptable and

tamping foot compactors with adequate length of tamping feet is a typical requirement. Disking of smooth surfaces should be required.

## **6.6 FILTERS AND DRAINS**

Filters and drains in dams is another critical design element that must be constructed properly. This is an area that needs special attention in the specifications. The Montana Dam Safety Program Technical Note 4 (TN4) contains guidance on design, specification and inspection requirements for filters and drains.

## **6.7 SITE DRAINAGE**

The specifications should include provisions to direct site drainage away from the work. On-site precipitation runoff should be controlled to prevent contamination of filter materials, erosion and deposition, or collecting in undesired areas to saturate completed fill or subgrade.

## **6.8 SEASONAL SHUTDOWN**

If a project is of a magnitude to require seasonal shutdowns of the construction operation, the specifications need to address measures that will protect the completed work and procedures to validate the previously completed work prior to resuming construction





## **7.0 SUBMITTALS**

During construction, the contractor is typically required to submit product data, shop drawings, samples, schedules and work plans to the engineer for review. These submittals convey additional detailed information of construction and serve as an important quality assurance step in the project. The submittal process serves as a documentation and communication aspect that provides specific information for completing the design intent.

### **7.1 SUBMITTAL REVIEW & APPROVAL**

The specifications should clearly define the formal submittal process that includes what information is to be submitted, the number of copies to submit, the time required for review and the distribution of reviewed submittal. A summary list of submittals for the project should be developed by the engineer. The review of submittals is an important process and should be carefully documented. The approval language should clearly define the limitations of review and the responsibilities of the parties in regard to the information on the submittals.

### **7.2 SUBMITTALS FOR INFORMATION ONLY**

Some submittals may be requested for information and coordination during construction but only deal with items that are under the contractor's sole control. There should be a process defined in regards to these submittals that ensures the submittal does not confuse the roles and responsibilities of the engineer and contractor. Submittals that convey information that is solely the contractor's responsibility should be designated "for information only" and should not be subject to the engineer accepting or rejecting the information.

### **7.3 SUBMITTAL SCHEDULE**

An anticipated listing of submittals should be included in the specifications to serve as a listing to track the progress of providing the necessary information. The initial listing should be expanded during construction to document the progress of all submittals, reviews, acceptance, rejection and revisions.

## **8.0 REFERENCES**

“Construction Specifications Practice Guide.” The Construction Specifications Institute. Published by John Wylie & Sons, Inc., Hoboken, New Jersey. 2011.

“Master Format, 2011 Update.” The Construction Specifications Institute; 110 South Union Street, Suite 100; Alexandria, VA 22314; [www.csinet.org](http://www.csinet.org). 2011.

“The Project Resource Manual; CSI Manual of Practice.” The Construction Specifications Institute. Published by McGraw-Hill Companies, Inc., New York, New York. 2005.

## **APPENDIX A**

### **Section & Page Format for Specifications**



**Figure SF-1**  
SectionFormat  
OUTLINE

<b>PART 1 GENERAL</b>	<b>PART 2 PRODUCTS</b>	<b>PART 3 EXECUTION</b>
<b>SUMMARY</b>	<b>MANUFACTURERS</b>	<b>INSTALLERS</b>
Section Includes	<b>EXISTING PRODUCTS</b>	<b>EXAMINATION</b>
Products Supplied But Not Installed Under This Section	<b>MATERIALS</b>	Site Verification of Conditions
Products Installed But Not Supplied Under This Section	<b>MANUFACTURED UNITS</b>	<b>PREPARATION</b>
Related Sections	<b>EQUIPMENT</b>	Protection
Allowances	<b>COMPONENTS</b>	Surface Preparation
Unit Prices	<b>ACCESSORIES</b>	<b>ERECTION</b>
Measurement Procedures	<b>MIXES</b>	<b>INSTALLATION</b>
Payment Procedures	<b>FABRICATION</b>	<b>APPLICATION</b>
Alternates	Shop Assembly	<b>CONSTRUCTION</b>
<b>REFERENCES</b>	Fabrication Tolerances	Special Techniques
<b>DEFINITIONS</b>	<b>FINISHES</b>	Interface with Other Work
<b>SYSTEM DESCRIPTION</b>	Shop Priming, Shop Finishing	Sequences of Operation
Design Requirements,	<b>SOURCE QUALITY CONTROL</b>	Site Tolerances
Performance Requirements	Tests, Inspection	<b>REPAIR/RESTORATION</b>
<b>SUBMITTALS</b>	Verification of Performance	<b>RE-INSTALLATION</b>
Product Data		<b>FIELD QUALITY CONTROL</b>
Shop Drawings		Site Tests, Inspection
Samples		Manufacturers' Field Services
Quality Assurance/Control Submittals		<b>ADJUSTING</b>
Design Data, Test Reports,		<b>CLEANING</b>
Certificates,		<b>DEMONSTRATION</b>
Manufacturers' Instructions,		<b>PROTECTION</b>
Manufacturers' Field Reports,		<b>SCHEDULES</b>
Qualification Statements		
Closeout Submittals		
<b>QUALITY ASSURANCE</b>		
Qualifications		
Regulatory Requirements		
Certifications		
Field Samples		
Mock-ups		
Pre-installation Meetings		
<b>DELIVERY, STORAGE, AND HANDLING</b>		
Packing, Shipping, Handling, and Unloading		
Acceptance at Site		
Storage and Protection		
Waste Management and Disposal		
<b>PROJECT/SITE* CONDITIONS</b>		
Project/Site* Environmental Requirements		
Existing Conditions		
<b>SEQUENCING</b>		
<b>SCHEDULING</b>		
<b>WARRANTY</b>		
Special Warranty		
<b>SYSTEM STARTUP</b>		
<b>OWNER'S INSTRUCTIONS</b>		
<b>COMMISSIONING</b>		
<b>MAINTENANCE</b>		
Extra Materials		
Maintenance Service		

\* Project Conditions is the preferred term in the U.S.,  
Site Conditions is the preferred term in Canada

**Figure PF-2a**  
Sample CSI Text. (front)

<p>SECTION 04100 MASONRY MORTAR</p>		
<p>PART 1 GENERAL</p>		
1.01	SECTION INCLUDES	
	A.	Mortar for unit masonry and stone veneer.
1.02	RELATED SECTIONS	
	A.	Section 04200 - Unit Masonry: Mortar for concrete unit masonry.
	B.	Section 04450 - Stone Veneer: Mortar for natural stone veneer.
1.03	REFERENCES	
	A.	ASTM C150 - Portland Cement.
	B.	ASTM C144 - Aggregate for Masonry Mortar.
	C.	ASTM C207 - Hydrated Lime for Masonry Purposes.
	D.	ASTM C270 - Mortar for Unit Masonry.
	E.	International Masonry Industry All-Weather Council (IMIAC) - Recommended Practices and Guide Specifications for Cold Weather Masonry Construction.
1.04	DELIVERY, STORAGE, AND HANDLING	
	A.	Deliver products to site under provisions of Section 01600.
	B.	Store and protect products under provisions of Section 01600.
	C.	Protect cement from moisture and humidity.
1.05	ENVIRONMENTAL REQUIREMENTS	
	A.	Cold Weather Requirements: IMIAC requirements.
	B.	Maintain materials and surrounding air temperature to minimum 10 degrees C (40 degrees F) prior to, during, and 48 hours after completion of masonry work.
<p>PART 2 PRODUCTS</p>		
2.01	MATERIALS	
	A.	Portland Cement: ASTM C150, Normal - Type I, white color for facebrick and grey color for common brick.
Project Name / 92-07 / 10-6-92	04100 - 1	Masonry Mortar

**Figure PF-2c**  
Sample CSI Text.(back)

- B. Mortar aggregate: ASTM C144, standard masonry type; clean, dry; protected from dampness, freezing, or foreign matter.
- C. Hydrated Lime: ASTM C207, Type S.
- D. Water: Clean and potable.
- E. Mortar Color: Mineral oxide pigment; chocolate brown color; "Great Stuff" manufactured by Acme Manufacturing Co. Ltd.

#### 2.02 MIXES

- A. Mortar for Load Bearing Walls and Partitions: ASTM C270, Type S, using proportion method.
- B. Mortar for Non-load Bearing Walls and Partitions: ASTM C270, Type N, using proportion method.

#### 2.03 MORTAR MIXING

- A. Thoroughly mix mortar ingredients in quantities needed for immediate use in accordance with ASTM C270.
- B. Add mortar color in accordance with manufacturer's instructions. Provide uniformity of mix and coloration.
- C. Do not use anti-freeze compounds to lower the freezing point of mortar.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Install mortar in conjunction with Sections 04200 and 04450.

#### 3.02 FIELD QUALITY CONTROL

- A. Field testing will be performed under provisions of Section 01400.

END OF SECTION

**Figure PF-2b**  
Sample CSI Text  
With Explanatory Notes.

Note: Begin section on right hand page.

Top margin: 13 mm (0.5 inch) minimum.

Section number: uppercase and centered. SECTION 04100

Section title: uppercase centered one line space below section number. MASONRY MORTAR

Part designation: uppercase two line spaces below section title. PART 1 GENERAL

Article heading: uppercase no following text, no punctuation, one line space below part designation, paragraph, or subparagraph text. 1.01 SECTION INCLUDES

Paragraph: upper- and lowercase one line space below article heading. A. Mortar for unit masonry and stone veneer.

1.02 RELATED SECTIONS

A. Section 04200 - Unit Masonry: Mortar for concrete unit masonry.

B. Section 04450 - Stone Veneer: Mortar for natural stone veneer.

1.03 REFERENCES

A. ASTM C150 - Portland Cement.

B. ASTM C144 - Aggregate for Masonry Mortar.

C. ASTM C207 - Hydrated Lime for Masonry Purposes.

D. ASTM C270 - Mortar for Unit Masonry.

E. International Masonry Industry All-Weather Council (IMIAC) - Recommended Practices and Guide Specifications for Cold Weather Masonry Construction.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 01600.

B. Store and protect products under provisions of Section 01600.

C. Protect cement from moisture and humidity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Cold Weather Requirements: IMIAC requirements.

B. Maintain materials and surrounding air temperature to minimum 10 degrees C (40 degrees F) prior to, during, and 48 hours after completion of masonry work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150, Normal - Type I, white color for facebrick and grey color for common brick.

Project Name / 92-07 / 10-6-92 04100 - 1 Masonry Mortar



**Figure PF-2d**  
Sample CSI Text With Explanatory Notes.

B. Mortar aggregate: ASTM C144, standard masonry type; clean, dry; protected from dampness, freezing, or foreign matter.

C. Hydrated Lime: ASTM C207, Type S.

D. Water: Clean and potable.

E. Mortar Color: Mineral oxide pigment; chocolate brown color; "Great Stuff" manufactured by Acme Manufacturing Co. Ltd.

2.02 MIXES

A. Mortar for Load Bearing Walls and Partitions: ASTM C270, Type S, using proportion method.

B. Mortar for Non-load Bearing Walls and Partitions: ASTM C270, Type N, using proportion method.

2.03 MORTAR MIXING

A. Thoroughly mix mortar ingredients in quantities needed for immediate use in accordance with ASTM C270.

B. Add mortar color in accordance with manufacturer's instructions. Provide uniformity of mix and coloration.

C. Do not use anti-freeze compounds to lower the freezing point of mortar.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install mortar in conjunction with Sections 04200 and 04450.

3.02 FIELD QUALITY CONTROL

A. Field testing will be performed under provisions of Section 01400.

END OF SECTION

End of section indication: uppercase, centered two lines below the last line of section text.

Project name, number, and the date.

Project Name / 92-07 / 10-6-92

Page number: 5-digit section number with hyphen and sequential page number.

04100 - 2

Masonry Mortar

Bottom margin: same as top margin.

Section title on unbound margin.



## **APPENDIX B**

This appendix contains NRCS standard specification sections for embankment dams. These specifications provide typical requirements included in specifying the construction of dams to serve as examples for the designer in preparation of specifications. Note that the format of these specifications does not follow the CSI format or organization of information that is recommended in this Technical Note (See Appendix A for preferred format).



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## Instructions for use Construction Specification 21—Excavation

### 1. Applicability

Construction Specification 21 is applicable to all types of excavation. The specification defines classes of excavation and includes special requirements for certain types of excavation, but does not establish and define all types of excavation. It is intended that the types of excavation be established on a job or project basis, as needed.

The *class* of excavation defines the kind of material to be excavated. The *type* defines the functional purpose of the excavation. Established types of excavation may include (but are not restricted to):

- Foundation excavation with or without stripping
- Cutoff, keyway, or core trench excavation
- Channel excavation
- Structure excavation
- Auxiliary spillway excavation
- Abutment shaping excavation
- Borrow area excavation

Any of the established types may include excavation of materials in any class. However, the excavation of a given class of material may be more difficult in one type of excavation than in another. These factors must be carefully considered as a basis for establishing types of excavation to be designated on the drawings and listed in the bid schedule.

For projects involving considerable quantities of excavation of different classes of material under conditions that vary in different part of the works, bids must be asked, and payments made, on the basis of both type and class of excavation. For such projects, the bid schedule must be set up in terms of both type and class of excavation (for example: channel excavation, common; and channel excavation, rock).

For projects involving only one type of excavation and for projects involving small quantities of excavation, it may be sufficient to include only the classes of excavation in the bid schedule.

### 2. Material specifications

No material specifications complement Construction Specification 21, Excavation.

### 3. Included items

Items to be included in contract specifications and drawings follow:

- a. The horizontal and vertical extent of each type of excavation. Indicate the vertical extent as approximate where the exact depth required is not known.
- b. Designation and definition of types of excavation.
- c. Excavation pay limits when method 1, section 9, is used.
- d. Surface finish requirements, such as grading tolerances. This may be especially important at the crest of an auxiliary spillway.
- e. The location and limits of all borrow areas. Outline all surface grading requirements following completion of borrow material utilization.
- f. The location and limits of all waste areas. When borrow areas serve also as waste areas, coordination of construction activities may be important.
- g. Boring logs and test pit logs pertinent to all areas to be excavated. In addition to descriptions of materials, logs must also include water table elevations and dates of observation, where applicable. For purposes of the construction drawings, no indications of correlation of materials

between logs shall be shown. Interpretation of materials is to be avoided and left to the contractor for determination.

- h. Existing access and haul roads.
- i. Special requirements for dewatering and keeping the excavation dry, with cross reference to Construction Specification 11, Removal of Water, where applicable.
- j. Special requirements for control of blasting, including written plans and approvals, if applicable.
- k. Special requirements for control of erosion, water pollution, and air pollution, with cross reference to Construction Specification 5, Pollution Control, as applicable.
- l. Requirements for control of the size gradation of excavated rock where necessary to obtain material of a particular gradation for rock fill or riprap.
- m. Methods of measurement and payment, if the standard specification includes more than one method.
- n. Requirements for concrete to fill voids from overexcavation (refer to Construction Specification 31, Concrete for Major Structures, or 32, Structure Concrete) if requirements in section 8 are not adequate.

#### 4. Methods

##### Section 4, Use of excavated materials

**Method 1**—Intended for use when the quality, condition, and relative location of significant quantities of the materials to be excavated are known to be suited to the economic construction of the required earthfills and earth backfills, and particularly where alternate sources of material are less desirable or do not exist.

**Method 2**—Intended for use when the known data indicate that the use of alternate sources of earthfill materials may result in more economical construction of the required earthfills and earth backfills.

##### Section 5, Disposal of waste materials

**Method 1**—Intended for use when areas for wasting unsuitable and/or excess materials are available at the site, when the waste fill will beneficially supplement the function of the permanent works, or if no known market is available for such waste materials as may be produced.

**Method 2**—Intended for use when areas for wasting unsuitable and excess material are not readily available at the site or if a known market for such waste materials is readily available.

##### Section 9, Measurement and payment

Note in section 10 when volume calculations other than the average cross-sectional end area method are used and describe the applicable method. Example: *In lieu of computing excavation volumes by the method of average cross-sectional end areas, the volume may be computed by the prismatic formula method with the assistance of computer aided design program.*

**Method 1**—Intended for excavations where the pay limits can best be defined on the drawings.

**Method 2**—Intended for excavations bounded by simple plane surfaces and constant or gradually varying cross section throughout.

**Method 3**—Intended for excavations where the lower limits are determinable only by examination of the materials encountered and where the lower limits have been designated on the drawings as approximate or to be determined by the engineer during construction.

**Method 4**—Intended for structure excavation bounded by fairly simple plane surfaces where pay limits are not shown on the drawings.

When specifications are prepared using electronic procedures and all methods but one are deleted for use in a contract specification, delete

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from the last paragraph *All Methods The following provisions apply to all methods of measurement and payment.* Left justify the remaining text.

### **5. Items of work and construction details**

Starting at the top of page 21-5, prepare and outline job specific "Items of Work and Construction Details" (IWCD) in accordance with these instructions. For ease of utilization, the use of recyclable color paper for the IWCD should be considered.





# Construction Specification 21—Excavation

## 1. Scope

The work shall consist of the excavation required by the drawings and specifications and disposal of the excavated materials.

## 2. Classification

Excavation is classified as common excavation, rock excavation, or unclassified excavation in accordance with the following definitions or is designated as unclassified.

*Common excavation* is defined as the excavation of all materials that can be excavated, transported, and unloaded using heavy ripping equipment and wheel tractor-scrapers with pusher tractors or that can be excavated and dumped into place or loaded onto hauling equipment by excavators having a rated capacity of one cubic yard or larger and equipped with attachments (shovel, bucket, backhoe, dragline, or clam shell) appropriate to the material type, character, and nature of the materials.

*Rock excavation* is defined as the excavation of all hard, compacted, or cemented materials that require blasting or the use of ripping and excavating equipment larger than defined for common excavation. The excavation and removal of isolated boulders or rock fragments larger than 1 cubic yard encountered in materials otherwise conforming to the definition of common excavation shall be classified as rock excavation. The presence of isolated boulders or rock fragments larger than 1 cubic yard is not in itself sufficient cause to change the classification of the surrounding material.

For the purpose of these classifications, the following definitions shall apply:

*Heavy ripping equipment* is a rear-mounted, heavy duty, single-tooth, ripping attachment mounted on a track type tractor having a power rating of at least 250 flywheel horsepower unless otherwise specified in section 10.

*Wheel tractor-scraper* is a self-loading (not elevating) and unloading scraper having a struck bowl capacity of at least 12 cubic yards.

*Pusher tractor* is a track type tractor having a power rating of at least 250 flywheel horsepower equipped with appropriate attachments.

*Unclassified excavation* is defined as the excavation of all materials encountered, including rock materials, regardless of their nature or the manner in which they are removed.

## 3. Blasting

The transportation, handling, storage, and use of dynamite and other explosives shall be directed and supervised by a person(s) of proven experience and ability who is authorized and qualified to conduct blasting operations.

Blasting shall be done in a manner as to prevent damage to the work or unnecessary fracturing of the underlying rock materials and shall conform to any special requirements in section 10 of this specification. When specified in section 10, the contractor shall furnish the engineer, in writing, a blasting plan before blasting operations begin.

#### **4. Use of excavated material**

*Method 1*—To the extent they are needed, all suitable material from the specified excavations shall be used in the construction of required permanent earthfill or rockfill. The suitability of material for specific purposes is determined by the engineer. The contractor shall not waste or otherwise dispose of suitable excavated material.

*Method 2*—Suitable material from the specified excavations may be used in the construction of required earthfill or rockfill. The suitability of material for specific purposes is determined by the engineer.

#### **5. Disposal of waste materials**

*Method 1*—All surplus or unsuitable excavated materials are designated as waste and shall be disposed of at the locations shown on the drawings.

*Method 2*—All surplus or unsuitable excavated materials are designated as waste and shall be disposed of by the contractor at sites of his own choosing away from the site of the work. The disposal shall be in an environmentally acceptable manner that does not violate local rules and regulations.

#### **6. Excavation limits**

Excavations shall comply with OSHA Construction Industry Standards (29CFR Part 1926) Subpart P, Excavations, Trenching, and Shoring. All excavations shall be completed and maintained in a safe and stable condition throughout the total construction phase. Structure and trench excavations shall be completed to the specified elevations and to the length and width required to safely install, adjust, and remove any forms, bracing, or supports necessary for the installation of the work. Excavations outside the lines and limits shown on the drawings or specified herein required to meet safety requirements shall be the responsibility of the contractor in constructing and maintaining a safe and stable excavation.

#### **7. Borrow excavation**

When the quantities of suitable material obtained from specified excavations are insufficient to construct the specified earthfills and earth backfills, additional material shall be obtained from the designated borrow areas. The extent and depth of borrow pits within the limits of the designated borrow areas shall be as specified in section 10 or as approved by the engineer.

Borrow pits shall be excavated and finally dressed to blend with the existing topography and sloped to prevent ponding and to provide drainage.

#### **8. Overexcavation**

Excavation in rock beyond the specified lines and grades shall be corrected by filling the resulting voids with portland cement concrete made of materials and mix proportions approved by the engineer. Concrete that will be exposed to the atmosphere when construction is completed shall meet the requirements of concrete selected for use under Construction Specification 31, Concrete for Major Structures, or 32, Structure Concrete, as appropriate.

Concrete that will be permanently covered shall contain not less than five bags of cement per cubic yard. The concrete shall be placed and cured as specified by the engineer.

Excavation in earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved, compacted earthfill. The exception to this is that if the earth is to become the subgrade for riprap, rockfill, sand or gravel bedding, or drainfill, the voids may be filled with material conforming to the specifications for the riprap, rockfill, bedding, or drainfill. Before correcting an overexcavation condition, the contractor shall review the planned corrective action with the engineer and obtain approval of the corrective measures.

## **9. Measurement and payment**

For items of work for which specific unit prices are established in the contract, the volume of each type and class of excavation within the specified pay limits is measured and computed to the nearest cubic yard by the method of average cross-sectional end areas or by methods outlined in section 10 of this specification. Regardless of quantities excavated, the measurement for payment is made to the specified pay limits except that excavation outside the specified lines and grades directed by the engineer to remove unsuitable material is included. Excavation required because unsuitable conditions result from the contractor's improper construction operations, as determined by the engineer, is not included for measurement and payment.

**Method 1**—The pay limits shall be as designated on the drawings.

**Method 2**—The pay limits shall be defined as follows:

- a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
- b. The lower and lateral limits shall be the neat lines and grades shown on the drawings.

**Method 3** —The pay limits shall be defined as follows:

- a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
- b. The lower and lateral limits shall be the true surface of the completed excavation as directed by the engineer.

**Method 4**—The pay limits shall be defined as follows:

- a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
- b. The lower limit shall be at the bottom surface of the proposed structure.
- c. The lateral limits shall be 18 inches outside of the outside surface of the proposed structure or shall be vertical planes 18 inches outside of and parallel to the footings, whichever gives the larger pay quantity, except as provided in d below.
- d. For trapezoidal channel linings or similar structures that are to be supported upon the sides of the excavation without intervening forms, the lateral limits shall be at the underside of the proposed lining or structure.
- e. For the purposes of the definitions in b, c, and d, above, any specified bedding or drainfill directly beneath or beside the structure will be considered to be a part of the structure.

**All methods**—The following provisions apply to all methods of measurement and payment.

Payment for each type and class of excavation is made at the contract unit price for that type and class of excavation. Such payment will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to the performance of the work except that extra payment for backfilling overexcavation will be made in accordance with the following provisions.

Payment for backfilling overexcavation, as specified in section 8 of this specification, is made only if the excavation outside specified lines and grades is directed by the engineer to remove unsuitable material and if the unsuitable condition is not a result of the contractor's improper construction operations as determined by the engineer.

Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10 of this specification.

## **10. Items of work and construction details**

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## Instructions for use Construction Specification 23—Earthfill

### 1. Applicability

Construction Specification 23 is applicable to all types of earthfill including fill sections constructed of rocky soils and embankments constructed of soft or friable rock that is expected to break down during compaction.

### 2. Material specifications

No material specifications complement Construction Specification 23.

### 3. Included items

Items to be included in the contract specifications and drawings

- a. Complete plans and cross sections of the required earthfills and earth backfills.
- b. Pay limits, where applicable.
- c. Borrow areas or other sources of material.
- d. Designation and description of the types of material required in the various parts of the work.
- e. Maximum allowable size of rock particles.
- f. Special requirements for foundation preparation.
- g. Maximum layer thickness before compaction for earthfill. (Table A-23 may be used as a guide. This table gives upper limits for the general classes of material listed. The specified maximum layer thickness may need to be substantially less than the tabulated value to obtain adequate compaction.)
- h. Maximum layer thickness before compaction for earth backfill by manually directed power tampers. (The maximum thickness that can be adequately compacted depends upon the tampers and upon the soil being placed. It varies from about 4 inches for plastic clays to about 8 inches for coarse grained material of low plasticity.)
- i. Special instructions for sectional or phased construction, where applicable.
- j. Allowable range of moisture content for each item. For example:
  - (1) "The moisture content of the fill matrix at the time of compaction shall be neither less than 2 percent below optimum moisture content nor more than 2 percent above optimum moisture content."
  - (2) "The moisture content of the fill material shall be maintained within the limits required to: (a) prevent bulking or dilatance of the material under the action of the hauling or compacting equipment, (b) prevent the adherence of the earthfill material to the treads and tracks of the equipment, and (c) ensure the crushing and blending of the soil clods and aggregations into a reasonably homogeneous mass."
- k. Compaction class for each item. (Table A-23 may be used as a guide.)
  - l. For Class A compaction—Compaction test method and required percent of maximum density. Typical compaction test results, if applicable.
  - m. For Class B compaction—Minimum mass density.
  - n. For Class C compaction—Type of roller, minimum weight or contact pressure of roller, minimum vibrating force and frequency for vibrating roller, and minimum number of passes.
  - o. Special rapid methods for moisture control (quick dry, speedy, alcohol, nuclear gauge), if used. These methods are only used on soils where they prove to be a reliable approximation to ASTM D 2216. When rapid methods are used, a reference to the

procedure to be followed should be included.

- p. When the *family of curves* and the one-point Proctor is the intended method for soil density standard determination and verification, it should be referenced and so specified in section 10.
- q. Special requirements, where applicable, for placing earth backfill adjacent to structures, such as reduced compactive effort for high, thin walled structures. This may include monitoring stresses and wall movements and/or specifying minimum in-place concrete strength requirements before the forms or other supports are removed or earth backfilling commences. Minimum in-place concrete strength requirements shall be determined by the designer and clearly stated.
- r. Required minimum strength of concrete, determined according to section 6, for starting compaction of backfill adjacent to structures, if applicable. Use of minimum strength is encouraged over minimum times listed in section 6.
- s. Methods of measurement and payment.
- t. Embedded structures or other elements whose volume will be excluded from the earthfill volume for payment. Major items may be listed for exclusion. The cost of measuring, computing, checking, recordkeeping, and other similar activities must clearly justify the exclusion.
- u. Special requirements pertaining to furnishing and applying water including designated source and details of ownership and water rights, if applicable, and water quality requirements if quality may be a concern.
- v. Special requirements for control of erosion, water pollution, and air pollution, with appropriate cross reference to Construction Specification 5, Pollution Control.
- w. Surface finish requirements, such as completed surface grade tolerances.

#### 4. Methods

##### Section 9, Measurement and payment

**Method 1**—Intended for structure earth backfill and other cases where pay limits can best be shown on the drawings.

The selected methods for pay limits must be compatible with those selected for use in Construction Specification 21, Excavation.

Methods 6 or 7 must be used with any or all methods 1 through 5.

- a. Method 6 is intended for use when no separate payment is to be made for water.
- b. Method 7 is intended for use with Construction Specification 10, Water for Construction, when the contractor is to be paid under a separate item for the water needed to bring the earthfill and earth backfill materials to the specified moisture content.

When specifications are prepared using electronic procedures and all methods but one are deleted for use in a contract specification, delete from the last paragraph ***All Methods The following provisions apply to all methods of measurement and payment.*** Left justify the remaining text.

#### 5. Items of work and construction details

Starting at the top of page 23–6, prepare and outline job specific "Items of Work and Construction Details" (IWCD) in accordance with these instructions. For ease of utilization, the use of recyclable color paper for the IWCD should be considered.

**Table A-23** Compaction class

Grading characteristics of soil fill material % > no. 4	% fines (passing #200)	Appropriate compaction classes	----- Maximum layer thickness ----- (before compaction)			
			tamping roller (in)	pneum. roller (in)	vibrating roller (in)	40,000 lb track tractor (in)
0 – 35	Over 5	A	9	9	—	—
	Under 5	A	9	12	24	—
		B, C	—	18	30	12
35 – 65	25 – 50	A	9	12	24	—
		B, C	9	18	24	—
	5 – 25	A	—	12	24	—
		B, C	—	18	24	—
Under 5	B, C	—	24	24	18	
Over 65	Over 5	B, C	—	18	24	—
	Under 5	B, C	—	24	24	18

**Note: Tabulated values are upper limits.** Actual maximum layer thickness for uniform compaction of a given soil material may be substantially lower. Maximum size of rock or rock fragments should not exceed two-thirds of the layer thickness prior to compaction. Soil plasticity should be a consideration.

**For weathered or weakly indurated rock materials:**

For material, such as shales, schists, disintegrated granite, soft sandstone, and siltstone, the appropriate compaction classes depend upon the degree of breakdown under the action of the excavating and compacting equipment. The maximum layer thickness before compaction must be determined on the basis of special laboratory tests or field compaction tests, or both. Field test fills should be considered to determine the least effort required to meet minimum density requirements.





# **Construction Specification 23—Earthfill**

## **1. Scope**

The work consists of the construction of earth embankments, other earthfills, and earth backfills required by the drawings and specifications.

*Earthfill* is composed of natural earth materials that can be placed and compacted by construction equipment operated in a conventional manner.

*Earth backfill* is composed of natural earth material placed and compacted in confined spaces or adjacent to structures (including pipes) by hand tamping, manually directed power tampers or vibrating plates, or their equivalent.

## **2. Material**

All fill material shall be obtained from required excavations and designated borrow areas. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the engineer.

Fill materials shall contain no frozen soil, sod, brush, roots, or other perishable material. Rock particles larger than the maximum size specified for each type of fill shall be removed prior to compaction of the fill.

The types of material used in the various fills shall be as listed and described in the specifications and drawings.

## **3. Foundation preparation**

Foundations for earthfill shall be stripped to remove vegetation and other unsuitable material or shall be excavated as specified.

Except as otherwise specified, earth foundation surfaces shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the fill or otherwise acceptably scored and loosened to a minimum depth of 2 inches. The moisture content of the loosened material shall be controlled as specified for the earthfill, and the surface material of the foundation shall be compacted and bonded with the first layer of earthfill as specified for subsequent layers of earthfill.

Earth abutment surfaces shall be free of loose, uncompacted earth in excess of 2 inches in depth normal to the slope and shall be at such a moisture content that the earthfill can be compacted against them to produce a good bond between the fill and the abutments.

Rock foundation and abutment surfaces shall be cleared of all loose material by hand or other effective means and shall be free of standing water when fill is placed upon them. Occasional rock outcrops in earth foundations for earthfill, except in dams and other structures designed to restrain the movement of water, shall not require special treatment if they do not interfere with compaction of the foundation and initial layers of the fill or the bond between the foundation and the fill.

Foundation and abutment surfaces shall be no steeper than one horizontal to one vertical unless otherwise specified. Test pits or other cavities shall be filled with compacted earthfill conforming to the specifications for the earthfill to be placed upon the foundation.

#### **4. Placement**

Earthfill shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the engineer. Earthfill shall not be placed upon a frozen surface nor shall snow, ice, or frozen material be incorporated in the earthfill matrix.

Earthfill shall be placed in approximately horizontal layers. The thickness of each layer before compaction shall not exceed the maximum thickness specified in section 10 or shown on the drawings. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified thickness before being compacted.

Hand compacted earth backfill shall be placed in layers whose thickness before compaction does not exceed the maximum thickness specified for layers of earth backfill compacted by manually directed power tampers.

Earth backfill shall be placed in a manner that prevents damage to the structures and allows the structures to assume the loads from the earth backfill gradually and uniformly. The height of the earth backfill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.

Earthfill and earth backfill in dams, levees, and other structures designed to restrain the movement of water shall be placed to meet the following additional requirements:

- (a) The distribution of materials throughout each zone shall be essentially uniform, and the earthfill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material. Zone earthfills shall be constructed concurrently unless otherwise specified.
- (b) If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.
- (c) The top surface of embankments shall be maintained approximately level during construction with two exceptions: A crown or cross-slope of about 2 percent shall be maintained to ensure effective drainage, or as otherwise specified for drainfill or sectional zones.
- (d) Dam embankments shall be constructed in continuous layers from abutment to abutment except where openings to facilitate construction or to allow the passage of streamflow during construction are specifically authorized in the contract.
- (e) Embankments built at different levels as described under (c) or (d) above shall be constructed so that the slope of the bonding surfaces between embankment in place and embankment to be placed is not steeper than 3 feet horizontal to 1 foot vertical. The bonding surface of the embankment in place shall be stripped of all material not meeting the requirements of this specification and shall be scarified, moistened, and recompacted when the new earthfill is placed against it. This ensures a good bond with the new earthfill and obtains the specified moisture content and density at the contact of the in-place and new earthfills.

#### **5. Control of moisture content**

During placement and compaction of earthfill and earth backfill, the moisture content of the material being placed shall be maintained within the specified range.

The application of water to the earthfill material shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the material after placement on the earthfill, if necessary. Uniform moisture distribution shall be obtained by disking.

Material that is too wet when deposited on the earthfill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted earthfill or a foundation or abutment surface in the zone of contact with the earthfill becomes too dry to permit suitable bond, it shall either be removed or scarified and moistened by sprinkling to an acceptable moisture content before placement of the next layer of earthfill.

## **6. Compaction**

**Earthfill**—Earthfill shall be compacted according to the following requirements for the class of compaction specified:

**Class A compaction**—Each layer of earthfill shall be compacted as necessary to provide the density of the earthfill matrix not less than the minimum density specified in Section 10 or identified on the drawings. The earthfill matrix is defined as the portion of the earthfill material finer than the maximum particle size used in the compaction test method specified.

**Class B compaction**—Each layer of earthfill shall be compacted to a mass density not less than the minimum density specified.

**Class C compaction**—Each layer of earthfill shall be compacted by the specified number of passes of the type and weight of roller or other equipment specified or by an approved equivalent method. Each pass shall consist of at least one passage of the roller wheel or drum over the entire surface of the layer.

**Earth backfill**—Earth backfill adjacent to structures shall be compacted to a density equivalent to that of the surrounding in-place earth material or adjacent required earthfill or earth backfill. Compaction shall be accomplished by hand tamping or manually directed power tampers, plate vibrators, walk-behind, miniature, or self-propelled rollers. Unless otherwise specified heavy equipment including backhoe mounted power tampers or vibrating compactors and manually directed vibrating rollers shall not be operated within 2 feet of any structure. Towed or self-propelled vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from a crane or hoist is not permitted.

The passage of heavy equipment will not be allowed:

- Over cast-in-place conduits within 14-days after placement of the concrete
- Over cradled or bedded precast conduits within 7 days after placement of the concrete cradle or bedding
- Over any type of conduit until the backfill has been placed above the top surface of the structure to a height equal to one-half the clear span width of the structure or pipe or 2 feet, whichever is greater, except as may be specified in section 10.

Compacting of earth backfill adjacent to structures shall not be started until the concrete has attained the strength specified in section 10 for this purpose. The strength is determined by compression testing of test cylinders cast by the contractor's quality control personnel for this purpose and cured at the work site in the manner specified in ASTM C 31 for determining when a structure may be put into service.

When the required strength of the concrete is not specified as described above, compaction of earth backfill adjacent to structures shall not be started until the following time intervals have elapsed after placement of the concrete.

Structure	Time interval (days)
Vertical or near-vertical walls with earth loading on one side only	14
Walls backfilled on both sides simultaneously	7
Conduits and spillway risers, cast-in-place (with inside forms in place)	7
Conduits and spillway risers, cast-in-place (inside forms removed)	14
Conduits, pre-cast, cradled	2
Conduits, pre-cast, bedded	1
Cantilever outlet bents (backfilled both sides simultaneously)	3

### **7. Reworking or removal and replacement of defective earthfill**

Earthfill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the specifications shall be reworked to meet the requirements or removed and replaced by acceptable earthfill. The replacement earthfill and the foundation, abutment, and earthfill surfaces upon which it is placed shall conform to all requirements of this specification for foundation preparation, approval, placement, moisture control, and compaction.

### **8. Testing**

During the course of the work, the engineer will perform quality assurance tests required to identify material; determine compaction characteristics; determine moisture content; and determine density of earthfill in place. Tests performed by the engineer will be used to verify that the earthfills conform to contract requirements of the specifications and not as a replacement for the contractor's quality control program. The contractor shall perform all quality control testing in conformance with the approved quality control system for Method 1 and the approved quality control plan for Method 2 in Construction Specification 94, Contractor Quality Control as required to assure that work performed meets contract requirements.

Densities of earthfill requiring Class A compaction will be determined in accordance with ASTM D 1556, D 2167, D 2922, or D 2937 except that the volume and moist weight of included rock particles larger than those used in the compaction test method specified for the type of fill will be determined and deducted from the volume and moist weight of the total sample before computation of density or, if using the nuclear gauge, added to the specified density to bring it to the measure of equivalent composition for comparison. The density so computed is used to determine the percent compaction of the earthfill matrix. Unless otherwise specified, moisture content is determined by one of the following methods: ASTM D 2216, D 3017, D 4643, D 4944, or D 4959.

### **9. Measurement and payment**

For items of work for which specific unit prices are established in the contract, the volume of each type and compaction class of earthfill and earth backfill within the specified zone boundaries and pay limits is measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Unless otherwise specified in section 10, no deduction in volume is made for embedded items, such as, but not limited to, conduits, inlet structures, outlet structures, embankment drains, sand diaphragm and outlet, and their appurtenances.

The pay limits shall be as defined below, with the further provision that earthfill required to fill voids resulting from overexcavation of the foundation, outside the specified lines and grades, will be included in the measurement for payment only under the following conditions:

- Where such overexcavation is directed by the engineer to remove unsuitable material, and
- Where the unsuitable condition is not a result of the contractor's improper construction operations as determined by the engineer.

Earthfill beyond the specified lines and grades to backfill excavation required for compliance with OSHA requirements will be considered subsidiary to the earthfill bid item(s).

**Method 1**—The pay limits shall be as designated on the drawings.

**Method 2**—The pay limits shall be the measured surface of the foundation when approved for placement of the earthfill and the specified neat lines of the earthfill surface.

**Method 3**—The pay limits shall be the measured surface of the foundation when approved for placement of the earthfill and the measured surface of the completed earthfill.

**Method 4**—The pay limits shall be the specified pay limits for excavation and the specified neat lines of the earthfill surface.

**Method 5**—The pay limits shall be the specified pay limits for excavation and the measured surface of the completed earthfill.

**Method 6**—Payment for each type and compaction class of earthfill and earth backfill is made at the contract unit price for that type and compaction class of earthfill. Such payment will constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work.

**Method 7**—Payment for each type and compaction class of earthfill and earth backfill is made at the contract unit price for that type and compaction class of earthfill. Such payment will constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work except furnishing, transporting, and applying water to the foundation and earthfill material. Water applied to the foundation and earthfill material is measured and payment made as specified in Construction Specification 10.

**All methods**—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10 of this specification.

## **10. Items of work and construction details**



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## Instructions for use Construction Specification 24—Drainfill

### 1. Applicability

Construction Specification 24 is applicable to the placing of drainfill in all types of structure drainage systems, such as:

- a. Drainage systems installed beneath concrete structures, lining, or pavements
- b. Wall drains for concrete structures
- c. Embankment drainage systems
- d. Interceptor drains installed adjacent to structures
- e. Foundation drains

### 2. Material specifications

Material Specification 521, Aggregates for Drainfill and Filters, complements Construction Specification 24.

### 3. Included items

Items to be included in contract specifications and drawings

- a. The location, extent, and dimensions of each drain.
- b. The grading limits of each type of drainfill.
- c. The allowable percentage of material (non-plastic) passing No. 200 Sieve.
- d. The source of drainfill materials, when applicable.
- e. Specifications for control of moisture if required. If water is to be added and is to be included in a separate pay item for water, add the statement in section 9: *Water applied to the drainfill material is measured and payment made as specified in Construction Specification 10, Water for Construction.*
- f. Class of compaction. Also specify the weight and number of passes of the compacting equipment required if more than the minimum amounts specified in Section

6. (Class A provides for control of compaction by minimum density requirements determined by ASTM D 698 for fine grain material. Classes I, II, and III specify the method of compaction. Relative density tests during construction generally should be made in connection with the method specifications to evaluate the compaction being accomplished and be compared to test data outlined in ASTM D4254. Class I is intended for use where highest densities are required, Class II is intermediate, and Class III may be used for wall drains in uncompacted backfill or for other applications where strength is not important.

Specify in section 9 the ASTM D 698 procedure to be modified to consist of one point value for maximum dry density determined on an oven-dried representative sample of the drainfill material. The procedure shall be repeated three times to obtain an average value for the one point.

When specifying Class II compaction, note in section 9 the method (a, b, or c) that applies. Note also if one or more of the methods are to be excluded.

- g. Special requirements for placing drainfill adjacent to new concrete as set forth in section 4.

### 4. Methods Section 2, Material

**Method 1**—Intended for use in specifications for drainage systems in areas where commercial aggregate is available in sufficient quantity to meet project needs.

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**Method 2**—Intended to be used in specifications for drainage systems in areas where the contractor will need to process the material from designated sources.

### **Section 8, Measurement and payment**

**Method 1**—Intended for use when quantities are determined from volume measurements and payment is made to the nearest cubic yard.

**Method 2**—Intended for use when quantities are determined by weight and payment is by the ton.

### **5. Items of work and construction details**

Starting at the top of page 24–4, prepare and outline job specific "Items of Work and Construction Details" (IWCD) in accordance with these instructions. For ease of utilization, the use of recyclable color paper for the IWCD should be considered.



# Construction Specification 24—Drainfill

## 1. Scope

The work consists of furnishing, placing, and compacting drainfill required in the construction of structure drainage systems.

## 2. Material

*Method 1*—Drainfill material shall conform to the requirements of Material Specification 521, Aggregates for Drainfill and Filters. A minimum of 30 days before delivery of materials to the site, the contractor shall inform the engineer in writing of the source(s) from which drainfill material will be obtained. The contractor shall provide the engineer free access to the source(s) for the purpose of obtaining samples for testing.

*Method 2*—Drainfill material shall be sand, gravel, or crushed stone, or mixtures thereof, obtained from the specified sources. The material shall be selected as necessary to avoid the inclusion of organic matter, clay balls, excessive fine particles, or other substances that would interfere with their free-draining properties.

## 3. Base preparation

Foundation surface and trenches shall be clean and free of organic matter, loose soil, foreign substance, and standing water when the drainfill is placed. Earth surfaces upon or against which drainfill will be placed shall not be scarified.

## 4. Placement

Drainfill shall not be placed until the subgrade has been inspected and approved by the engineer. Drainfill shall not be placed over or around pipe or drain tile until the installation of the pipe or tile has been inspected and approved.

Drainfill shall be placed uniformly in layers not to exceed 12 inches thick before compaction. When compaction is accomplished by manually controlled equipment, the layers shall not exceed 8 inches thick. The material shall be placed to avoid segregation of particle sizes and to ensure the continuity and integrity of all zones. No foreign material shall be allowed to become intermixed with or otherwise contaminate the drainfill.

Traffic shall not be permitted to cross over drains at random. Equipment cross-overs shall be maintained, and the number and location of such crossovers shall be established and approved before the beginning of drainfill placement. Each crossover shall be cleaned of all contaminating material and shall be inspected and approved by the engineer before the placement of additional drainfill material.

Any damage to the foundation surface or the trench sides or bottom occurring during placement of drainfill shall be repaired before drainfill placement is continued.

The upper surface of drainfill constructed concurrently with adjacent zones of earthfill shall be maintained at a minimum elevation of 1 foot above the upper surface of adjacent earthfill.

Drainfill over and/or around pipe or drain tile shall be placed to avoid any displacement in line or grade of the pipe or tile.

Drainfill shall not be placed adjacent to structures until the concrete has attained the strength specified in section 9 of this specification. The strength shall be determined by compression testing of concrete

test cylinders cast and field cured at the project site in accordance with ASTM Method C 31 for determining when a structure may be placed into service.

When the required strength of the concrete is not specified as described above, placement of drainfill adjacent to concrete structures shall not be commenced until the following item intervals have elapsed following placement of the concrete:

Structure type	Time interval (days)
Vertical or near-vertical wall with earth loading on one side only (retaining walls and counterforts)	14
Walls backfilled on both sides simultaneously	7
Conduits and galleries, cast-in-place (with inside forms in place)	7
(inside forms removed)	14
Conduits, precast, cradled	2
Conduits, precast, bedded	1
Cantilever outlet bents backfilled on both sides simultaneously	3

## 5. Control of moisture

The moisture content of drainfill material shall be controlled as specified in section 9 of this specification. When additional water is required, it shall be applied in a manner to avoid excessive wetting to adjacent earthfill. Except as specified in section 9 of this specification, control of moisture content will not be required.

## 6. Compaction

Drainfill shall be compacted according to the following requirements for the class of compaction specified:

**Class A compaction**—For drainfill materials with more than 70 percent passing the 3/4 inch sieve, each layer of drainfill shall be compacted to a minimum dry density of not less than the density specified in section 9 of this specification as determined by ASTM D 698. For drainfill materials with 70 percent or less passing the 3/4 inch sieve, each layer of drainfill shall be compacted to a relative density of not less than 70 percent as determined by ASTM D 4254.

**Class I compaction**—Each layer of drainfill shall be compacted by a minimum of two passes over the entire surface with a steel-drum vibrating roller weighing at least 5 tons and exerting a vertical vibrating force of not less than 20,000 pounds at a minimum frequency of 1,200 times per minute, or by an approved equivalent method.

**Class II compaction**—Each layer of drainfill shall be compacted by one of the following methods or by an approved equivalent method. (A pass is defined as at least one complete coverage of the roller wheel, tire, or drum over the entire surface for each layer.)

- a. A minimum of two passes over the entire surface with a pneumatic-tired roller exerting a minimum pressure of 75 pounds per square inch.
- b. A minimum of four passes over the entire surface with the track of a crawler-type tractor weighing at least 20 tons.
- c. Controlled movement of the hauling equipment so that the entire surface is traversed by not less than one tread track of the loaded hauling equipment.

**Class III compaction**—No compaction will be required beyond that resulting from the placing and spreading operations.

When compaction other than Class III compaction is specified, material placed in trenches or other locations inaccessible to heavy equipment shall be compacted by manually controlled pneumatic or vibrating tampers as specified in section 9 of this specification.

Heavy equipment shall not be operated within 2 feet of any structure. Vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from cranes, hoists, or similar equipment will not be permitted.

## **7. Testing**

The contractor shall conduct such tests as necessary to verify that the drainfill material and the in-place drainfill meets the specification requirements.

The engineer shall be granted access to perform such tests as are required to verify that the drainfill materials and the drainfill in place meets the requirements of the specifications. These tests are not intended to provide the contractor with information needed to assure that the materials and workmanship meet the specification requirements. These verification tests will not relieve the contractor of the responsibility of performing required tests for that purpose.

## **8. Measurement and payment**

**Method 1**—For items of work for which specific unit prices are established in the contract, the volume of drainfill within the neat lines shown on the drawings are measured and computed to the nearest cubic yard. Where the engineer directs placement of drainfill outside the neat lines to replace unsuitable foundation material, the volume of such drainfill is included. The volume included is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operation in the determination of the engineer.

Payment for drainfill is made at the contract unit price for each type of drainfill, complete in place. Except as otherwise specified in section 9 of this specification, such payment will constitute full compensation for all labor, equipment, material, and all other items necessary and incidental to the performance of the work.

**Method 2**—For items of work for which specific unit prices are established in the contract, the quantity of drainfill placed within the specified limits is computed to the nearest 0.1 ton by actual weight. Where the engineer directs placement of drainfill outside the neat lines to replace unsuitable foundation material, the weight of such drainfill is included. The weight included is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operation in the determination of the engineer.

Payment for drainfill is made at the contract unit price for each type of drainfill, complete in place. Except as otherwise specified in section 9 of this specification, such payment will constitute full compensation for all labor, equipment, material, and all other items necessary and incidental to the performance of the work.

Compensation for any item of work described in the contract, but not included in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 9 of this specification.

## **9. Items of work and construction details**



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## Instructions for use Construction Specification 25—Rockfill

### 1. Applicability

Construction Specification 25 is applicable to rockfill constructed of hard, durable rock with sufficiently open grading to drain freely. It does not apply to riprap slope protection nor to earthfill constructed of rocky soils or of soft rock that is expected to break down during compaction activities.

### 2. Material specifications

No material specifications complement Construction Specification 25.

### 3. Included items

Items to be included in contract specifications and drawings

- a. Complete plans and cross-sections of the required fills. Include any required construction tolerances measured from the lines and grades shown on the drawings.
- b. Zoning plans, including gradation requirements for material in each zone.
- c. Specifications for bedding.
- d. Pay limits where applicable.
- e. The source of each type of fill.
- f. Screening or other processing requirements.
- g. Specifications for wetting during placement and compaction, if required. If water is to be added and is to be included in the separate pay item for water, add the statement: *Water applied to the fill material will be measured and payment will be made as specified in Construction Specification 10, Water for Construction.*

- h. Class of compaction for rockfill. Specify more passes or heavier equipment if test fills or other sources of information indicate the need for it. (Class I is intended for use where the highest degree of compaction is required. Class II is intermediate, and Class III is for use where no special compaction is needed.)

When specifying Class II compaction, note in section 10 the method (a, b, or c) that applies. Note also if one or more of the methods are to be excluded.

- i. Class of compaction for bedding. Also specify more passes or heavier equipment if more than minimum amounts specified in section 8 may be needed.

### 4. Methods

#### Section 5, Placement

**Method 1**—Intended for use whenever the grading of materials within the fill is not a critical element of the design.

**Method 2**—Intended for use when the piping or cracking potential of the core zone is a critical element of the design or when the percentage of large rock is relatively low and special slope protection is desired.

### 5. Items of work and construction details

Starting at the top of page 25–4, prepare and outline job specific "Items of Work and Construction Details" (IWCD) in accordance with these instructions. For ease of utilization, the use of recyclable color paper for the IWCD should be considered.