Presentations From The 1992 Coal Mining Impoundment Informational Meeting

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PRESENTATIONS FROM THE 1992 COAL MINING IMPOUNDMENT INFORMATIONAL MEETING

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INTRODUCTION

On May 20 and 21, 1992, the MSHA Coal Mining Impoundment Informational Meeting was held at the National Mine Health and Safety Academy in Beckley, West Virginia. Fifteen presentations were given on key issues involved in the design and construction of dams associated with coal mining. The sessions were attended by approximately 180 people representing mining companies, consultants, and government. The format allowed seven groups of 26 to 30 attendees each to rotate through seven classrooms to discuss the issues.

The attendees were told that to improve the consistency among the plan reviewers, engineers from the Denver and Pittsburgh Technical Support Centers meet twice annually to discuss specific technical issues. It was soon discovered that the topics being discussed needed to be shared with anyone involved with coal waste dam design, construction, or inspection. The only way to accomplish that goal was through the issuance of Procedure Instruction Letters. The Letters present a consensus of engineering philosophy that could change over time. They do not present policy or carry the force of law.

The first meeting was held in Denver, Colorado, in September 1986. The first PIL, on Compaction Specifications, was issued with an effective date of July 1, 1990. Currently, thirteen position papers have been disseminated and more will follow as the need arises.

RESERVOIR EVACUATION BY PUMPING

Bill Cannon
and

EROSION PROTECTION FOR SPILLWAYS

Stephen W. Dmytriw

Summary of Presentations

Mr. Dmytriw made a few brief remarks about Technical Support's approach toward evaluating open-channel spillways. He addressed the appropriateness of location, alignment, material excavated or the lining used to secure permanence during the life of the hydraulic conveyance. It was emphasized that overall spillway quality is a function of facility hazard classification. For example, a large, high hazard structure where loss of the spillway could result in dam breach and possible loss of life demands there is no substitute for quality. The dam structure and hydraulic conveyance must function as designed under the most rigorous conditions without assistance from maintenance personnel. This position is firm, since it is unlikely that workers and equipment would be available when needed and most likely could not get to the site due to a myriad of storm related conditions and consequences. In this light, most MSHA review engineers insist that spillways for large, high hazard dams should be excavated though competent rock or the channel lined with reinforced concrete to gain an approval recommendation. This example represents one end of the classification quality response spectrum.

On the opposite end of the spectrum are spillways designed in concert with small, low hazard facilities where there is no expectation for loss of life. Under this condition and in conjunction with discharge velocity, the channel could be adjacent to or located over the dam crest and formed from embankment material. A lining, if required, could consist of grasses, riprap, or synthetic materials such as ArmorForm, FabriForm, Enkamat, articulated mats, gabions, pre-formed blocks, and the like. The Agency's reviewers consider these erosion protection linings in the experimental stage similar to geotextiles for drainage systems more than a decade ago. As new products prove their worth and gain acceptance they can be applied in more hazardous situations.

Riprap of course is not a new product, but new calculative methods have been developed which result in larger rock sizes and blanket thicknesses for equivalent velocities compared to older design techniques. Early in the oversight responsibility, MSHA engineers relied on methods advocated by the Federal Highway Administration (FHWA). Through utilization, implementation, and field performance, the Technical Support Centers learned that many riprap linings failed at less than the design discharge. As

a result of these findings MSHA undertook a study to compare six separate design methods. The methods included FHWA, U.S. Bureau of Reclamation (USBR), Corps of Engineers (CE), California Department of Transportation (CALTRAN), Columbia River Model (CRM), and Simons and Senturk. Using the USBR method as the standard, the various techniques yield maximum stone size variations as follows: FHWA -0.76; USBR -1.0; CE -2.04; CALTRAN -2.67; CRM -1.45; and Simons and Senturk -3.16.

This normally concluded Mr. Dmytriw's considered remarks and the floor was thrown open for questions. Questions received generally fall into six broad categories that are addressed later in this report.

Mr. Bill Cannon addressed Reservoir Evacuation by Pumping by simply reading the PIL including several observational anecdotes. This subject is the least technical of the 13 Letters issued, contains no bibliography, and few questions were asked.

During each session, either Bill or Stephen asked the attendees if the PIL's have generally been helpful or simply an unnecessary exercise. The general consensus leaned toward helpful in that the Letters gave guidance and direction to the design engineer.

Several attendees suggested additional PIL topics during the seven periods of lecture and discussion. They include (1) a guide to a more complete open-channel spillway alignment exploratory investigation to define subsurface conditions and rock quality, (2) the advantages and pitfalls of placing emergency spillways over the dam crest, and (3) reinforced concrete testing and inspection features. A non-Federal regulator suggested that MSHA prohibit installation of open-channel spillways over or adjacent to embankment dams while another stated that MSHA should insist upon greater concrete testing variety and frequency.

Questions Regarding Presentation

1. What is MSHA's policy toward multiple stage, open-channel spillways; changing, say, every four months?

Spillway quality is a function of facility hazard classification; that is, the consequences of failure dictate how substantial or durable the spillway and/or lining must be constructed to withstand the erosional forces expected. If failure of a spillway can lead to failure' of the embankment, the channel and/or lining shall be designed and constructed to preclude failure. Under the conditions described, if a company or an agent of the company chooses to design and construct numerous short-term spillways for a large, high hazard dam, each channel shall be substantial. In most instances, the channel will be either carved into competent rock or lined with reinforced concrete with suitable seepage control measures. As the Agency develops more

knowledge about alternate methods that have been proven successful, those systems will be considered.

2. Can a hazard classification be altered or reduced through remediation techniques?

Yes. For example, imagine a small impounding facility constructed on a strip mine property above the active mine area for flood control abatement. By definition this would be classified a small or moderately sized, high hazard dam, because if the dam were to fail with a full pool, miners would probably be killed. Therefore, the open-channel spillway must be sized to pass runoff from a PMF. However, if the company and/or their consultant can devise an emergency warning system in conjunction with an emergency action plan to evacuate the work area, it is conceivable that the hazard could be downgraded to low. Through a hydrological analysis, the designer can choose a specific flood pool elevation below the spillway crest where the warning is activated. The reservoir level selected should be compared to the inflow hydrograph to permit a reasonable time for miners to leave the pit prior to spillway activation. Therefore, the hazard is abated and the classification altered. In addition to the hydrologic, hydraulic, and emergency action plan, the reviewer will examine embankment stability thoroughly.

3. Is the review process affected by slipshod and/or noncompliance work even if such work constitutes a small percentage of all design submittals?

Sadly, the answer is yes. It is unfortunate that designers who pay attention to details and companies that follow the approved plan are often penalized by the delays in the review process caused by incompetent or shoddy professional work and operators who knowingly deviate from the drawings and specifications.

4. Why is MSHA reluctant to adopt or permit utilization of new synthetic spillway liners such as FabriForm, ArmorForm, and articulated mats?

MSHA is utilizing essentially the approach the Mine Waste Divisions used when geotextiles were developed for drainage systems. Our reviewers, for the most part, do not want to experiment with unproven products where failure of the product could lead to dam failure and probable loss of life. Most of the products being introduced have not been subjected to flood flows with the attendant debris that is expected from the storms we anticipate.

MSHA'S CONCERNS REGARDING SEISMIC ANALYSIS OF COAL MINE REFUSE EMBANKMENTS

Wade E. Cooper

I've been asked to talk about MSHA's concerns regarding seismic stability analysis of coal mine refuse embankments. More specifically, MSHA is concerned with the procedures used to evaluate the seismic stability of moderate and high hazard impoundments constructed using either centerline or upstream construction methods. This talk will be concerned with only these types of embankments constructed on nonliquefiable foundations. For the limited time provided, this talk simply cannot cover all aspects of seismic stability analysis. The talk primarily covers the most commonly used methods concerning only liquefaction and deformation, and MSHA's concerns in this area. For example, this talk does not address pore pressure dissipation after the earthquake, reservoir seiches, and active faults within the embankment foundation.

Anyone who has designed a coal refuse embankment using either centerline or upstream construction methods should, by now, know that the task of evaluating seismic stability is a complex, tedious, and potentially costly process with many uncertainties. The complexities and uncertainties make it extremely difficult for both MSHA and designers to make a determination as to what constitutes current, prudent engineering practice. It must be recognized that seismic stability analysis is of concern only when there is the potential for a catastrophic failure of the embankment due to seismicity. This usually equates to a significant loss or settlement of the embankment crest which could result in loss of life or significant damage to major structures.

In performing a seismic stability analysis of an embankment there are primarily three main components:

1. Select appropriate seismic ground motion parameters;
2. Liquefaction analysis; and
3. Deformation analysis.

An accurate and reliable assessment in each of these components is vital for properly evaluating the seismic stability of the embankment. Each one will be discussed separately.

GROUND MOTION PARAMETERS

The objective of the design earthquake evaluation is to obtain the ground motion parameters at the site to be used in the dynamic response analysis for assessing liquefaction and deformation. Current Federal guidelines (8)[1] indicate that extensive investigations and design analyses may be required for high hazard dams or where seismic conditions are severe. The guidelines serve as an excellent tool for the factors which need to be considered in performing a local or site specific seismotectonic study. For moderate and high hazard dams, where failure of the embankment could cause loss of life or significant damage to major structures, the controlling maximum credible earthquake (CMCE) appears to be appropriate as the design earthquake. Procedures for determining the CMCE are presented in the guidelines and will not be reiterated here. In regions of the United States where active faults are not well defined, such as in many eastern states, the Bureau of Reclamation (1) indicates that they determine earthquake loading in a probabilistic manner. They also indicate that they exclude usage of earthquakes with a probability of occurrence of less than 2E-5. MSHA is in the process of seeking current seismic criteria used by other Federal agencies involved in earthen dam construction.

MSHA has some concern that the selection of the CMCE is a highly complex procedure and is usually out of the realm of expertise for most registered engineers certifying design plans as well as MSHA reviewers. For this reason, it may be prudent to leave determination of the CMCE up to recognized seismologists. In addition, MSHA recognizes that it needs to perform more research to determine acceptable probabilistic seismic design criteria.

One of the more important aspects in any liquefaction and deformation assessment is determining the dynamic response of the embankment. The dynamic response analysis determines the ground motion parameters (such as acceleration, velocity, shear stress and shear strain) within the embankment during the earthquake motion. These motions are needed for deformation analyses and may be needed for application in laboratory tests used to determine pore pressure development, strains, and whether or not liquefaction can be expected.

Many computerized models are currently available for performing the dynamic response analysis. Selecting which model to use can be a complicated task. Some of the computerized models proceed even further and contain models for determining liquefaction and deformation based on soil input data derived from laboratory tests. Of the available computerized models for determining dynamic response alone, SHAKE is probably the most common. It is

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[1]Underlined numbers in parentheses refer to the list of references at the end of this report.

a one-dimensional linear elastic analysis method which assumes level ground conditions utilizing total stress concepts. Some references (1,6) indicate that it can significantly underestimate both accelerations and cyclic shear stresses near the crest of the embankment because it does not take into account the geometrical shape of the embankment. This appears to indicate that two-dimensional dynamic response analyses may be more appropriate for embankments. SHAKE may also result in a greater response than any of the nonlinear analysis methods because of resonance caused by the site period matching the period of the input motion. Many of the more recent methods incorporate effective stress concepts as well as nonlinear stress-strain properties and may result in more reliable results. At this time, there appears to be no consensus about which method is most appropriate for coal refuse embankments.

Dynamic soil parameters are needed for input into all of the computerized dynamic response analysis programs. These parameters include the shear modulus, damping coefficient, bulk modulus, and how they change with shear strain. Many of the available programs contain typical soil input parameter values. However, most of the values were obtained on natural soils which have a higher specific gravity and different granular shape than fine coal refuse. Their validity for coal refuse appears questionable. Rather than using the software provided values, it appears necessary to perform adequate laboratory and field tests to determine these dynamic parameters. Instead of relying on laboratory tests to determine the in situ shear modulus, most experts recommend measuring in situ shear wave velocity via either cross-hole or down-hole techniques. Dynamic properties are usually determined using laboratory tests, such as either strain or stress-controlled cyclic triaxial tests, on preferably undisturbed samples. MSHA has some concern about (1) whether the laboratory samples are truly undisturbed, (2) whether the effects due to disturbance are significant and how significant, (3) whether it would be better to reconstitute the samples, and (4) what are the uncertainties in response due to using reconstituted samples.

The Committee on Earthquake Engineering (7) provides some information indicating that pore pressure development is fundamentally more related to cyclic strain than to cyclic stress. This casts some concern as to whether stress-controlled or strain-controlled laboratory tests should be performed for assessing dynamic soil properties.

LIQUEFACTION ANALYSIS

In evaluating the stability of the embankment against liquefaction, current practice allows the designer essentially two choices: either assume liquefaction and assign a shear strength to the liquefied soil or assess liquefaction by determining if the earthquake is of sufficient magnitude and duration to cause liquefaction. In this report, liquefaction of a soil is considered to occur when the undrained steady-state shear strength, as a result of strain softening, is the available shear strength in the soil. Care must be taken to not confuse it with cyclic mobility or limited liquefaction as defined by Vaid and Chern (11). Soils that are dilative in situ need not be evaluated for liquefaction, but should be evaluated for strain and deformation. Dilative soils do not liquefy because their undrained strength is greater than their drained strength.

(A) Assume liquefaction: Assume that the fine refuse liquefies as a result of the design earthquake and perform a post-earthquake static stability analysis to demonstrate that the embankment is statically stable after the earthquake. If the embankment is not statically stable (i.e., fails) in the liquefied mode, then additional analyses are necessary to determine if the design earthquake is of sufficient magnitude and duration to cause liquefaction.

This type of analysis appears rather straight forward, however, the difficulties or pitfalls of the method are not so apparent. One of the major difficulties of the method is in choosing the appropriate shear strengths for the soils assumed to be liquefied. Basically three shear strengths are commonly used for the liquefied soils:

1) Assume the worst case; i.e., zero shear strength. Obviously, this case would not provide adequate factors of safety for embankments constructed using upstream construction methods. However, it may provide adequate factors of safety for centerline constructed embankments with wide crests.

2) Another procedure, advocated by many experts, is to use residual shear strengths derived empirically from standard penetration test results (SPT) or cone penetration test results correlated with SPT. However, in using these, one must recognize that they were determined from site specific data on natural soils which have a higher specific gravity than fine refuse. Therefore, their applicability for coal refuse facilities is certainly questionable. In addition, a specific blow count shows a wide range of residual shear strengths. Choosing which residual strength over the wide range could pose a problem.

3) Without the availability of appropriate empirical correlations of residual strength, many designers turn to the field and laboratory test methods presented by Poulos et. al. (1,2,3,12) to determine the undrained steady-state shear strength of the liquefiable soil. This method requires relatively undisturbed samples from the field for consolidated-undrained triaxial tests in the laboratory. The method is highly dependent on accurate measurement of the in situ void ratio. Although the method appears to be relatively straight forward for determining the undrained steady-state shear strength, there can be significant shear strength uncertainties due to the relatively flat slope of the steady-state line (void ratio vs log of the steady state shear strength) and the subjective amount of void ratio adjustment. The method is highly dependent on obtaining relatively "undisturbed" samples. Some consultants contend that "undisturbed" samples of fine refuse may be obtained because of the slight cohesiveness and plasticity of most fine refuse. MSHA still has some concerns whether or not relatively "undisturbed" samples can be obtained for laboratory analysis. In addition, some recent research developments suggest factors other than in situ density, such as stress path, dynamic pore pressure fluctuation, soil fabric, and stratification, may also play a role in the actual steady-state strength available in the field (4,9).

Another method of estimating the undrained steady-state shear strength that has been proposed is to use in situ vane shear tests. MSHA has some concerns that this method may overestimate undrained shear strengths due to the effects of plasticity and the potential for the presence of granular particles (5).

Other concerns that arise include whether or not adjustments in available shear strength should be made for the nonliquefiable soils and deciding on what is an acceptable factor of safety for the stability analysis. The Bureau of Reclamation (1), as well as some other, use a shear strength reduction of up to 20 percent depending on the type of soil, its standard Proctor density, and consolidation. Acceptable factors of safety for the liquefied mode appear to range from about 1.0 to 1.5 in the literature, depending greatly on the reliability of the shear strengths used in the analysis.

Although this method has some advantages over performing a laboratory based "triggering" analysis, it still must be carefully used before it can be considered a reliable analysis.

(B) ASSESS LIQUEFACTION POTENTIAL

There are basically two approaches to evaluating liquefaction potential: either use empirical methods based on field tests or use laboratory tests in conjunction with results of dynamic response analyses.

1) Empirical Methods: The majority of empirical methods, such as SPT, CPT, or liquefaction potential graphs, for assessing liquefaction potential are based on natural soils with much higher specific gravities than fine refuse. Again, for this reason, the use of these empirical methods for assessing liquefaction potential of coal refuse facilities is questionable.

However, it may be possible to obtain a database which may at some latter date show a correlation between the empirical methods and the laboratory methods used on fine refuse. MSHA believes that the empirical methods are not by themselves adequate at this time for verifying nonliquefaction of fine refuse. The empirical method results can provide additional information for making an informed decision as to whether or not liquefaction can be expected. Some of the more recent updates in empirical methods for evaluating liquefaction potential are presented by the Bureau of Reclamation (1) and Seed and Harder (6).

2) Laboratory "Triggering" Method: Once the dynamic response analysis is completed and undisturbed samples of the fine refuse are obtained, laboratory testing to assess pore pressure increase, strain, and liquefaction potential can be performed. The most common laboratory testing method is the stress-controlled cyclic triaxial test under undrained conditions on samples consolidated to their in situ effective stress. Other methods such as torsional shear and strain-controlled tests are reported in the literature. In order to obtain the in situ effective stress (both horizontal and vertical), it may be necessary to perform a finite element analysis which contains a model for the stress-strain behavior of the soils. The shear stresses obtained from the dynamic response analysis are normally converted into an equivalent number of cyclic shear stresses for use in the stress-controlled cyclic triaxial tests. Measurements in the test include stress, strain, and pore pressure, which are used to determine pore pressure development and whether liquefaction, based on the amount of strain, can be anticipated within the soil.

MSHA has many of the same concerns with this laboratory test as it does with all laboratory tests on "undisturbed" samples. These concerns are whether or not the sample is truly undisturbed, whether the in situ effective consolidation stresses are properly modeled, and whether the initial states, such as void ratio, are properly modeled. It is well documented that sample disturbance and confining effective stresses can have major effects on pore pressure and strain development. Anisotropic consolidation conditions can have opposite effects depending on the initial states of the soil (11); therefore, proper modeling of the initial states of the soil in the laboratory is vitally important. Considerable uncertainties in

strain development from cyclic triaxial tests are apparent for soils which have high permeability and no cohesion (12).

The Bureau of Reclamation (1) presents the following concerning the use of laboratory tests for assessing liquefaction potential:

> "Finally, the triggering analysis using laboratory tests is the last bastion of hope in the effort to disprove or prove liquefaction. It should only be considered for application to materials which have some cohesion and then should be used with considerable judgment and a comfortable margin of safety with regard to strain (e.g., a factor of safety> 2) because if the phased approach is employed as described previously, use of the triggering analysis as a basis for ruling out liquefaction implies post liquefaction instability."

In addition, the Committee on Earthquake Engineering (7) present the following concerning laboratory tests for predicting pore pressure buildup:

> "The major difficulty lies in the parameters relating to the rate of pore pressure generation. The earliest efforts to predict pore pressures used results from laboratory tests on specimens reconstituted to the in situ void ratio or sometimes "undisturbed" samples. The practice of predicting pore pressures solely on the basis of laboratory tests, without the benefit of in situ measurements such as SPT or shear wave velocity, is now recommended only if great precaution is taken to obtain samples with least disturbance. Such practice is particularly important for some types of soil for which there is as yet little or no experience."

DEFORMATION

A deformation analysis must be performed for embankments that do not liquefy, as well as those that do, to ensure the safety of the embankment. There are currently two main approaches used to evaluate deformation as a result of the design earthquake. The Newmark approach (10) is commonly used and has been modeled in several computerized software programs. Meanwhile, the computerized finite element or finite difference methods are becoming much more common. There are so many finite element and finite difference models available that it is extremely difficult to access their validity. Some experts rely heavily on the use of a specific model for assessing deformation. Practically all of the computerized methods rely heavily on modeling the dynamic properties of soils from laboratory test results such as those from cyclic triaxial tests or consolidated-undrained triaxial tests. MSHA's main concern with all of these computerized

methods is that it is extremely difficult to determine if they properly or conservatively model the shear strengths and strains of the soils during the earthquake motion. This causes problems for MSHA as well as others in evaluating the appropriateness of the methods for evaluating deformation of fine refuse embankments.

CONCLUSIONS

MSHA has some concern that the empirical methods of liquefaction assessment may not be appropriate due to the difference in specific gravity of the soils used in the empirical methods and the soils used in coal refuse embankments. However, it appears they can provide additional insight into assessing the potential for liquefaction and possibly supply data which may show correlation with laboratory methods. MSHA also has many concerns about the validity of laboratory methods for assessing liquefaction and deformation of coal refuse embankments because of the problems of obtaining "undisturbed" samples for testing and the apparently drastic effects of disturbance on test results. This is particularly important since practically all of the computerized methods for assessing liquefaction and estimating deformation are based on models using parameters obtained from laboratory tests. There can be considerable uncertainties in liquefaction and deformation assessments based on laboratory and field tests for coal refuse embankments. It is evident that considerable judgement must be exercised in evaluating the seismic stability of coal refuse embankments constructed using either centerline or upstream construction methods.

REFERENCES

1. Bureau of Reclamation, 1989, "Chapter 13, Seismic Design and Analysis," Embankment Dams Design Standards, U.S. Dept. of Interior, 77p.

2. Poulos, S.J., G. Castro, and J.W. France, 1985, "Liquefaction Evaluation Procedure," Journal of Geotechnical Engineering, ASCE 111(b), pp. 772-791.

3. Poulos, S.J., 1981, "The Steady State of Deformation, Journal of the Geotechnical Engineering Division, ASCE, Vol. 107, No. GT5, May, pp. 513-562.

4. Lo R.C., E. Klohn, and W.D. Liam Finn, 1991, "Shear Strength of Cohesionless Materials Under Seismic Loadings," IX Panamerican Conference Proceedings, pp. 1047-1052.

5. Holtz, R.D., and W.D. Kovacs, 1981, "An Introduction to Geotechnical Engineering," Prentice-Hall Civil Engineering and Engineering Mechanics Series, pp. 572-577.

6. Seed, R.B., and L.F. Harder, Jr., 1990, "SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength," Proceedings, H. Bolton Seed Memorial Symposium, J. Michael Duncan (ed.), Vol. 2, May, pp.351-376.

7. Committee on Earthquake Engineering, 1985, "Liquefaction of Soils During Earthquakes," National Academy Press, Washington, D.C., pp. 89-192.

8. Design Earthquake Task Group Subcommittee 1 Interagency Committee on Dam Safety, 1985, "Federal Guidelines for Earthquake Analyses and Design of Dams," Federal Emergency Management Agency, March, 45 p.

9. Finn, W.D. Liam, 1990, "Analysis of Post-Liquefaction Deformations in Soil Structures," H. Bolton Seed Memorial Proceedings, Vol. 2, J. Michael Duncan (ed.), May, 21p.

10. Newmark, N.M., 1965, "Effects of Earthquakes on Dams and Embankments," Geotechnique, vol. 15, No. 2, pp. 139-160.

11. Vaid, Y.P., and J.C. Chern, 1985, "Cyclic and Monotonic Undrained Response of Saturated Sands," Proceedings of Geotechnical Engineering Division, ASCE Convention, October 24, 1985, Advances in the Art of Testing Soils Under Cyclic Conditions, pp. 121-147.

12. Poulos, Steve J., 1986, "Liquefaction and Related Phenomena," Advanced Dam Engineering for Design, Construction, and Rehabilitation.

PHREATIC SURFACE

Wade E. Cooper

Summary of Presentation

The phreatic surface within embankments must be conservatively depicted or evaluated to calculate the minimum slope stability factors of safety for both static and earthquake conditions. The phreatic surface must be conservatively depicted or evaluated for the long-term steady state seepage condition assuming the water surface is maintained at the elevation of the lowest ungated water outlet. If a rapid reservoir drawdown stability analysis is provided, a phreatic surface evaluation for this condition may be required.

Many different methods are currently available for determining phreatic surface and seepage quantities. The computerized finite-element methods are becoming increasingly popular. However, no matter which method is used, extreme care must be exercised to ensure that the assumptions inherent in the method and procedures are fully satisfied or do not significantly affect the results.

For design purposes, a minimum horizontal to vertical permeability ratio of at least 9 appears appropriate. Lower ratios may be allowed provided they are adequately substantiated and documented.

Drains which have been used to lower the phreatic surface used in the stability analysis must be properly designed. They must be designed for material compatibility, relative permeability, minimum thicknesses of at least 3 feet, and with seepage capacity factors of safety of at least 10.

Questions Regarding Presentation

1. In recent years, more emphasis has been placed on 95 percent standard Proctor maximum dry density instead of 90 percent. Is there a difference in the horizontal to vertical permeability ratio due to the higher compaction requirement?

There may be some change due to the higher compaction, however, we do not know for sure whether there is and how much it is, although we estimate it to be inconsequential.

2. Is it a good idea to install piezometers near internal drains to assess drain operation?

Generally "no" for several reasons. Proper operation of drains is normally evaluated through monitoring effluent characteristics of the drain such as quantity of flow and amount of fines. Piezometers are normally installed to monitor the phreatic

surface in the embankment. The readings are used to evaluate the stability of the embankment. They may be used for assessing drain operation, however, it is not considered common practice.

3. One person commented that he had some problems with using a minimum horizontal to vertical permeability ratio of 9.

With regards to this comment we could only reiterate what is stated in the Procedure Instruction Letter. The minimum ratio of 9 is based on a thorough search of the available literature which indicates the ratio can vary from 1 to over 100. It is based on what appears to be a reasonable minimum for design purposes. A lower ratio may be utilized provided it is fully substantiated and depending on how crucial the ratio is to the safety of the embankment. MSHA reviewers would be more inclined to accept a lower ratio provided its use does not significantly affect the stability or safety of the embankment.

4. Why do we need to determine coefficients of permeability for homogeneous embankments without drains?

There is really no need to determine coefficients of permeability for this case, except when someone is interested in obtaining an estimate of the total anticipated seepage quantity.

Additional Discussion

It was commented that one operator kept dozer operators and other equipment operators from breaking piezometers by installing a U.S. flag on each piezometer. This apparently kept the operators a significant distance from the piezometer. Bicycle pennants or reflective driveway markers on flexible poles serve equally well as markers and raise no questions regarding flag protocol.

EFFECTS OF MINING ON DAMS AND IMPOUNDMENTS

John W. Fredland

Summary of Presentation

If underground mining occurs near a dam, the ground disturbances caused by the mining can damage the dam. In the design and construction of a dam, a great deal of effort and expense is taken to ensure that seepage will be controlled, and piping, or internal erosion, will not occur. In this regard, measures are taken such as foundation exploration and testing, foundation preparation, placement of drains, and controlled compaction of materials. Furthermore, careful analyses are performed to determine the required minimum freeboard, and to design structurally safe decant pipes. The effects of mining can undo any or all of these measures and jeopardize the safety of a dam.

The ground movements induced by mining (see Figure 1) can cause the opening of joints in the foundation, cracking of embankment materials, damage to decant pipes, loss of freeboard, and other adverse effects. It is for these reasons that a "safety zone" is recommended under and around dams. An example of a safety zone is shown in Figure 2. This is a zone where no mining takes place. If mining is proposed within the "safety zone," then designers should realize that 1.) the design and justification will be more involved than normal, and 2.) the dam design will need to include design measures to compensate for potential mining effects. The Procedure Instruction Letter includes a listing of some of these design measures.

Because of the uncertainties involved in predicting both the effects of mining (pillar strengths, sinkhole development, mining induced surface strains, etc.) and the response of the foundation and the dam itself to differential movements, designers must take a conservative approach to this issue.

Questions Regarding Presentation

1. Does the Procedure Instruction Letter mean that no mining is permitted under a dam?

No. It is not the intent of the PIL to totally prohibit mining under a dam. However, as indicated in the PIL, plans which propose mining under a dam will not be approved unless the potential effects of the mining, and the associated uncertainty, are fully taken into account, and a complete, well-documented analysis is provided.

Because of the nature of the ground disturbances created by full extraction mining, such mining is normally not permitted under a dam and must be kept a safe distance away from a dam.

2. What about building a dam over an old room-and-pillar area?

With room-and-pillar mining, MSHA would be concerned that the strength of the pillars would be adequate to provide the required long-term support. The possibility of the pillars punching into a moisture-softened fireclay layer beneath the coal seam would be a concern. Sinkholes can develop in areas of shallow rock cover. All of these potential effects would need to be specifically investigated and analyzed. Testing should be performed as needed to characterize the properties of the materials involved.

In the case of old abandoned workings, an additional concern would be for the accuracy of the older mine maps, especially with respect to the robbing of pillars, which may not be reflected on the map. The site would need to be explored to a sufficient extent to allow the accuracy of the mine map to be verified.

3. What about building a dam over longwalled areas?

The mining of longwall panels will affect the surface at virtually any depth of mining. Since total extraction mining creates zones of tension on the surface, it can be particularly dangerous in the vicinity of dams. Much uncertainty is associated with determining how the strains will be distributed on the surface, estimating how much strain will occur at a particular location, and predicting the impact of the strains on the foundation. The loading of the dam itself may cause additional movements.

If dam construction is proposed over an area which has already been longwalled, the designer would need to address issues such as the following: are the mining induced movements completed and has the area stabilized; how has the mining affected the foundation with respect to its permeability; have cracks occurred or joints opened up which could provide a path for excessive seepage, or for piping; how will the foundation exploration program identify the effects of the mining; how will the foundation preparation compensate for the mining effects; what compensating features should be included in the dam design; what type of monitoring should be done to ensure that the design is working as anticipated.

4. Our company is considering longwall mining under a high hazard dam. What's your opinion?

As previously stated, longwall mining will affect the surface, and the impact cannot be predicted with a high degree of confidence. For these reasons, longwall mining under a dam is not normally permitted. Mine planning, so that a slurry dam would be undermined after it is filled up and capped off, for example, is recommended over mining near the impoundment when it is active.

5. Can subsidence be considered to be over after a certain period of time, say 20 years?

With room-and-pillar mining, subsidence incidents have been documented to have occurred 50 years or more after the mining. In many older mines, long, narrow pillars were left in place. These pillars are particularly susceptible to deterioration over time because of the lack of confinement of the pillar core area, and because locally overstressed pillars can cause higher loads to be transferred to neighboring pillars. Deterioration of roof supports, especially timbers, is also a contributing factor.

The majority of the subsidence which is related to longwall mining normally occurs within a couple of months of the mining. Further subsidence would depend on the nature of the overburden strata, water conditions, and, probably to a small extent in most cases, the impact of surface loadings.

In the case of total extraction, actual records of subsidence in the area, under similar conditions, are probably the best indicator of whether movement may have stabilized. Where the safety of a high hazard dam is at issue, conservative assumptions of the potential for movement must be made.

6. In defining a safety zone around a dam, how is the draw angle determined?

The angle of draw delineates the surface area influenced by underground mining. It is the vertical angle between a line drawn vertically at the edge of the mining, and a line drawn from the edge of the mining to the nearest point on the surface where no movement occurred. Draw angles from 5 to 45 degrees are found in the literature, with the more common values being from 15 to 25 degrees. The draw angle will depend on the nature of the overburden.

Preliminary estimates of draw angles can be obtained from the subsidence literature. Draw angles should normally be based on measurements taken in the area of concern, under similar conditions of overburden and depth. Draw angles should be verified by surveys at the dam site.

7. How do you determine the rock properties needed in a subsidence analysis?

In dealing with a high hazard dam, site specific properties are needed. This means that, in most cases, samples of the rock and coal from the dam site will need to be obtained for testing. Coal is a difficult material to sample and test. Test results may need to be adjusted to take into account the fact that only stronger samples may survive the sampling and preparation process.

8. In determining the safety of pillars, what methods are recommended by MSHA?

A variety of pillar design methods have been developed. For a given set of conditions, these methods will predict a range of safety factors. In dealing with the safety of dams, a conservative approach needs to be taken. Therefore, MSHA recommends that one of the more conservative methods, such as Holland's method, should be used, with a conservative factor of safety.

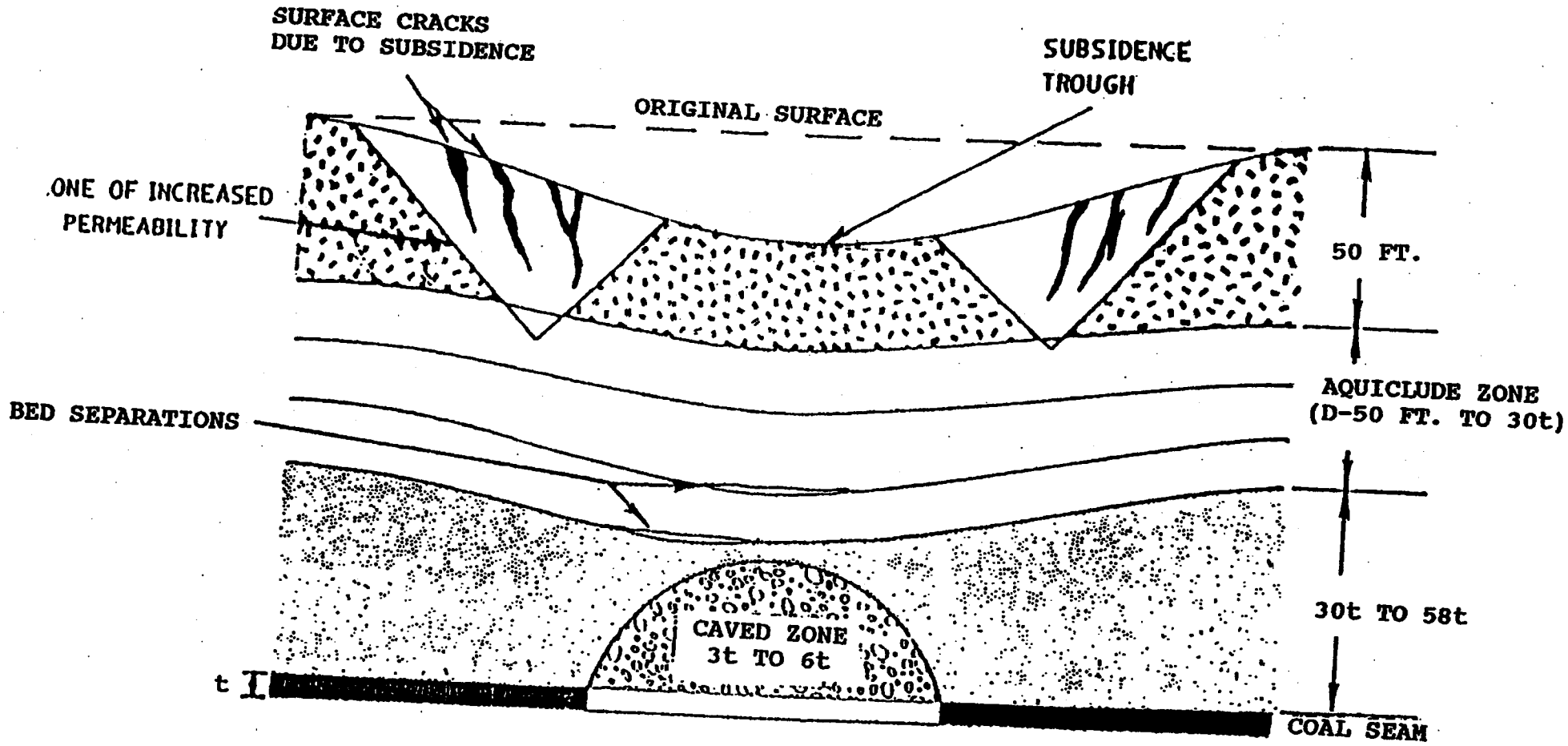
9. Which subsidence prediction model does MSHA recommend?

MSHA doesn't endorse a particular subsidence prediction model. The designer must investigate the available methods of analyses and determine which is most applicable to the particular site. Designers should keep in mind that the models are based on empirical data, and so they are generally considered to be applicable only for the area where the empirical data came from.

10. What happens when one company has constructed an impoundment with an approved plan, and another company has the mineral rights for the coal under the impoundment, and wants to mine it?

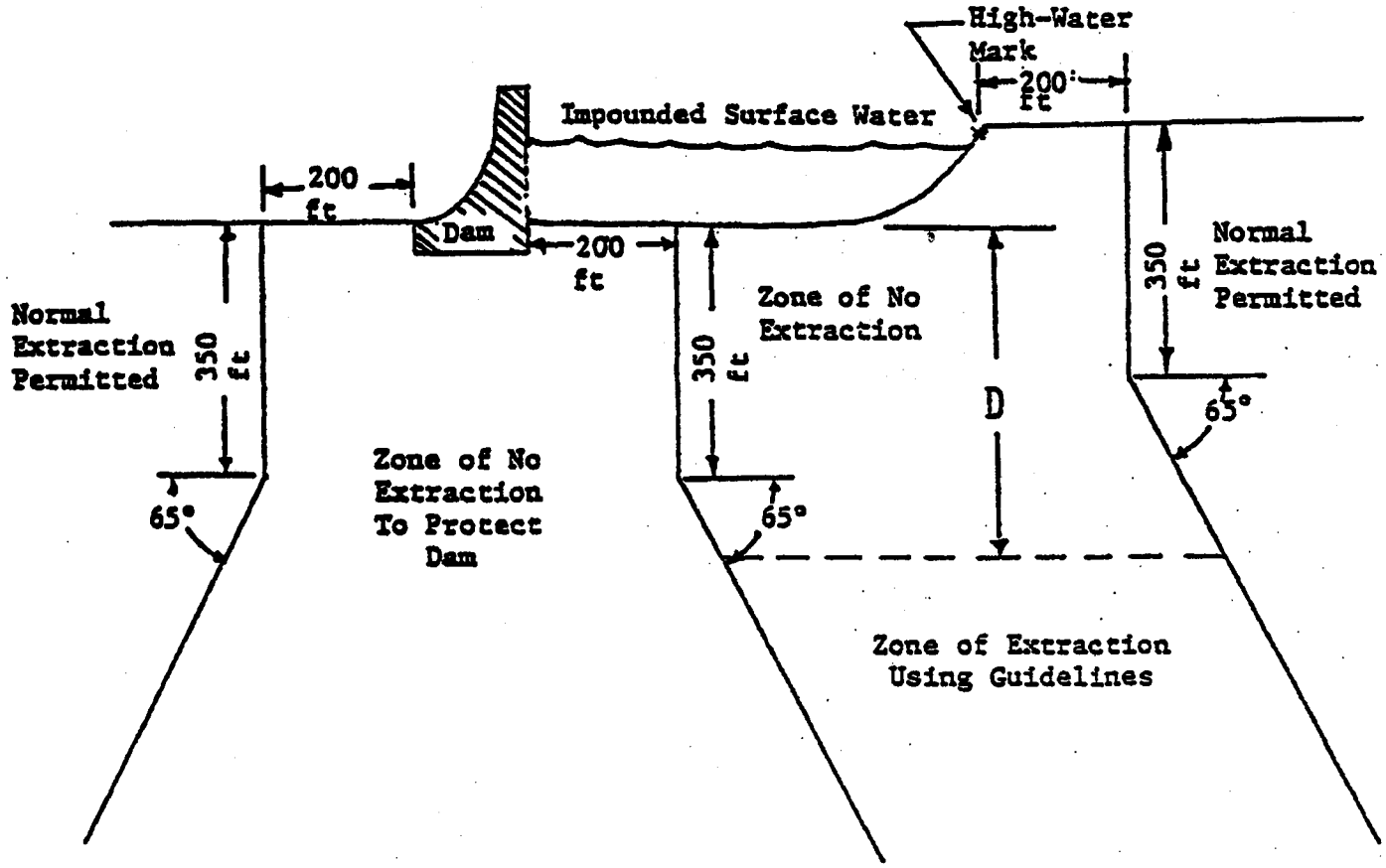
If the impoundment plan was approved without the mining having been taken into account, then mining near the impoundment would not be consistent with the approved plan. MSHA would require the company with the impoundment to show that the impoundment would be safe with the mining, or to indicate what measures would be taken to ensure the dam's safety. In other words, the company with the impoundment would have to have their approved plan modified to account for the mining.

MSHA would encourage the two companies to attempt to come to an acceptable arrangement between themselves, so that the safety of the dam, and the mine, would both be safeguarded.



GENERALIZED SKETCH / TOTAL EXTRACTION

FIGURE NO. 1



D is Determined From the Following Table:

	D*
Room & Pillar	5s or 10t
Panel & Pillar	3p or 270 ft.
Total Extraction	60t

* Whichever Value is Larger

Safety Zone Beneath Surface Structure Impounding Large Body of Surface Water (after Babcock and Hooker, 1977) (IC 8741)

FIGURE NO. 2

USE OF GEOTEXTILES AS A FILTER

George Gardner

Summary of Presentation

The four primary design criteria were emphasized: Soil Retention, Permeability, Clogging Resistance, and Ability to Survive Installation Stresses (i.e. ultraviolet resistance, resistance to tearing, puncturing, etc.) (Fig. 1).

Characterization of a fabric by Apparent Opening Size (AOS) was discussed (Fig. 2). Mechanisms of adequate filtration and clogging were illustrated with drawings from the literature (Figs. 3 and 4). Various semi-empirical criteria for particle retention (Fig. 5) and fabric permeability (Fig. 6) were mentioned.

Empirical clogging criteria were shown (Fig. 7). In addition to meeting such criteria, in critical applications where clogging of the fabric may lead to failure of the dam, MSHA believes that a soil-fabric interaction test is warranted. The advantages and limitations of using the Gradient Ratio Test (Fig. 8) to measure clogging resistance were discussed. While the Gradient Ratio Test has an ASTM standard, and can be run in a shorter time period than a long-term flow test, it is generally considered to be more of an "index test" than a "performance test." Test data from the literature was used to illustrate that with some soil/fabric systems there may be a significant increase in the gradient ratio with increasing silt content (Fig. 9).

The Long-Term Flow Test simply involves testing the soil/fabric system in a permeameter. This type of test seems to be preferable, however, the test may take a considerable period of time to run (depending on the permeability of the soil/fabric system), and may be influenced by laboratory conditions which may not exist in the field. It appears that in justifying critical installations, the Long-Term Flow Test is more appropriate than the Gradient Ratio Test for verifying that the fabric will not clog. The results of several Long-Term Flow Tests from the literature are illustrated in Fig. 10. The second segment of the bi-linear curve is generally used as an indication of whether the system can be expected to clog over a long period of time.

Although ASTM has not yet developed a standard for a Long-Term Flow Test, various procedures are available such as that used by the Geotextile Research Institute. Figure 11 includes a comparison of Gradient Ratio and Long-Term Flow Test results. It can be seen that, under some conditions, the Gradient Ratio Test, when performed for a 24-hour period, may not yet be simulating the long-term behavior. A note from ASTM D 5101 - 90, shown at the bottom of this figure, suggests that this test may, at times,

need to be run for longer times. Other newer tests such as the Fine Fraction Filtration (F^3) Test may also be considered as they begin to gain acceptance by the engineering community.

Often, when considering coarse refuse materials, the potential for clogging will be much more of a concern than the possibility of soil passing through the fabric. Therefore, to improve the factor of safety against clogging, it is recommended that the largest practical apparent opening size (AOS), which is also consistent with the particle retention criteria, should be used.

It was emphasized that MSHA requires the use of piezometers to monitor the phreatic surface in cases where a geotextile fabric is used to wrap the underdrain (and failure of the underdrain would effect the stability of the dam). The purpose of piezometers is to verify that the phreatic surface is being drawn down as anticipated in the design.

Finally, the fabric must be able to tolerate installation stresses. The installation should be able to be completed with minimal tearing or puncturing of the fabric. Any damage which may occur should be repaired. The "Recommended Minimum Properties for Geotextiles Used in Non-Critical/ Non-Severe Drainage, Filtration, and Erosion Control Applications," as recommended by Task Force 25, were presented (Fig. 12). In addition, manufacturers' recommendations should not be exceeded. Since MSHA often sees fabrics proposed in critical applications, these criteria should also be supplemented by field trials to verify the construction procedure, and construction monitoring by the designer, or his representative who is knowledgeable in the area of geosynthetic construction and filter criteria. In addition, construction specifications should be sufficiently rigorous to ensure a good installation. Limiting drop-height for rockfill and providing protective sand or gravel layers should be considered.

In summary, it was emphasized that it is important to recognize that geotextiles are engineering materials and need to be treated as such. The geotextile is part of a soil-fabric system and the components of this system must be compatible. The same fabric may not be suitable in all situations. While this seems obvious, it seems that a few designers have indiscriminately specified the same fabric regardless of the application, and with little or no testing or analysis. MSHA's move toward site-specific testing seems consistent with current prudent engineering, as such tests are often performed even for far less critical applications.

The figures attached were taken from transparencies used in the presentation and are intended to illustrate typical guidelines from the literature. They do not necessarily represent the only acceptable criteria. Other information sources may differ. Ultimately, it is the designer's responsibility to make a conservative fabric selection based on thorough consideration of each of the design requirements.

Questions Regarding Presentation

1. Often material is not available sufficiently ahead of time to conduct long-term flow tests prior to the initial design. How should clogging potential be evaluated in such cases?

We would recommend that based on Index tests like the gradient ratio test, various empirical relationships, and experience with similar materials, a fabric could be selected. When material is available, a long-term test could be initiated. If the test passes, the original design is verified. If the test fails, construction would likely not be too far along for compensating design modifications to be made to the facility. The risk of having to perform modifications should be weighed against the uncertainty in the design, with consideration of how soon the drain needs to be constructed following the refuse material becoming available.

2. If a geotextile is used as a separator, rather than as a filter itself, is it still necessary to test it for clogging resistance?

If a fabric is in a location where if it were to become clogged, it would not affect the stability of the embankment, we would not require it to be tested for clogging resistance. If, on the other hand, clogging of the fabric (regardless of its perceived function) could reduce the factor of safety against slope instability below acceptable levels, it should be tested.

Additional Discussion

The participants were asked for input regarding their experiences with the use of geotextile fabrics in filtration applications. The response was generally favorable. The only negative experience, which was relayed, involved one case where the fabric was contaminated by runoff of fines during construction. Care should be taken to avoid this situation.

A comment was made that the gradient ratio test is not really representative of the field conditions. We agree and recommend the use of a Long-Term Flow Test. The participant expressed that this test, also, may not be representative of field conditions. We expressed that we are certainly aware of its limitations, however, similar limitations exist with all of the small-scale laboratory tests which are traditionally performed (i.e. triaxial compression, permeability, consolidation, etc.) This should always be accounted for in interpretation of the results and by including reasonable factors of safety, consistent with the uncertainty. In closing, we indicated that, in other areas of the Civil Engineering community, it appears that such testing is performed for far less critical installations.

Procedure Instructions

To perform acceptably as a filter in a drainage application, a geotextile must function as follows:

1. retain the protected soil to prevent piping;

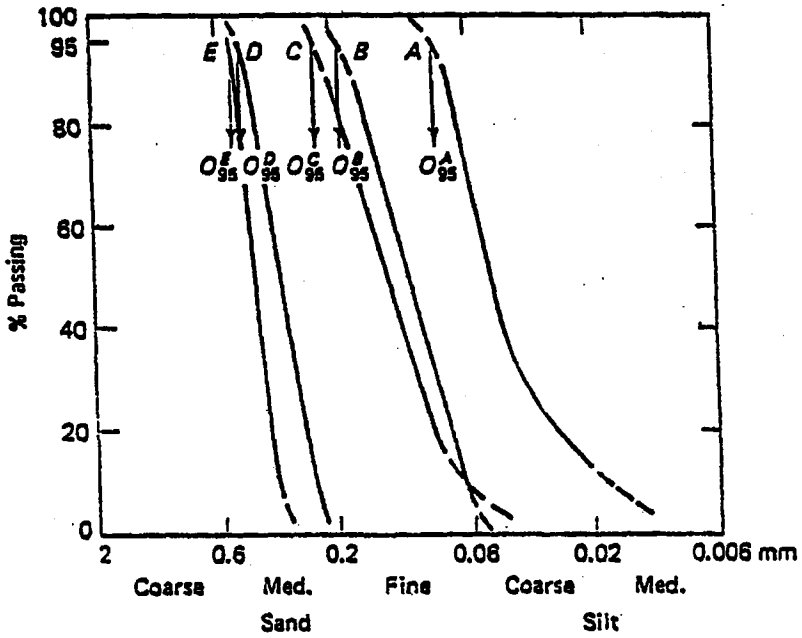
2. have sufficient permeability to prevent the build-up of water pressure;

3. not become clogged; and

4. have sufficient strength to survive the construction procedures.

Figure 1

Standard Test Method for Determining Apparent Opening Size of a Geotextile[1]



Legend

A. 7.4 oz./yd.^{2} (250 gm/m^2) resin-bonded
B. 8.8 oz./yd.^{2} (300 gm/m^2) needle-punched
C. 4.1 oz./yd.^{2} (140 gm/m^2) melt-bonded
D. 11.2 oz./yd.^{2} (380 gm/m^2) hessian woven
E. 5.5 oz./yd.^{2} (185 gm/m^2) woven terylene

Figure 2

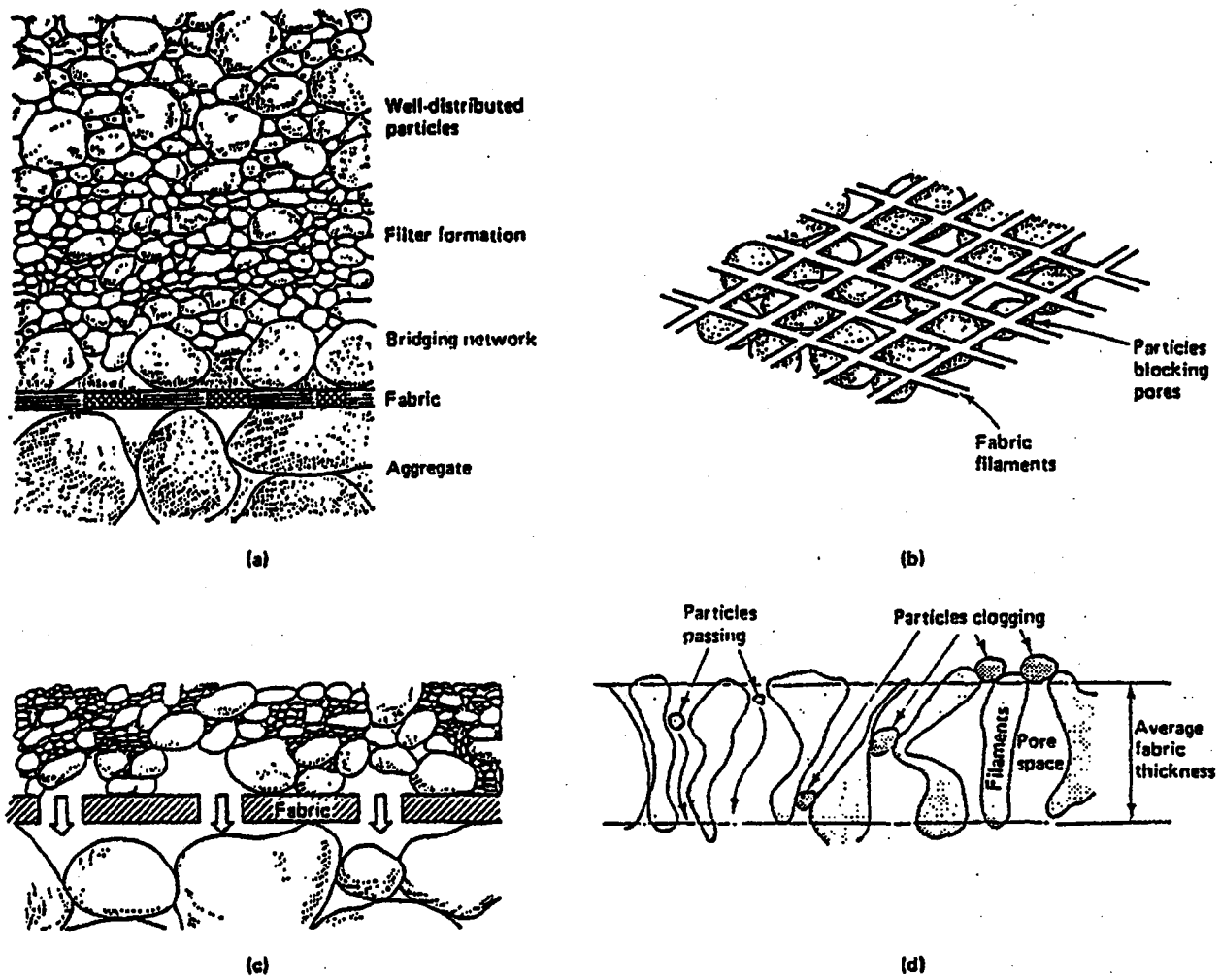


Figure 2.23 Various hypothetical mechanisms involved in long-term soil-to-fabric flow compatibility (after McGown [43]). (a) Formation of an upstream soil filter. (b) Upstream particles blocking geotextile openings. (c) Upstream particles arching over geotextile openings. (d) Soil particles clogged within geotextile structure.

Figure 3

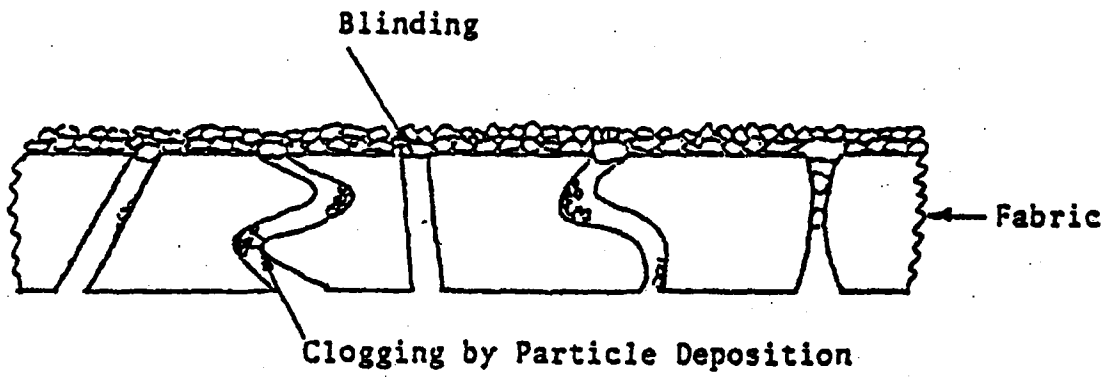


Figure 3-1. Methods of Clogging and Blinding
(Bell and Hicks, 1980)

Figure 4

SUMMARY OF GEOTEXTILE DESIGN AND SELECTION CRITERIA FOR DRAINAGE, FILTRATION, AND EROSION CONTROL APPLICATIONS

I. SOIL RETENTION (PIPING RESISTANCE CRITERIA)[1]

Soils	Steady State Flow	Dynamic, Pulsating, and Cyclic Flow
$\leq$50% Passing[2] U.S. No. 200 sieve	AOS --- $O_{95} \leq B\ D_{85}$	$O_{95} \leq D_{15}$ (If soil can move beneath fabric)
	$C_u \leq 2$ or ≥ 8 $\quad B = 1$	OR
	$2 \leq C_u \leq 4$ $\quad B = 0.5\ C_u$	$O_{50} \leq 0.5\ D_{85}$
	$4 < C_u < 8$ $\quad B = \frac{8}{C_u}$	
$\geq$50% Passing U.S. No. 200 sieve	Woven: $O_{95} \leq D_{85}$	$O_{50} \leq 0.5\ D_{85}$
	Nonwoven: $O_{95} \leq 1.8\ D_{85}$	
	AOS No. (fabric) $\geq$ No. 50 sieve	

1. When the protected soil contains particles from 1 inch size to those passing the U.S. No. 200 sieve, use only the gradation of soil passing the U.S. No. 4 sieve in selecting the fabric.

2. Select fabric on the basis of largest opening value required (smallest AOS)

Figure 5

II. PERMEABILITY CRITERIA[1]

A. Critical/Severe Applications

$k\ (\text{fabric}) \geq 10\ k\ (\text{soil})$

B. Less Critical/Less Severe and (with Clean Medium to Coarse Sands and Gravels)

$k\ (\text{fabric}) \geq k\ (\text{soil})$

1. Permeability should be based on the actual fabric open area available for flow. For example, if 50% of fabric area is to be covered by flat concrete blocks, the effective flow area is reduced by 50%.

Figure 6

III. CLOGGING CRITERIA

A. Critical/Severe Applications[1]

Select fabrics meeting I, II. IIIB, and perform soil/fabric filtration tests before specification, prequalifying the fabric, or after selection before bid closing. Alternative: use approved list specification for filtration applications. Suggested performance test method: Gradient Ratio ≤ 3

B. Less Critical/Non-Severe Applications

1. Whenever possible, fabric with maximum opening size possible (lowest AOS No.) from retention criteria should be specified.

2. Effective Open Area Qualifiers[2]: Woven fabrics: Percent Open Area: $\geq 4\%$.
   Nonwoven fabrics: Porosity[3] $\geq 30\%$

3. Additional Qualifier (Optional): $O_{95} \geq 3D_{15}$

4. Additional Qualifier (Optional): $O_{15} \geq 3D_{15}$

Note: 1. Filtration tests are performance tests and cannot be performed by the manufacturer as they depend on specific soil and design conditions. Tests to be performed by specifying agency or his representative. Note: experience required to obtain reproducible results in gradient ratio test.

Figure 7

Standard Test Method for Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio[1]

D 5101

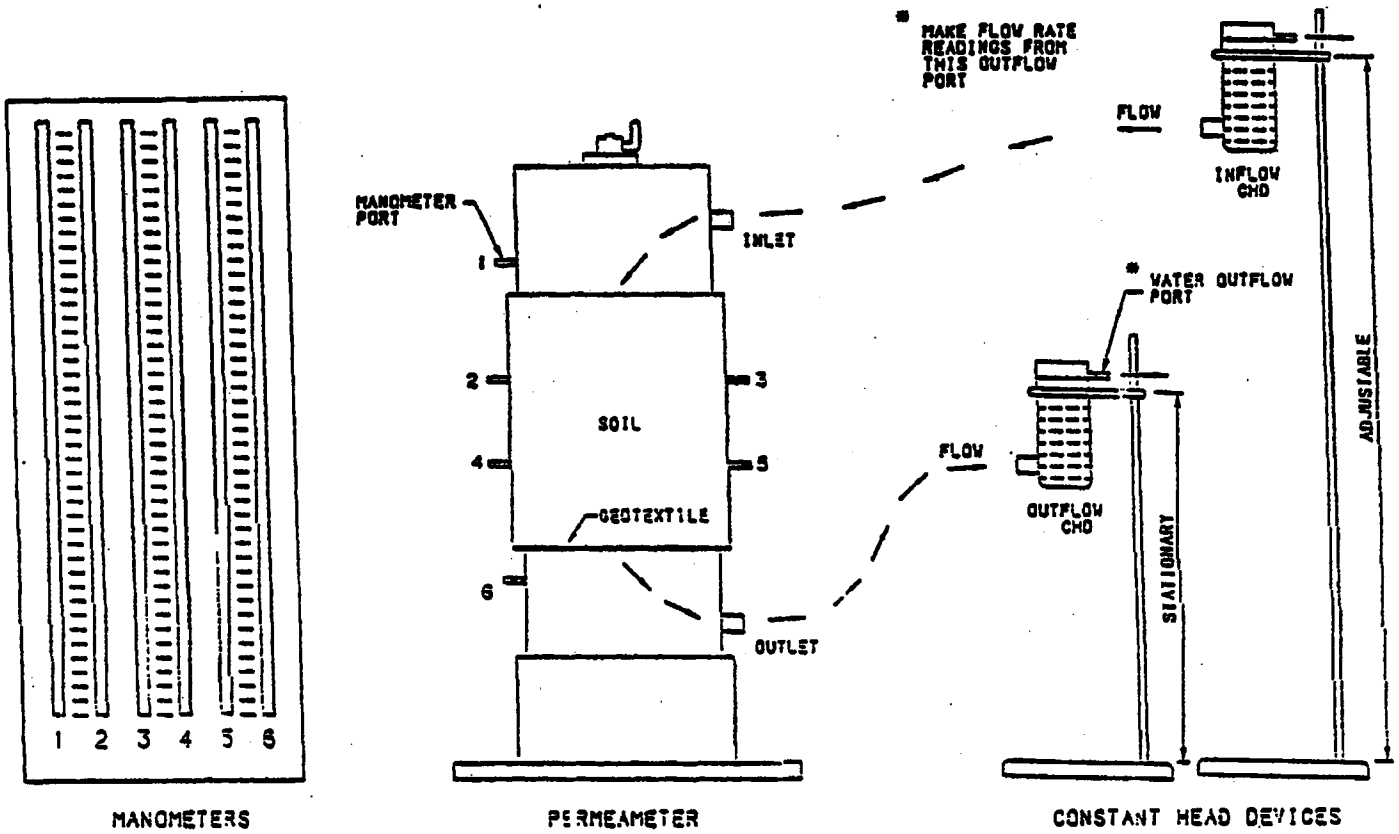


FIG. 3 Geotextile Permeameter "Set Up" Diagram

$$\text{Gradient ratio} = \frac{\Delta h_{f+1.0}/S_{f+1.0}}{\Delta h_{2.0}/S_{2.0}}$$

$\Delta h_{f+1.0}$ = the head change in inches from the bottom of the fabric to 1.0 in. (25 mm) of soil above the fabric,

$S_{f+1.0}$ = the fabric thickness plus 1.0 in. (25 mm) of soil,

$\Delta h_{2.0}$ = the head change in inches between 2 in. (50 mm) of soil above the fabric,

$S_{2.0}$ = 2.0 in. (50 mm) of soil.

Figure 8

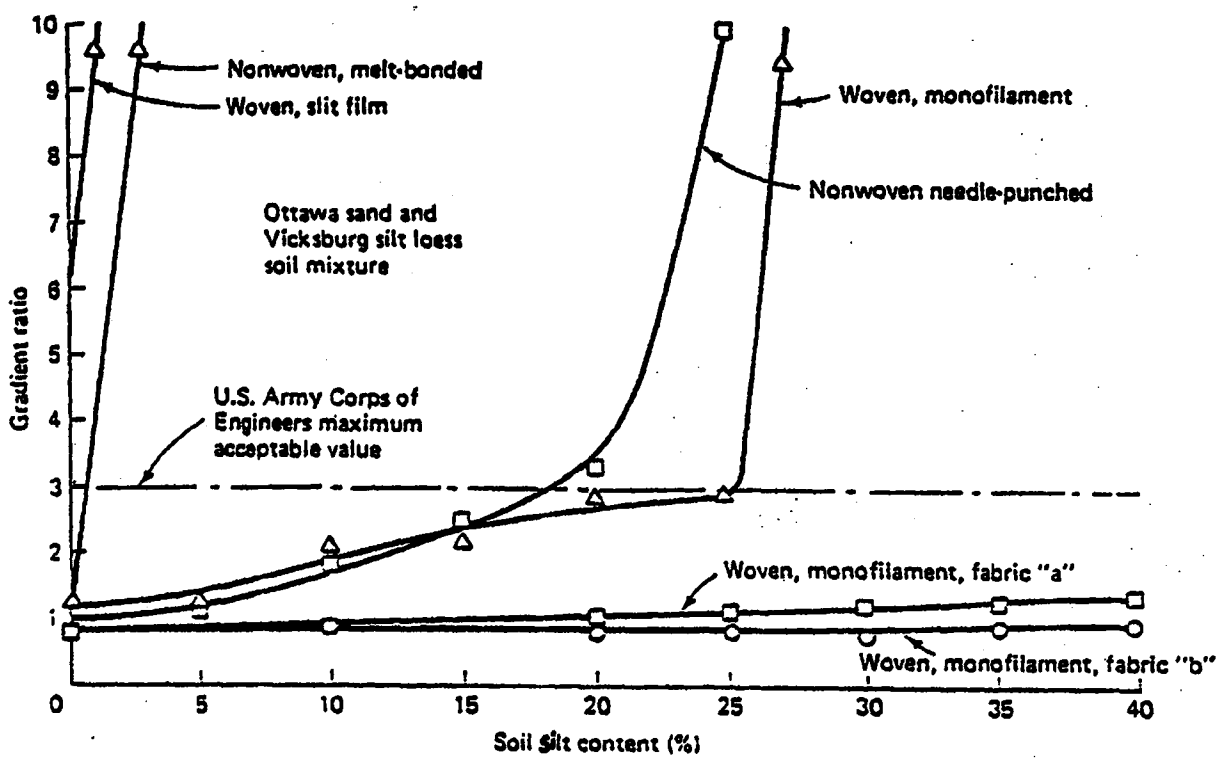
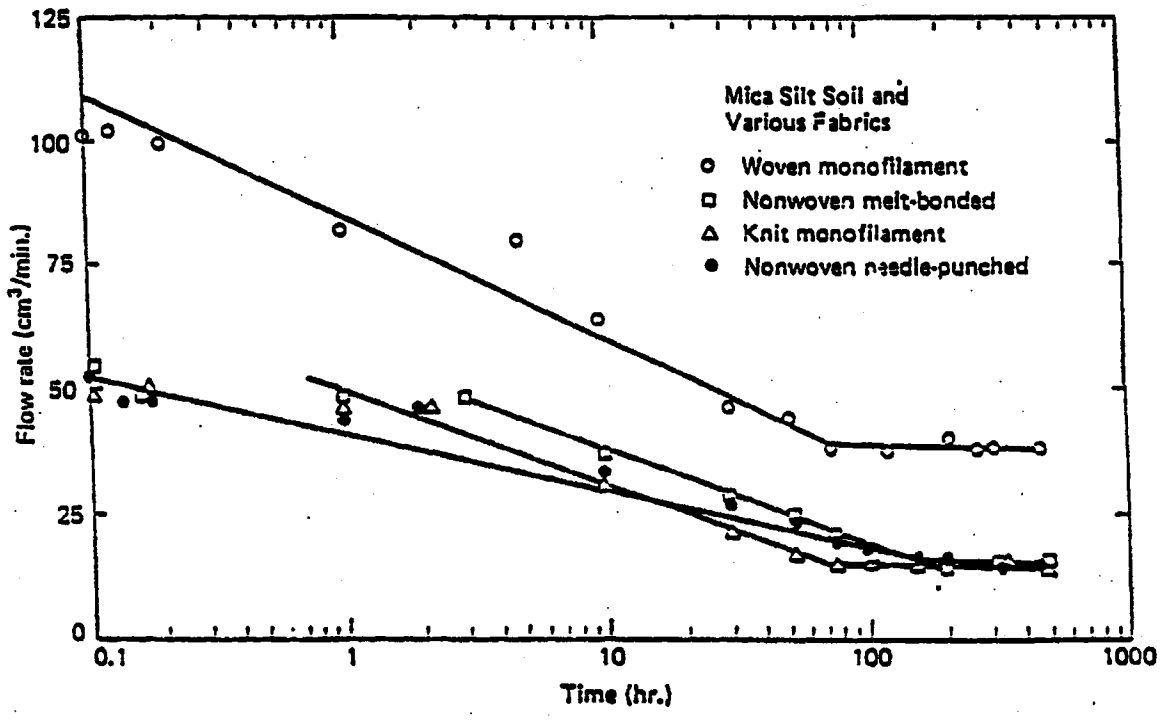


Figure 2.17 Gradient ratio test data used to illustrate fabric clogging potential (after Haliburton and Wood [27]).

Figure 9

Long-Term Flow (Clogging) Test



(b)

Figure 2.16 Long-term flow tests on soil-fabric systems and typical response curves (after Koerner and Ko [25]).

Figure 10

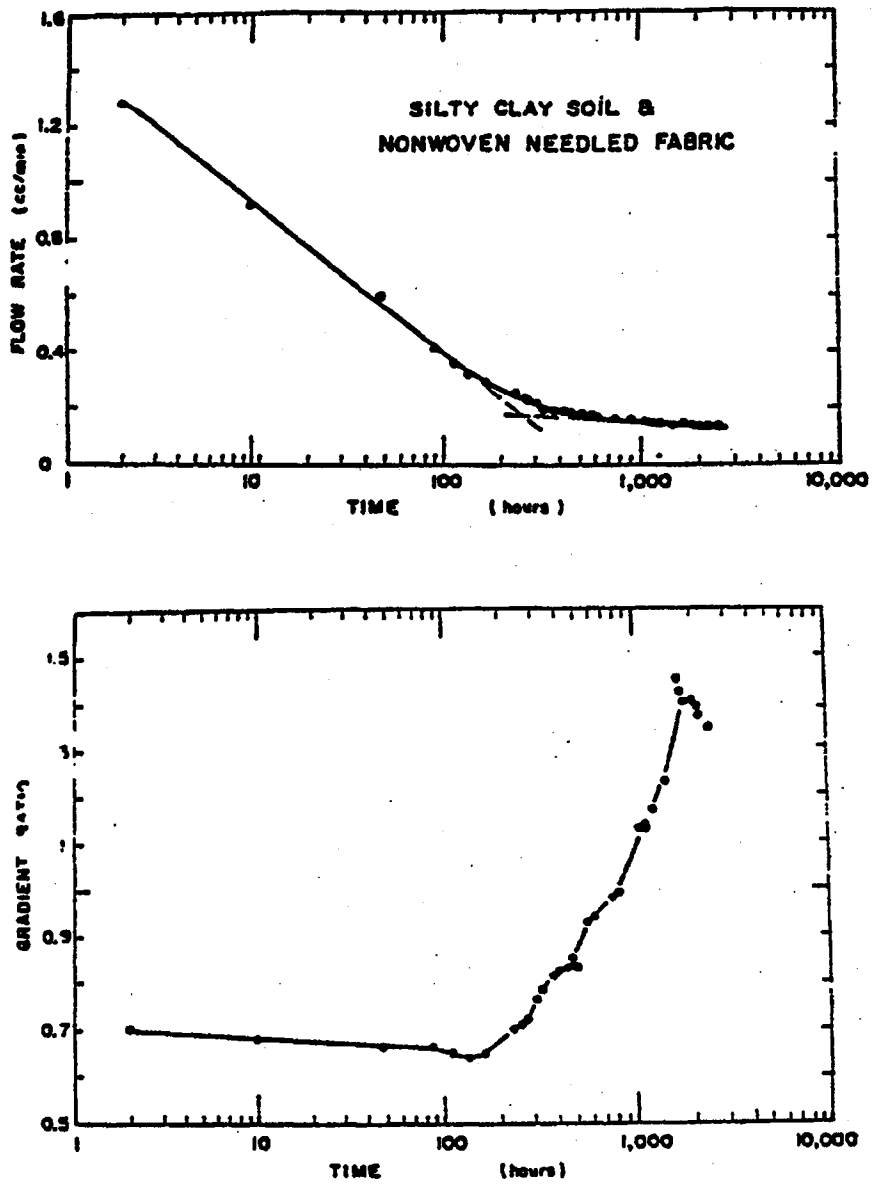


Fig. 6. - Long-Term Flow Curve of Silty Clay Soil and Nonwoven Needled Fabric (Upper) and Corresponding Values of Gradient Ratio (Lower).

NOTE 4—This test can be run at hydraulic gradients other than those specified in this procedure, for example, $i = 3$ for 24 h. In all cases, the system hydraulic gradient should be increased gradually and in increments no greater than $i = 2.5$ and maintain those incremented levels for a minimum of 30 min. The test may also be run at longer intervals than 24 h, until some recognizable equilibrium or stabilization of the system has occurred.

Figure 11

Task Force No. 25
COMBINED TABLES 3-4 AND 3-5

REVISED 5-30-85

RECOMMENDED MINIMUM PROPERTIES FOR GEOTEXTILES USED IN NONCRITICAL/[1] NONSEVERE[2] DRAINAGE, FILTRATION, AND EROSION CONTROL APPLICATIONS

I. MINIMUM SURVIVABILITY PROPERTIES

A. Fibers used in the manufacture of geotextiles shall consist of long chain synthetic polymers, composed of at least 85% by weight of polyolaphins, polyesters, or polyamides.

B. Geotextiles with low resistance to ultraviolet degradation (more than 30% strength loss at 500 hours exposure ASTM D-4355) should not be exposed to sunlight for more than 7 days.

Geotextiles with higher resistance to ultraviolet degradation should not be exposed for more than 30 days.

NOTE: Geotextiles can be manufactured or finished to resist degradation due to prolonged exposure to ultra-violet radiation, i.e., fabrics resistant to exposure for multi-year periods (from 5 to 25 years) are not uncommon.

C. Physical Property Requirements:

	Drainage[3]		Erosion Control[3]	
Test Method *	Class A[4]	Class B[5]	Class A[6]	Class B[7]
Grab Strength (TF #25 method 1) (Min. in either principle direction)	180 lbs.	80 lbs.	200 lbs.	90 lbs.
Elongation (TF #25 method 1) (Min. in either principle direction)	Not Specified	Not Specified	15%	15%
Puncture Strength (TF #25 method 4)	80 lbs.	25 lbs.	80 lbs.	40 lbs.
Burst Strength (TF #25 method 3)	290 psi	130 psi	320 psi	145 psi
Trapezoid Tear (TF #25 method 2) (Min. in either principle direction)	50 lbs.	25 lbs.	50 lbs.	30 lbs.

*Test method is in accordance with procedures in Appendix B of FHWA Geotextile Engineering Manual.

FIGURE 12 (1 of 2)

[1]Critical applications involve the risk of loss of life, potential for significant structural damage, or where repair costs would greatly exceed installation costs.

[2]Severe applications include draining gap graded or pipable soil, high hydraulic gradients, or reversing or cyclic flow conditions.

[3]All numerical values represent minimum average roll values, i.e., values measured for a sample (average of all specimen results) should meet or exceed specified values within a 2 sigma confidence level. These values are considerably lower than those commonly presented in manufacturer's literature.

[4]Class A Filtration and Drainage applications for fabrics are where installation stresses are more severe than Class B applications, i.e., very sharp angular aggregate is used, a heavy degree of compaction is specified, or depth of trench is greater than 10 feet.

[5]Class B Filtration and Drainage applications are those where fabric is used with smooth graded surfaces having no sharp angular projections, no sharp angular aggregate is used; compaction requirements are light, and trenches are less than 10 feet in depth.

[6]Class A Erosion Control applications are those where fabrics are used under conditions where installation stresses are more severe than Class B, i.e., stone placement height should be less than 3 feet and stone weights should not exceed 250 pounds. Field trials are required where stone placement height exceeds 3 feet or where stone weight exceeds 250 pounds.

[7]Class B Erosion Control applications are those where fabric is used in structures or under conditions where the fabric is <u>protected</u> by a sand cushion or by "zero drop height" placement of stone.

II. MINIMUM HYDRAULIC PROPERTIES

A. <u>Piping Resistance</u> (soil retention)[1]

1. Soil with 50% or less particles by weight passing U.S. No. 200 Sieve[2]:
   AOS[3] less than 0.6mm (greater than #30 U.S. Std. Sieve)
2. Soil with more than 50% particles by weight passing U.S. No. 200 Sieve[2]:
   AOS[3] less than 0.3mm (greater than #50 U.S. Std. Sieve)

B. <u>Permeability</u>

k of fabric[4] greater than k of soil

---

[1]Design values as determined by an engineering analysis which assures compatibility between soil hydraulic conditions and geotextile are recommended (especially for critical/severe applications). Problem soils where the above guidelines may not apply are silts and uniform sands with 85 percent passing the #100 sieve.

[2]When protected soil contains particle sizes greater than #4 U.S. Std. Sieve size use only the gradation of soil passing the #4 U.S. Std. Sieve in selecting the fabric.

[3]AOS determined for geotextiles according to TF #25 Method 6.

[4]Permeability determined for geotextiles according to TF #25 Method 5.

FIGURE 12 (2 of 2)

CONTROLLING SEEPAGE ALONG THE CONDUITS

Abdul Hamid

Summary of Presentation

Conduits are routinely installed through embankments by mining companies to control the design storm. This creates an opportunity for seepage along the conduit. Uncontrolled seepage along the conduit could cause piping of backfill material and possible subsequent failure of the embankment. Therefore, it is very important that seepage along the pipe be discharged in a controlled manner to preclude piping and hazard to the embankment.

Historically, anti-seep collars have been used around the conduits to control seepage. However, anti-seep collars are labor intensive and require skillful labor and hand compaction along the collars. In spite of best efforts and quality control, these seepage control devices have been known to function improperly. For the last 15 to 20 years, the use of anti-seep collars has been abandoned by many professionals in favor of filters and drains around the conduits at the downstream portion of the embankment. Drains and filters are able to control seepage along the conduits better than anti-seep collars.

It must be emphasized that drains and filters for conduit seepage control should meet the same criteria as the other drains and filters in the embankment.

Questions Regarding Presentation

1. What is a filter-drainage diaphragm?

Filters and drainage diaphragms are used around the pipes which extend through the dams to control and safely discharge seepage water around the pipes. They are used in lieu of anti-seepage collars. The drainage material is designed to filter criteria, so that piping, and internal erosion of backfill material does not take place. The drainage material must be sufficiently permeable to allow seepage along the pipe to collect and discharge safely in a controlled manner. The outlet drain may follow along the pipe, or it may be tied to the dam's underdrain system. For more information, consult the references cited in the Procedure Instruction Letter. Specific requirements for size and location can be found in the references numbered 10 and 13.

2. In designing a filter and drain system to be used instead of anti-seepage collars, what filter criteria is preferred?

When filters are used instead of anti-seepage collars around pipes to collect and safely discharge the seepage water, piping and internal erosion are of primary concern. As explained in the Procedure Instruction Letter on "Graded Filters," there are two

design methods commonly used to ensure that filter criteria is met and piping and erosion of surrounding material will not take place. Either the method developed by Terzaghi, or the method developed by the Soil Conservation Service can be used.

3. What suggestions do you have for handling leakage at a pipe joint?

The author no longer allows the use of mechanical joints, since leakage in the joints cannot be prevented. If there are existing pipes with leaking joints, they present serious problems, particularly if the pipe is used in flood routing. If the pipe flows under pressure, the joints could separate completely and jeopardize the safety of the structure. The solution would be to grout and abandon the pipe and install a new one with welded joints.

4. Does a filter-drainage diaphragm need an outlet drain?

Yes, since the purpose the filter-drainage diaphragm is to collect seepage that may occur around a pipe, and discharge it in a controlled manner.

5. Are filter-drainage diaphragms used in earthen dams, or just coarse refuse dams?

They can be used in both earth dams and coarse refuse dams.

6. What is a good reference for filter-drainage diaphragms?

Several references are listed in the Procedure Instruction Letter.

7. What material is most useful for seepage collars?

It is preferable that seepage collars be of the same material as the pipe. Otherwise, differences in thermal coefficients could have adverse effects.

8. Which method is cheaper?

We do not have information on the relative costs. It would appear that filter-diaphragm would be less costly because anti-seepage collars are very labor intensive and may not function properly. They may require remedial action.

9. Comment: "Just because the Government says that graded filters are the way to go does not mean it is state-of-the-art."

As indicated in the procedure instruction letter, when properly designed, MSHA will accept either the filter and drain approach or the anti-seepage collar approach.

DESIGN OF PIPES FOR EXTERNAL LOADING

Donald Kirkwood

Brief Summary of Presentation

The discussion began with an overview of the recommendations contained in the Procedure Instruction Letter. The various potential structural failure modes were discussed, as well as under what conditions each failure mode might be expected to govern. The manufacturer's recommendations for fill height were then discussed, including the advice that these maximum fill height recommendations should be used as only a rough guide. If the installation is critical, detailed analysis and calculations should be done. The discussion then turned to the lack of consensus among the experts with respect to the best method for structural design of flexible pipes. It was recommended that several methods be applied and the results compared. The more critical the installation is, the more sophisticated the analysis should be. The finite element models were then discussed, and in particular, the CANDE-89 program. Finally, monitoring as a vital component of design, approval, and model verification was discussed.

Questions Regarding Presentation

1. What has been MSHA's experience with failures of the different types of pipes?

We have seen numerous failures in corrugated pipe installations. Most of these are believed to have been caused by either improper installation or by inadequate pipe couplings. There have also been cases of welded steel pipe failures, but these have been related to improper welds. We have yet to see a failure of a plastic pipe due to excessive loading.

2. Why isn't hydrostatic pressure used to test plastic pipe for their design deflections?

Pipe deflections are a function of the pipe properties, the soil backfill properties, and the pipe-soil interaction. Actual tests on pipes that have not included the backfill, and consequently the pipe-soil interaction, have not been able to predict field deflections.

3. What is the maximum amount of deflection that MSHA will accept?

Normally the manufacturer's recommendation for maximum deflection based on pipe SDR are considered the maximum allowable deflection. However, the actual factors of safety built into the manufacturer's allowable deflection limit is not certain. The PIL specifies a minimum factor of safety of 2.0 for wall crushing

and buckling while none is specified for deflection. In some cases, a factor of safety exceeding 2.0 results in deflections that are in excess of the manufacturer's recommendations. It should be noted that the allowable deflection is a performance limit based on the pipe properties only, therefore, there should be considerably less doubt concerning the allowable deflection performance limit than there obviously is about the actual deflection under the maximum fill height.

4. The restrictions on maximum fill heights over flexible pipes have led to designs with the periodic abandonment of the pipe and the installation of a new pipe at a higher elevation. Isn't this building additional avenues for failure?

The risk for failure from seepage through or around an abandoned flexible pipe is very small compared to the risk of going beyond available technology relative to the performance of these pipes under high fills. The technology for sealing these pipes is well established, and their abandonment can be done with minimum potential for future deflection given adequate care in their abandonment.

5. Do we have data on the effect of high temperatures on the high density, polyethylene pipes?

Yes, high temperatures can accelerate the softening process of the hdpe pipe material. We believe that has not been a problem at our facilities for several reasons. Coal waste is highly compacted, eliminating the availability of oxygen which can cause spontaneous combustion. In addition, a considerable portion of the pipe is below the phreatic surface. This coupled with air and water moving through the interior of the pipes creates a temperature regulating effect.

Normally hdpe pipe experiences some softening even without elevated temperatures, due to the effects of time. Therefore, it's the soil envelope which provides most of the strength to the pipe-soil system.

6. Is the trench width critical?

Yes, it can be. Trenching can significantly impact the loading distribution around the flexible pipe, because the trench walls act as rigid abutments. If the trench gets too wide, the load is not distributed to the rigid abutments. The load is carried as an "embankment" load, or a load on a pipe not installed in a trench.

7. The Modified Iowa formula uses a modulus of soil reaction. How large of a modulus of soil reaction will MSHA allow?

The modulus of soil reaction is a function of the pipe-soil interaction. It is not strictly a soil parameter and cannot, therefore, be taken directly from a soils test. The only known published values of this modulus are from the work of A. K.

Howard in 1977, where he constructed an apparatus to test the pipe-soil system together. This work was done only for fill heights up to about 50 feet. Other work since 1977, particularly work back-figuring soil reaction moduli from large diameter installations, under relatively high fills, suggests that this modulus should increase significantly with increasing fill height. This work is, however, inconclusive. Therefore, the soil reaction moduli, to be used in the Modified Iowa formula, should be taken from the acknowledged, conservative Howard values.

8. Why isn't plastic pipe less sensitive to installation errors?

Plastic pipe carries load by deflecting and mobilizing the supporting strength of the pipe backfill material. This ideally happens in a uniform, symmetric fashion. Actual installations likely rarely deflect either uniformly or symmetrically. However, if the deflection becomes too asymmetric, the pipe may be subject to failure from localized buckling. The ability of the pipe to shed a large portion of the load to the surrounding backfill is paramount to the adequate performance of the flexible pipe under high fills. Therefore, if excessive deflection is induced in the pipe during installation, or if there are hard or soft areas in the backfill around the pipe, failure may result long before the design, based on uniform symmetric deflection, would predict it. Steel pipe, on the other hand, has considerably larger modulus of elasticity than does plastic pipe. The steel pipe, therefore, relies considerably less on the backfill for support, although the backfill support is still significant. Therefore, the steel pipe installation can actually be somewhat more forgiving relative to installation errors.

9. How much fill height has been approved over flexible pipes, and has there been a requirement for monitoring of these installations?

MSHA has yet to catalog specifics such as fill height over decant pipes for all of the approved plans. However, the maximum fill height approved over a flexible pipe is believed to be between 150 and 200 feet. When the fill height reaches the stage where some of the analyses, such as the Modified Iowa formula, suggest that the factor of safety is less than 2.0, yet other analyses, such as a finite element analysis, suggest that the factor of safety is greater than 2.0, the installation can be approved. MSHA usually requires monitoring to verify its performance. This has been the case with all known approved fill heights of between 150 and 200 feet.

10. Does MSHA have a position on maximum acceptable fill height?

No, other than the position that until performance data is established for high cover situations, conservative design methods need to be used and factors of safety of at least 2.0 should be maintained.

11. Will pipe deflection monitoring data become available to everyone from the MSHA approved installations?

Although the deflection monitoring data will be available to and used by MSHA for its reviews, the details of these installations will only be made available to others if the company permits its release or if the information can be obtained through the "Freedom of Information" act. However, MSHA will likely be able to share the data in a general sense, relative to performance trends if the installations are not identified.

12. Are only plastic pipes being monitored?

To date, very little actual monitoring has taken place. The only proposed deflection monitoring in MSHA approved installations is for plastic pipes. That is not to say that monitoring might not be requested or proposed for a steel pipe installation. Like plastic pipes, steel pipes usually rely on backfill support for a large part of their strength. If these installations approach the limit of known, conservative design deflection estimates, monitoring will likely be requested.

13. Has MSHA approved plans with lower factors of safety with provisions for monitoring of the pipe?

There is not one method of analysis that is, at this time, used at the exclusion of all others. Each of the various methods of flexible pipe deflection analysis gives unique results. Some methods give drastically different results than others. Therefore, what the factor of safety is depends on which method was used for predicting that deflection. All factors of the installation must be considered in the review, including: the results of various deflection prediction methods, the consequences of failure of the installation, whether the pipe is relied on for drawing down the design flood, the length of time the pipe will be relied on for flood routing, the degree of conservativeness in the design, the care in installation, and whether the installation will be supervised by a qualified engineer. Given all of these factors, there are installations for which some of the deflection prediction methods might not result in an adequate factor of safety, yet the installation is approved. In order for these installations to be approved, an acceptable deflection prediction method will have to show an adequate factor of safety, and monitoring will likely be required.

14. Can a flexible pipe be installed, and continually monitored until it exceeds the allowable deflection, and then abandoned?

The monitoring data, along with any research which may be being done, will determine how much fill these pipes can be approved under. For the time being, we can approach the design limits and monitor the pipe deflection. If the monitoring program shows the deflection to be considerably less than the predicted deflection, then it is possible for the pipe to be approved beyond this fill height based on the performance data collected from the monitoring program. This is most likely in non-critical installations and for deflections below the performance limits. It seems highly unlikely, at this time, that MSHA would approve any pipe installations in critical areas and allow the deflection to reach failure.

15. Have there been any pipe installations, proposed to MSHA, where the pipe is to be monitored with strain gages?

I haven't heard of any cases where monitoring pipes with strain gages has been proposed.

16. What are you solving for in the CANDE-89 program?

The CANDE-89 program solves for stresses in the pipe wall and deflections of the pipe. The results are stated in the form of factors of safety for pipe displacement, pipe wall outer fiber stresses, and elastic buckling.

17. Is the use of the CANDE-89 buried pipe, structural design, finite element program acceptable?

Yes, there is no one deflection prediction method, at this time, accepted to the exclusion of all other methods. The CANDE-89 program has strong points and weak points, as do all finite element programs. We do believe that when care is taken in the input parameters, CANDE-89 can give an additional, useful estimate of the maximum pipe deflection and pipe wall stresses under high fill conditions. MSHA uses the CANDE-89 program as another indicator of the pipe performance.

18. Does the CANDE-89 program take arching in the soil above the pipe into account?

Yes, the CANDE-89 finite element program incorporates load reduction due to pipe deflection which is soil arching. The load once carried by the pipe is being transferred to the surrounding soil, i.e. arching.

19. How does one determine the elastic/plastic soil properties for input into the CANDE-89 program?

There are soil types built into the CANDE-89 program. If your soil behaves like any of these soil types, the built in properties can be chosen. If however, your soil is significantly different than the built-in soils, the elastic/plastic soil properties must be put into the program. These properties are hyperbolic properties and may be obtained from a triaxial test if the test is modified to carefully measure nonstandard details. The supporting CANDE-89 documentation should be referred to for an understanding of what is required.

20. Is the CANDE-89 program more or less conservative than the Modified Iowa formula?

The output of the CANDE-89 program is highly dependent on the input. Therefore, the CANDE-89 output can either be more or less conservative than the Modified Iowa formula depending on what parameters are input. In general, however, our experience has been that if great care is taken in modeling both analyses the same, the CANDE-89 program usually results in somewhat less conservative values.

21. Do all pipe installations require sophisticated analyses?

No, when pipe designs are taken very close to their stated performance limit, more verification of their potential performance is requested and consequently, more the sophisticated analyses are often necessary. Installations which are shown to have conservative factors of safety and which have conservative design parameters such as backfill type and installation procedures, do not require sophisticated analyses. Many times, showing that the manufacturers fill height limits have not been approached and that the Modified Iowa formula gives a factor of safety greater than 2.0 is all that is required.

22. Do all approvals require deflection monitoring to verify deflection?

No, as with the required level of sophistication of the analyses, the installations which are obviously conservative in design and installation normally will not be required to be monitored.

23. What research is being done to check the accuracy of the various models?

We know of very little research being done of the performance of flexible pipes under high fills. As far as we know, none of the plastic pipe manufacturers are undertaking their own research in this area. This is understandable since such a small proportion of their overall sales are for high fill applications. The research that is being done, that we know of, is being done at various universities. Most of this research is not for small diameter, low SDR, plastic pipes under high fills. It appears reasonable to assume, at this time, that what performance data will be forthcoming, will come from coal waste related installations.

24. By taking the conservative route in every phase of the design, aren't we creating ultra conservative designs?

Perhaps, but we won't know how conservative the installations are until the performance data is available. For the time being, we are choosing what we believe to be conservative parameters and methods. We don't have the data to prove that all of these methods and parameters are conservative, and under what conditions they might be non-conservative. We hope to become more liberal as the performance data, or research data, shows us how conservative we've been. Even now, we are being somewhat less conservative than in the past by considering multiple prediction models, and relying more heavily than ever before on monitoring. Hopefully, this trend will continue towards more exact and less conservative designs. For now, we must not forget that we are leading the way in using plastic pipes under high fills and we are often doing it in high hazard dams.

PROBABLE MAXIMUM FLOOD

Daniel S. Mazzei

Summary of Presentation

The presentation of the methodology used in developing the design inflow parameters for the determination of the Probable Maximum Flood began with a discussion of the criteria involved. The factors that must be considered include: the principal storm, the antecedent storm, the loss rates or initial moisture conditions, the rainfall distribution, the initial reservoir conditions, and windwaves. It was shown that many of the Agencies involved in Dam design vary specific parameters according to Agency policy and that it is important to be consistent.

The procedures and references used in selecting each of the hydrologic design parameters was discussed in depth. Particular attention was devoted to a discussion of the impact of the use of AMC III. The use of the computer program "HMR-52" in obtaining the temporal rainfall distribution for the principal storm was also reviewed.

Questions Regarding Presentation

1. At which pool level should the storm routing begin?

When a facility has an open channel spillway and a pipe spillway, the routing should begin at the invert of the open channel, unless a substantial justification is developed. That justification must address in detail what measures are in place to assure that the primary spillway will not malfunction.

2. Why don't we develop a "cookbook" type guide for the hydrology and hydraulic portion of the impoundment plan?

A guide of this type is not practical in that every site is unique and the response to an input can vary considerably as a result of small differences in design parameters. Additionally, such a guide would infringe on the engineering that must be exercised by a company or their consultant due to design constraints that MSHA cannot consider, such as costs. MSHA can specify a desired end but does not have the right to dictate the means.

3. Would it be practical to use the default rainfall distributions in the HEC-1 computer program?

All hydrologic developments that are submitted to MSHA fo approval will be tested against the methodology which is specified in HMR-51, and HMR-52, for sites covered by those publications. Other HMR publications have been developed for different regions of the country and those references should be used. The criteria for the test will be the "hydrologically most critical" distribution. The HEC distributions may or may not fulfill this requirement, based on the watershed/reservoir response.

4. Can one use the minimum soil infiltration rates in the development of the Probable Maximum Flood?

The use of a linear relationship in an extreme event raises concern. It seems to be more consistent to use the curve number approach. Evaluation of the HEC output indicates that a more reasonable build-up in losses results. The hydrologically most critical test would again apply.

5. The use of extreme event, the PMF, seems to be unreasonable in this age of hazard and risk analysis.

The Buffalo Creek disaster focused us as an industry on how serious a failure can be. In that light we have the responsibility to provide for the safety of those living in the shadows of our dams. Hence, the PMF is our design storm. Yes, the use of incremental hazard and risk analysis might be considered for structures for which a high degree of confidence exists. However, in dealing with mine waste impoundments there are too many uncertainties in too many critical areas, and conservatism is needed. In addition, current Federal guidelines recommend the PMF as the inflow design flood for high hazard sites.

COMPACTION SPECIFICATIONS

Stanley Michalek

Brief Summary of Presentation

Proper compaction of embankment material is one of the most important elements in the construction of a safe dam. Compaction is performed to increase the density and shear strength and to decrease the compressibility and permeability of the construction material. Specifications for compaction place limits on the minimum dry density, the range of placement water content, and the maximum lift thickness.

This Procedure Instruction Letter recommends that the material be compacted to at least 95 percent of the maximum dry density as defined by the standard Proctor test (ASTM D698). The placement water content should not exceed the range -2 to +3 percent of optimum water content. The loose lift thickness should not exceed 12 inches for coarse coal refuse used in structural portions of the dam. Refuse used in non-structural portions of the dam can generally be compacted to lesser requirements. Where fine-grained soils are used in the embankment, a loose lift thickness of approximately 8 inches should be specified.

Questions Regarding Presentation

1. Why does MSHA require compaction to 95 percent of maximum dry density as found by the standard Proctor test? Can this requirement be lowered?

Several statements were made that adequate embankment stability can be achieved at lower compaction standards. MSHA's requirement is that all structural fill (coarse coal refuse) be compacted to at least 95 percent of the maximum dry density found using the standard Proctor test (ASTM D698). MSHA normally permits less strict requirements in non-structural portions of an embankment. Non-structural fill could include material placed on the downstream toe of the embankment to act as a buttress.

Compaction, or densification, of the fill material achieves several goals: reduces settling, increases material strength, and reduces permeability. MSHA believes the compaction practices used by experienced dam builders are proper and therefore have been adopted by MSHA. This is partially true due to the fact that MSHA does not have the capability to conduct laboratory analyses to determine acceptable compaction densities. All references cited in the PIL state that compaction to 95 percent of maximum dry density is proper.

Several specific statements were made during the discussions.

Statement: The references deal with strictly soil materials. Coarse coal refuse is not comparable to soil and less compaction will still achieve adequate strength.

Response: Coarse coal refuse is similar to coarse grained soils. Some properties may vary; however, after compaction and weathering the material is similar. One reference cited in the PIL reports results of compaction tests specifically on coarse coal refuse. The accurateness of this reference was questioned during the discussions. However, MSHA sees no reason to dispute the work done in the study.

Statement: To achieve 95 percent, an operator needs to average 97 to 100 percent compaction. This causes degradation of the particles near the surface of a lift.

Response: Excessive degradation of the refuse is not desirable from the standpoint of permeability. Horizontal stratifications can occur if a layer of finely broken refuse is present. Some degradation has to be expected due to the composition of the coarse coal refuse. Therefore, compaction to a lower density would still cause breakdown. MSHA inspection personnel commonly report that field densities well over 95 percent are being achieved. More care should be taken by the operator not to over-compact the material and cause unnecessary breakdown. If excessive rolling is required to achieve the specified density at the bottom of the lift, then thinner lifts should be used.

2. Why does MSHA require moisture range specifications?

Several statements were made that specified densities were achieved with moisture contents well outside the specification. MSHA's requirement is that all structural fill (coarse coal refuse) will be compacted with a placement water content not exceeding the range of -2 to +3 percent of optimum.

As in the selection of required minimum density, MSHA has adopted the practices and recommendations of experienced dam builders. Each of the references cited in the PIL stress the importance of placing material within the proper moisture range. The Bureau of Reclamation's Earth Manual states that "securing the maximum benefit from compaction requires that the moisture in the soil be controlled. The specifications will require that the water content be uniform throughout the layer to be compacted and that it be as close as practicable to that content which will result in the maximum densification of the material." The fact that

coarse coal refuse exhibits a definite Proctor curve demonstrates that moisture plays a part in the material's compaction.

Statement: Material does not pass moisture specification when the weather is wet.

Response: Material should not be placed when moisture content exceeds the specified range. Material may be placed and spread in loose lifts during wet weather. However, the material should be allowed to dry to the proper moisture content before compaction. Some operators commented that construction of the embankment must continue in all weather or coal production will suffer. This is not considered adequate justification to cut corners when constructing high hazard impoundments.

3. Why does MSHA require placement of material in lifts not exceeding one foot?

Comments were made that adequate densities were being achieved when lifts exceeding one foot were used. In addition, it was pointed out that MSHA did allow two-foot thick lifts in the past. This practice was abandoned when seepage problems at the sites surfaced. MSHA's requirement is that all structural fill (coarse coal refuse) will be compacted in lifts not exceeding 12 inches. When fine-grained soils are involved, lift thickness should not exceed 8 inches.

The references state that adequate densities can not be achieved when lift thickness exceeds approximately 12 inches. Over-compaction of the surface materials usually occurs in order to obtain specified densities at the bottom of the lift. Over-compaction results in a severe breakdown of material thereby leading to horizontal stratification of the material.

No substantive proof has been submitted demonstrating that lifts in excess of 12 inches can be used. Any test would have to show that proper densities are being achieved at depth without causing excessive breakdown of surface material.

NEW ADMINISTRATIVE PROCEDURES/ALTERNATE PLAN REVIEW PROCESS

John J. Mulhern

Summary of Presentation

This session, presented by John J. Mulhern, Assistant Director for Safety, Technical Support, discussed possible changes to the existing plan approval process. Assisting at these sessions were Roger Schmidt from Coal Mine Safety and Health, Kelvin Wu, Chief of the Mine Waste and Geotechnical Engineering Division, Pittsburgh Safety and Health Technology Center and John Odell, Chief of the Mine Waste and Construction Division, Denver Safety and Health Technology Center.

The introduction to this discussion began with a synopsis of the program's background initiated by the Buffalo Creek disaster where 125 lives were lost. This disaster started a series of events that included review of the design and construction procedures used at that time by the mining industry, inspection and evaluation of all coal mine waste disposal sites, and developing and promulgating stringent regulations for the construction of water, sediment or slurry impoundments and impounding structures. After the initial review for each site minimal plan review by Technical Support was expected. A copy of the presentation is included in Appendix 1.

In today's program, approximately 20 years later, plans are still being reviewed. However, there are relatively few plans for new sites being submitted for review and approval. Most of the reviews are for modification to existing sites. This past year MSHA reported to the Intergovernmental Committee on Dam Safety (ICODS) that four new sites and 66 existing sites requiring major modifications were approved.

MSHA's present program requires plans to be submitted to the District Manager, where they are administratively reviewed, then forwarded to Technical Support for technical review. These technical reviews have requested additional or more complete technical information on all dams classified as high hazard. Those classified as low hazards have a 9 percent rejection rate.

The Federal Emergency Management Agency's (FEMA) role with respect to dam safety was discussed. MSHA represents the Department of Labor as a member of the ICODS which is chaired by FEMA. As required, by Presidential Order, MSHA prepares a biennial report on the Agency's compliance with "Federal Guidelines for Dam Safety". This report, and those of the other Federal Agency members of ICODS, is forwarded to FEMA for preparing the report on the Nation's Dam Safety Program. This report is sent to the President and Congress.

MSHA's plan backlog has been steadily increasing. Some considerations to possible changes in the plan review process

were discussed. One option presented a proposal to have administrative changes. This proposal suggested a limited administrative review by the District prior to transmittal to Technical Support. If Technical Support did not recommend approval, then the plan would be returned to the company. They would have 60 days to provide the requested information. If that reply is also found unacceptable, the company would have 30 days to reply. Should the third review be returned as "not approved" any resubmittal would be considered a newly submitted plan and reviewed in the order received for all plans. The second option addressed alternative procedures for the technical review. These were:

1. If the company needs the plan sooner than MSHA can conduct the review, an accredited independent reviewer would be retained at the expense of the company.

2. The plan would be reviewed to conform to established criteria set by MSHA.

3. Technical Support's role would be to resolve differences between the designer and reviewer.

4. The accredited independent reviewer would make recommendations to Technical Support. Technical Support would recommend approval to the District. Some limits on this option would include:

    1. New dams (sites) would not be included in this program.

    2. A size limitation of the dam (i.e. not exceeding twice the size of the existing site).

    3. The designer must inspect the dam after any major rain event.

    4. Initially, limit the program to modifications of low hazard sites.

Included in the appendix are copies of the presentation that discussed obvious concerns. Also included in the appendix are other technical review options that were part of the presentation.

Questions Regarding Presentation

1. **If industry will have a 60 day and 30 day limitation on resubmittal of plans, will MSHA have a limitation on the turnaround time for the review of plans?**

Procedures are being reviewed in an attempt to become more responsive. One of the goals of this conference is to seek ways to improve our turnaround time. We are here soliciting ways that you can suggest will improve our review time.

2. **Comment: MSHA needs to be more responsive to the industry and streamline the review process.**

   Again, we agree that current procedures need improving. The major objective of this session is to seek your ideas and assistance in improving the design review process.

3. **If the operator has a conceptual plan, can they come in for a discussion?**

   Yes, they can. However, because of current backlogs we would want to minimize "philosophical design discussions" and limit these discussions to specific site/design considerations.

4. **Several questions were raised about tripartite contracts in which the mine operator would pay a consultant to review the design under MSHA supervision.**

   Many variations of this idea were discussed. No firm procedure was recommended by the group.

5. **Why doesn't MSHA hire independent reviewers?**

   A consultant was hired to provide independent reviews of plans in the late 1970s. These reviews were unsuccessful and to the best of everyone's memory, were not completed before the funds were spent.

6. **A comment repeated several times was "hire more reviewers".**

   This would solve the review time problem, however, current budget constraints preclude any major personnel increases.

7. **Why doesn't MSHA allow the company to start construction prior to approval?**

   The regulations require the District Manager to approve the plan "prior to the beginning of any work . . ."

8. **Why not work closer with the states?**

   Most states wait until MSHA reviews and approves the plan. We welcome an opportunity to work with states. To this end, we will investigate possible ways to work together.

9. **Can plans be approved by stages?**

   Yes, we are currently doing this.

10. **Why not have an independent reviewer have total approval responsibility?**

At least for the initial stages of any independent review program, Coal Mine Safety and Health prefers Technical Support be responsible for the plan approval process.

11. **Why not use other government money, such as that collected by the Office of Surface Mining (OSM) and the Environmental Protection Agency (EPA), and money collected from industry to hire more people?**

Government monies are obligated by each Agency's budget, which is a law, referred to as General Appropriations. Its language on how monies are spent is specific. It requires enabling legislation called "Authorizations". Any industry money collected without specific enabling legislation (Authorization) would go into the general fund and could not be used by MSHA.

12. **What are some of the major causes for the plan to be rejected?**

Some causes of rejection are deficiencies in the seismic, pipe cover, phreatic line, spillway erosion protection, and compaction analyses.

13. **Why not have a peer review group established by industry to review and approve plans?**

This suggestion may be used as the preliminary review. If we could establish a mechanism to provide this initial review it might streamline the process.

14. **Why doesn't MSHA establish a priority list for plan reviews that would be based on a high fee, guaranteeing the plan would be reviewed within a month?**

Again, the fees could not be used by MSHA, and without additional reviewers, it would not help shorten the review process.

15. **Why doesn't MSHA charge a review fee?**

As stated above, this fee would go to the General Treasury and could not be used to add personnel.

16. **Comment: If plans are in the "to be reviewed" stack for 1 1/2 or more years, the guidelines change and the plans are rejected.**

Plans are seldom that long in the preliminary review cycle. We are attempting to develop solutions to the long review times that would resolve this concern.

IMPOUNDING STRUCTURES SAFETY DESIGN PROCEDURES: PRESSURE TESTING SPILLWAY CONDUITS

Harold Owens

Summary of Presentation

In general, a buried pipe must be capable of tolerating both the maximum internal and external pressures which it may experience during its service life in order to eliminate the potential for infiltration and exfiltration. It was pointed out that infiltration may cause loss of pipe backfill material which may lead to structural collapse of the pipe or it may cause piping within the embankment. Exfiltration may cause saturation of the surrounding embankment and associated slope stability problems. Hence, MSHA recommends pressure testing of conduit spillways in accordance with the provisions of Procedure Instruction Letter I90-II-4, pertinent manufacturers' recommendations, and current prudent engineering practice. Testing should be at, or some factor of safety above, the maximum anticipated hydrostatic head under design storm conditions. Any leaks need to be repaired.

The recommended allowances for "apparent leakage" based on criteria from other agencies were discussed. The limitations of such criteria were pointed out. For instance, it was indicated that it would be improper to apply an allowable "apparent leakage", intended to account for surface absorption in concrete pipe, to a fused polyethylene, or welded steel pipe.

The relationship between temperature and pressure, and its implications to pressure testing, was discussed. Changes in temperature during the test may result in dangerous or damaging pressures, or may need to be accounted for in interpreting the test results. An experience in District 4 involving a very large pressure increase in a pipe during pressure testing was relayed. Pressure relief valves are useful in protecting the pump and pipe from high pressures. Temperatures should be monitored in case calculation becomes necessary.

Pressure-testing procedures, which have been used in the past, were discussed. Photographic slides were used to illustrate some of these typical procedures and possible problems.

When pressure testing is necessitated by lengthening an existing pipe, there are possible complications arising from air which is entrapped in risers which have been abandoned at lower elevations. Pressure test results become difficult to interpret, presumably due to compression and dissolution of the entrapped air. This should be considered when determining the capping procedure for inlets.

Questions Regarding Presentation

1. Would MSHA require pressure testing of that portion of a pipe which is within the impoundment area, or only that part which is under the structural embankment?

We consider pressure testing necessary if the pipe is to be in, or in close proximity to, the foundation area of future upstream construction. If it is in the impoundment, away from the structural embankment (and no future upstream construction will occur), in general, we do not consider pressure testing necessary from a dam-safety standpoint. However, pressure testing would seem prudent, in order to minimize the potential for a black water discharge.

Additional Discussion

Several of the participants expressed similar experiences with pressure test results being difficult to interpret due to temperature and pressure effects.

FREQUENCY OF MOISTURE DENSITY TESTING TO VERIFY COMPLIANCE WITH COMPACTION SPECIFICATIONS

Terence M. Taylor

Summary of Presentation

In this presentation the following issues were discussed: the reasons for moisture density testing, recommended minimum testing frequencies, exceptions to the recommended minimum frequencies, locations for testing, and the keeping of test records.

Also discussed as an additional topic was the use of rock-correction formulas for correcting field readings for oversized particles. The reasons for using correction factors along with three empirical approaches to correcting for oversize particles were presented. The three formulas were the ASTM equation based on the research of Shockley, the FAA equation, and the West Virginia Department of Transportation equation. Comparisons of the equations to the results of actual experimental 18" full scale specimens were made to show which equation is the best predictor based on the percentage of gravel content. Also mentioned during the sessions, was the problem of companies reporting measured densities that appear to be above the 95% maximum dry density limit, when in fact the results are really below the suggested 95% minimum, once the proper rock-correction factor is applied.

Questions Regarding Presentation

1. Why did MSHA select a testing frequency of one test every 2000 cubic yards?

MSHA has adopted a frequency consistent with the minimum testing frequencies established by the Department of the Navy and the Bureau of Reclamation for mass earthwork. A listing of these references can be found on the final page of the PIL.

2. Can the restriction of one test every 2000 cubic yards be altered? How?

As stated in the PIL, in cases where a record of consistent test results is established, or in cases involving low-hazard dams, less frequent testing may be considered if justification is provided. In the case of a new impoundment, the operator would be responsible for initially following the 1 test / 2000 cyds requirement. After a history of consistently meeting the moisture-density criteria is established the company could then propose a variance to the above interval. Proof of test result consistency should be established using statistical controls.

In regard to the testing interval, at this time MSHA does not

have an exact interval number. Although the variation will have to be reviewed on a site by site basis, intervals of say 1 test / 3000 cyds with at least 1 test per lift may be considered acceptable by the reviewer.

Achieving consistency in meeting the moisture-density specification will be related to the relative homogeneity of the material. It can often be expected that consistency will be much easier to achieve with coarse refuse than it would be with material taken from a borrow pit.

3. Can the frequency of testing in the non-structural zone be relaxed?

The frequency of testing in the non-structural zone can be relaxed, assuming the non-structural zone has been properly delineated. If a non-structural zone is to eventually become part of a structural zone it would be prudent to test more frequently, as this would simplify future modifications greatly. At this time, MSHA does not have an alternative testing interval for the non-structural zone. As mentioned above the variation will have to be reviewed on a site by site basis.

4. Where should tests be performed?

The tests should be conducted at random locations throughout the lift. In addition, any area thought to have been ineffectively compacted should be tested. Areas subjected to the greatest vehicle compactive effort (primary haul roads) should be avoided.

In cases where two-foot lifts have been specified, tests should be conducted at mid-depth of the lift and at the top of the lift. The same is true for 18" thick lifts. The question was raised during one of the sessions by an operator who mentioned the top 6" of each 12" lift were disturbed due to dozer tracking. In this case, MSHA recommends testing 6" down in each lift which would essentially be the same as testing every 12" depth of material placed.

5. Where should new material for laboratory compaction tests be obtained?

Assuming this question pertains to the 1 Proctor test / 20 field density tests, MSHA normally recommends that the material be taken directly from the plant.

6. Can MSHA approve an "exceedence criteria" for moisture-density testing?

This question relates to an acceptable amount of failed tests per "X" passing tests. At this time MSHA does not have such a criteria. The decision on whether a particular amount of failures is acceptable has been left up to the MSHA field inspecting personal.

7. In relation to the 1 Proctor test / 20 moisture density tests, is it appropriate to use the "one-point Proctor" test?

MSHA has not established a criteria concerning usage of the "one-point Proctor". If results of your moisture-density tests show consistency in meeting the established values, the company may propose to periodically check a point on the Proctor curve. MSHA recommends that the "one-point Proctor" not be used exclusively. Perhaps the one-point Proctor test could be used every other or every third time the full Proctor curve is developed. Again, this would have to be addressed on a site by site basis, and would be at the discretion of the reviewer.

Also, this would be related to the overall homogeneity of the material. Coarse refuse materials may tend to be more uniform than material taken from a borrow pit.

SHORT TERM CRITERIA

Larry Wilson

Summary of Presentation

Occasionally, impounding structures cannot safely handle the full design storm for short periods of time. The implementation of Short Term Design Criteria for a particular site may be necessary because of procedural changes at the facility or transitions from one stage to the next. During these unavoidable periods, a less severe design storm may be considered.

The maximum length of time considered under Short Term Criteria is two years. This does not mean that in all instances two years is appropriate. Short Term Criteria is limited to the shortest possible time required to complete the transition.

The appropriate Short Term design storm is listed in MSHA's Design Guidelines and is based on size and hazard rating.

Questions Regarding Presentation

There was only one question concerning Short Term Design Criteria that was not addressed in the PIL.

1. When does the short term clock start when a site is to be abandoned?

When the impoundment is no longer able to handle the full design storm.

GRADED FILTERS

Larry Wilson

Summary of Presentation

The main purpose of graded filters is to prevent base materials from flowing into internal drainage systems. This is accomplished by either of two widely accepted methods.

The first method was developed by Mr. K. Terzaghi in the early 1940s. The second method was developed by the SCS in the mid-1980s. The second method is recommended by the Bureau of Reclamation. Both are based on the relative grain sizes of the filter and base material.

The primary difference between MSHA's requirements and these methods is that MSHA uses maximum/minimum gradation sizes to make the comparisons in the formulas rather than the average values. The reason for this difference is that the mining industry has such a wide range of possible materials that will be allowed in an impounding facility. A very coarse material may not be compatible with a very fine material.

Questions Regarding Presentation

1. Is it acceptable to use coarse refuse as the filter medium in a graded filter?

Coarse refuse will deteriorate with time and exposure to the elements. It is therefore not generally used as a granular filter medium. If, however, the coarse waste material is very clean, sound, and is buried immediately, coarse waste material may sometimes be used in a filter zone. This zone must be substantially larger than a conventional filter zone to compensate for degradation of the coarse waste material. The coarse waste material may also need to be enclosed in a filter media to help prevent fines migration.

2. Is the use of limestone material in a drain ever permitted?

There are many drains with limestone material in them. Most of these, however, are in underdrains below refuse piles. There are some instances of limestone in drains in impounding structures, but these are rare.

Drains and filters are critical design features of many dams. Drains are used to maintain internal seepage patterns at prescribed levels. If they were to malfunction, the phreatic surface could exceed design levels and result in a significant reduction in the slope stability of an impounding facility.

Filters are designed to control seepage so that piping of embankment material is prevented. The failure of a filter could result in uncontrolled seepage and the development of piping. It is therefore obvious that if a drain or filter is necessary in maintaining internal seepage at a certain level, or controlling seepage exiting a facility, their performance over the long term must be ensured.

The acidic environment that drains and filters in mine waste structures are exposed to dictate special considerations. Dissolution of calcareous limestone and sandstone will occur if exposed to mine acid. Seepage flowing through structures constructed of coarse mine waste will generally become acid as a result of pyrite oxidation.

Specification for <u>any</u> aggregate to be used in drains and filters must detail soundness, durability and resistance to dissolution resulting from exposure to acidic environments. Appropriate test and acceptable performance limits should also be specified.

3. How do you know when a filter is clogged?

There are several warning signs that a drain may have become plugged or is not functioning properly.

A. A decrease (or increase) in flow from the outlet of the drain.
B. An increase in the piezometric level in the area of the drains.
C. Seepage flowing around the outlet to the drain.
D. Discoloration or fine particles being transported with the water being discharged from the drain.

APPENDIX A

ALTERNATIVES TO THE PLAN REVIEW PROCESS

BACKGROUND

* 125 LIVES LOST IN 1972 - *BUFFALO CREEK*
* SEVERAL STUDIES REVIEWED DESIGN & CONSTRUCTION PROCEDURES
* EXISTING SITES WERE EVALUATED
* RECOMMENDATIONS --------- DEVELOP DESIGN GUIDELINES -- PROMULGATE REGULATIONS

INITIAL PROGRAM

* MAY 1976 REQUIRE PLANS FOR ALL COAL MINE WASTE IMPOUNDMENTS
* *EXPECTED* MANY PLANS
* AFTER INITIAL SUBMITTALS PLAN REVIEWS *EXPECTED* TO BE MINIMAL
* TECH SUPPORT *EXPECTED* TO PHASE OUT OF PLAN REVIEW PROCESS
* *EXPECTED* TO PROVIDE TECHNICAL ASSISTANCE WITH *ONLY* OCCASIONAL PLAN REVIEW

TODAYS PROGRAM

* RELATIVELY FEW NEW SITES
* MANY MODIFICATIONS TO EXISTING STRUCTURES
* ABOUT 15 MODIFICATIONS TO ONE NEW SITE
* 1991 ---- 4 NEW SITES
* 1991 ---- 66 MODIFICATIONS

FEDERAL GUIDELINES

OCT 1, 1989 TO SEPT 30, 1991

DOL (MSHA) MEMBER ICODS - CHAIRED BY FEMA

SECRETARY SENDS BI-ANNUAL REPORT TO FEMA

COMPILED REPORT ON DAM SAFETY SENT TO PRESIDENT AND CONGRESS

TOTAL COAL MINE WASTE IMPOUNDMENTS -- 853

- 243 SITES WERE NEW OR MODIFIED SINCE LAST REPORTING
- NUMBER LOW HAZARD -- 300

PRESENT REVIEW PROGRAM

* SUBMIT PLAN TO DISTRICT MANAGER
* SOME ADMINISTRATIVE REVIEW
* PLAN FORWARDED TO TECH SUPPORT
* HIGH HAZARD SITES HAVE 100% RETURN RATE
* LOW HAZARD SITES HAVE 95% RETURN RATE

POSSIBLE CHANGES

ADMINISTRATIVE

* MINIMUM ADMINISTRATIVE REVIEW BEFORE ACCEPTING PLAN
* FIRST REVIEW *NOT APPROVED* - 60 DAY REPLY
* SECOND RETURN *NOT APPROVED* - 30 DAY REPLY
* THIRD REVIEW RETURNED ------ *NOT APPROVED*
* ANY RESUBMITTAL CONSIDERED - *NEW PLAN*

POSSIBLE CHANGES

SECOND REVIEWER

* ACCREDITED INDEPENDENT REVIEWERS
* PLAN REVIEWED TO ESTABLISHED CRITERIA
* RESOLVE DIFFERENCES WITH DESIGNER
* PROVIDE RECOMMENDATIONS TO TECH SUPPORT
* TECH SUPPORT RECOMMENDS TO DISTRICT

SECOND REVIEWER

SOME LIMITS

* NOT USED ON NEW DAMS
* LIMIT TO TWICE EXISTING SIZE
* DESIGNER MUST INSPECT AFTER MAJOR RAIN EVENT
* COULD START WITH MODIFICATIONS FOR LOW HAZARD SITES

EXPRESSED CONCERNS

* REVIEWERS COULD HAVE NO INTEREST IN COAL
* LESS MSHA PLAN REVIEW
* LESS MSHA INSPECTION
* OPERATOR PAYS FOR SECOND REVIEW
* OPERATOR RESPONSIBLE – EMERGENCY ACTION
* PRESENT REVIEWS REJECT 100% OF HIGH HAZARD PLANS SUBMITTED
* WOULD REVIEW BE *INDEPENDENT*?

OTHER OPTIONS

* CHARGE FEES
* OPERATOR ASSUME MORE RESPONSIBILITY
* DISAPPROVE PLAN AFTER MINIMAL REVIEW
* ?
* ?
* ?
* ?
* ?
* ?

APPENDIX B

U.S. Department of Labor

Mine Safety and Health Administration
4015 Wilson Boulevard
Arlington, Virginia 22203-1984

EFFECTIVE DATE: 07/01/90 EXPIRATION DATE: 03/31/92

PROCEDURE INSTRUCTION LETTER NO. I90-II-1

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Compaction Specifications

Scope

This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose

Design and construction plans for active and proposed impounding structures are submitted by coal mine operators to MSHA for review and approval. It is MSHA's intent to maintain its design and construction requirements to the latest proven principles of "current, prudent engineering practices."

Mine waste dams and impoundments have some features which may differ from typical earth dams. When proposed design plans deviate from standard design criteria for dam safety, the plans and supporting documentation must clearly indicate the reason for the deviation, and provide a technical basis for the proposed design. While this information is presented to guide the reviewer, it remains the responsibility of the designer to keep abreast of changes in technology for impoundment structures and to design accordingly.

This letter is the first in a series addressing important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation. The issues addressed have been selected based on MSHA's experience with reviewing submitted plans. They represent items of particular concern or points of contention. They do not address all of the issues which must be considered in designing an impounding facility. MSHA intends to update and expand on the issues as needed.

The following information presents MSHA's current consensus on an important design issue.

Procedure Instructions

Proper compaction of embankment material is one of the most important elements in the construction of a safe dam. As stated in Engineering and Design Manual - Coal Refuse Disposal Facilities, E. D'Appolonia Consulting Engineers, Inc., 1975, "Any soil placed as a constructed structural fill, including coal refuse embankments, is normally compacted to increase density and shear strength and to decrease compressibility and permeability." Testing has shown that a small change in the density of coarse coal refuse can have a significant impact on some of its properties.

Compaction specifications need to place acceptable limits on the following: 1) the minimum dry density, 2) the range of placement water content and, 3) the maximum lift thickness. In arriving at these specifications, it is prudent that the recommendations and practices of authoritative, experienced dam builders be used for guidance.

Some pertinent references on compaction specifications are as follows:

1. Naval Facilities Engineering Command, NAVFAC DM-7.2, May 1982, Table 4, page 7.2-46, for earth dam greater than 50-feet high the required density is 95 percent of modified Proctor, moisture limits of -1 to +2 percent of optimum, and 12(±)-inch compacted lift thickness.

2. Corps of Engineers, Earth and Rock Fill Dams, EM 1110-2-2300, March 1971, pages 5-13, "Selection of design densities, while a matter of judgement, should be based on the results of test fills or past experience with similar soils and field compaction equipment. The usual assumption is that field densities will not exceed the maximum densities obtained from the standard compaction test nor be less than 95 percent of maximum densities derived from this test."

3. Bureau of Reclamation, Design of Small Dams, Third Edition, 1987, Table E-1, page 657. Cohesive soils controlled by Proctor test having 0-25 percent plus No. 4 fraction by weight should have a minimum acceptable density of 95 percent and a desirable average density of 98 percent; and 26-50 percent plus No. 4 fraction by weight should have a minimum acceptable density of 92.5 percent and a desirable average density of 95 percent. More than 50 percent plus No. 4 fraction by weight should have a minimum acceptable density of 90 percent and a desirable average density of 93 percent. These percentage densities are based on the minus No. 4 fraction and limit moisture content to -2 to +2 percent

of optimum. Permeability testing should be performed on cohesive soils which contain more than 50 percent gravel and are used as a water barrier.

4. S. K. Saxena, D. E. Lourie, and J. K. Ras, Compaction Criteria for Eastern Coal Waste Embankments, Journal of Geotechnical Engineering, Volume 110, No. 2, February 1964, "Recommendation. - Based on the findings of this study, it is recommended that coarse coal refuse, typical of eastern United States coal regions, be compacted near the optimum moisture content to a density greater than 95 percent of maximum dry density determined in accordance with ASTM D-698. Compacted lifts should not be greater than 1 ft. (0.3m) in thickness."

The following recommendations are made for the structural fill portions of impounding structures:

1. Material should be compacted to at least 95 percent of the maximum dry density as defined by the standard Proctor test, with the placement water content not exceeding the range of -2 to +3 percent of optimum.

2. In compacting coarse coal refuse, the lift thickness should not exceed 12 inches. When fine-grained soils are used for embankment construction, lift thickness should not exceed 8 inches.

3. For materials where the Proctor moisture-density relationship does not apply, specifications should be based on relative density test values.

Less stringent compaction specifications than those cited above would not generally be consistent with current, prudent engineering practices. Plans with such specifications cannot be recommended for approval unless a detailed technical justification, which demonstrates that the proposed practice would have no adverse affect on the safety of the dam, can be provided by the designer. The designer would need to show through testing and analyses that all potential problems, including settlement, cracking, piping, instability, stratification, and seepage, have been taken into account in the design and that compensating design features have been incorporated. It should be noted that less stringent compaction specifications can generally be used in areas which can be shown to be "non-structural" portions of the dam.

References

1. Bureau of Reclamation, Design of Small Dams, U.S. Department of the Interior, 1987.

2. Chen, C.Y., Engineering Properties of Compacted Coal Mine Waste, American Society of Civil Engineers, New York, New York, May 1981.

3. Corps of Engineers, Earth and Rockfill Dams, EM 1110-2-2300, U.S. Department of the Army, March 1971.

4. Corps of Engineers, Engineering and Dam Design - Stability of Earth and Rockfill Dams, EM 1110-2-1902, U.S. Department of the Army, April 1, 1970.

5. E. D'Appolonia Consulting Engineers, Inc., Engineering and Design Manual - Coal Refuse Disposal Facilities, U.S. Department of the Interior, Mining Enforcement and Safety Administration (MESA), 1975.

6. Naval Facilities Engineering Command, NAVFAC DM-7.2, U.S. Department of the Navy, May 1982.

7. Saxena, S.K., et. al., Compaction Criteria for Eastern Coal Waste Embankments, Journal of Geotechnical Engineering, Volume 110, No. 2, February 1984.

8. Shah, N.S., et. al., Compaction Criteria for Coal Waste Embankments, U.S. Department of the Interior, Bureau of Mines, Contract No. J0100031, August 1981.

Authority
These procedures were developed as an aid to compliance with the provisions of 30 CFR 77.216 through 77.217.

Filing Instructions
MSHA personnel should file this letter behind the tab marked "Procedure Instruction Letters" in the binder labelled "Program Policy Handbooks and Procedure Instruction Letters."

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PROCEDURE INSTRUCTION LETTER NO. I90-II-2

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Graded Filters

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the second letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
There are several axioms that apply to dam design, construction, and operation. First, all dams leak. Second, the leakage must be controlled. In concrete dams the expected seepage is accommodated through the inclusion of collection galleries, whereas granular drains are commonly employed to control seepage in earth structures. When including a drain or filter in an earth structure, the designer should always consider material compatibility. That is, the granular material serving as the drainage medium should be much more permeable than the material (base soil) from which the seepage flowed. It should also exhibit explicit grain size grading to preclude the potential for base material particle migration. There are two major calculative methods available to determine piping potential and drain adequacy.

The first method was developed by Bertram and Terzaghi in the early 1940s and is still widely accepted. This procedure can be found in the Engineering and Design Manual - Coal Refuse Disposal Facilities as well as Cedergren's Seepage, Drainage, and Flow Nets, Sherard's Earth and Earth-Rockfill Dams, and Seepage Analysis and Control for Dams by the Corps of Engineers.

The second method was developed by the Soil Conservation Service (SCS) in their Soil Mechanics Laboratory in Lincoln, Nebraska. It became the SCS official policy on January 15, 1986, with the publication of Soil Mechanics Note No. 1, 210-VI-Guide for Determining the Gradation of Sand and Gravel Filters. After reviewing the work done by the SCS, the Bureau of Reclamation has also adopted this method of designing graded filters. A design standard was published on May 13, 1987, by the Bureau of Reclamation titled, Design Standards - Embankment Dams No. 13, Chapter 5, Protective Filters.

Criteria differences exist between these authoritative sources, but both methods are well documented and widely accepted. MSHA deviates from these procedures in only one area. The criteria specify that average gradation band sieve size values should be utilized in developing sieve ratios. In each method, developers assume parallel, narrow, well defined gradation bands representative of well-controlled, manufactured granular drain material and relatively homogeneous base soils. Many filter and drain gradations examined by Technical Support personnel reveal that the bands are neither narrow nor parallel to the base material. Therefore, MSHA will continue to utilize extreme limit values in their analyses of associated gradation bands. It should be noted that, except for the deviation in the standard procedure mentioned above, all criteria listed in the method utilized should be followed explicitly.

If any other method is to be used, sufficient documentation and proof of acceptance should be submitted.

REFERENCES

1. Bureau of Reclamation, Design Standards - Embankment Dams, No. 13, Chapter 5, Protective Filters, U.S. Department of the Interior, 1987.

2. Cedergren, H.R., Seepage, Drainage, and Flow Nets, 2nd Edition, John Wiley & Sons, 1977.

3. Corps of Engineers, Seepage Analysis and Control for Dams, EM 1110-2-1901, Appendix D, U.S. Department of the Army, 1986.

4. E. D'Appolonia Consulting Engineers, Inc., Engineering and Design Manual - Coal Refuse Disposal Facilities, U.S. Department of the Interior, Mining Enforcement and Safety Administration (MESA), 1975.

5. Sherard, J.L., Woodard, R.J., Gizenski, S.F., and Clevenger, W.A., Earth and Earth-Rockfill Dams, John Wiley & Sons, 1963.

6. Soil Conservation Service (SCS), Soil Mechanics Note No. 1, 210-VI-Guide for Determining the Gradation of Sand and Gravel Filters, U.S. Department of Agriculture, 1986.

Authority
These procedures were developed as an aid to compliance with the provisions of 30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I90-II-3

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Reservoir Evacuation by Pumping

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the third letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
When pumps are used as part of the hydraulic system, prudent engineering practice must be followed to ensure adequate safety. The following discussion presents ideas that might be helpful in the design and review of a pump facility.

First, a pump system may not be used to route storm runoff through an impoundment. Second, if a pump system is the primary evacuation strategy for an impounding structure, the pump system must meet the drawdown criteria of removing 90 percent of the volume of water stored during the design event within 10 days.

Since many types of pumps are available for various functions, it will be necessary to have all pertinent design data submitted regarding the proposed pump facility. It must be substantiated with design calculations that the pumps can discharge the impounded runoff from the design storm under all possible conditions within the allowable time.

Because of the possibility of operational pump failure during the initial stages of the design storm, an impounding facility without an adequate spillway must be of sufficient size to store the runoff from the appropriate design event. A backup pump capable of meeting drawdown criteria should be immediately available in case the primary pump fails.

Upon initial installation, the pumps should be operated for a sufficient length of time to ensure proper operation of the system. Since it is possible that capacity under actual conditions will vary from the manufacturer's data, the outflow should be monitored and recorded whenever the system is tested.

The design operating criteria should include the requirement that the pump system be activated for a short time once every week to ensure that damage has not occurred within the system. It should also be required that the pump system be activated just before a forecasted storm of significant magnitude. Check valves should be installed on all pumps to prevent reverse flow that could cause damage to any pump's internal mechanism.

Due to the nature of significant storm events, electrically powered pumps that obtain their power from sources away from the immediate vicinity of the pump are unacceptable. Power lines and electrical auxiliary power sources may become inoperable during a storm. The only acceptable power source is an internal combustion engine, either coupled to the pump or as an adjacent generator specifically for the pump. The method of storage for the pump's fuel supply should be clearly presented. Since additional local, state, and federal regulations may apply to such installations, it is the mining companies' responsibility to ensure the appropriate agencies are contacted and that their requirements are considered.

It will be necessary to evaluate each system on its specific design features. Therefore, the designer must submit complete design criteria, data, calculations, and all other pertinent information that will clarify the pump system design.

Authority
These procedures were developed as an aid to compliance with the provisions of 30 CFR 77.216 through 77.217.

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EFFECTIVE DATE: 12/14/90 EXPIRATION DATE: 03/31/92

PROCEDURE INSTRUCTION LETTER NO. I90-II-6

FROM: MADISON McCULLOCH
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Probable Maximum Flood (PMF)

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the sixth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
Current, prudent engineering practice requires that dams that are located where failure may cause loss of life or severe property damage be designed for the probable maximum flood (PMF). The PMF is defined as the maximum runoff condition resulting from the most severe combination of hydrologic and meteorologic conditions that are considered reasonably possible for the drainage area. It defines the upper limit of expected flooding from meteorologic events.

Components of the PMF, that must be determined by the designer for a particular site, include the principal storm, the antecedent storm, the subsequent storm, the time and spatial distribution of the rainfall and snowmelt, and the runoff conditions. While there is basic agreement among dam safety authorities on the combination of conditions and events that comprise the PMF, there are significant differences in the individual components that are used. For the antecedent storm, for example, the Soil Conservation Service and the Bureau of Reclamation use the 100-year frequency storm while the Corps of Engineers may use 50 percent of the probable maximum precipitation (PMP).

A reasonable set of conditions for the PMF appears to be the following:

1. Antecedent Storm: 100-year, 6-hour, with antecedent moisture condition II (AMC II), occurring within 5 days prior to the principal storm.

2. Principal Storm: Probable maximum precipitation (PMP) of 6-hour duration with AMC III. In cases where a storm of longer duration results in a higher water level in the impoundment, the storm must be extended, up to 72 hours, to the hydrologically most critical duration. The principal storm rainfall increments must be distributed with time so as to produce the most severe condition.

   Recommended procedures for determining critical rainfall time distribution for areas east of the 103rd meridian are given in Hydrometeorological Report No. 52. The Corps of Engineers' computer program HMR52 can be used to compute precipitation values in accordance with these procedures.

   PMP rainfall estimates, for areas east of the 103rd meridian, are given in Hydrometeorological Report No. 51. For the region between the 103rd meridian and the continental divide, probable maximum storms should be developed using the recommended procedures in Hydrometeorological Report No. 55A. For areas west of the Continental Divide, Hydrometeorological Report No. 36, No. 43, or No. 49 should be consulted.

3. Subsequent Storm: In this procedure, a subsequent storm would be considered to be handled by meeting the 10-day drawdown criterion.

As an alternative to using the PMF as defined above, a design that follows the applicable methodology used by a recognized dam safety authority would be acceptable. However, designers are cautioned that storm criteria that are considered acceptable for dams with a properly designed open channel spillway, may not be appropriate for dams where the runoff is to be stored. In storage situations, longer duration storms need to be considered.

REFERENCES

1. Ad Hoc Interagency Committee on Dam Safety, Federal Guidelines for Dam Safety, prepared for the Federal Coordinating Council for Science, Engineering, and Technology, Washington, D.C., 1979.

2. National Weather Service, Probable Maximum Precipitation Estimates, U.S. East of the 103rd Meridian, Hydrometeorological Report No. 51, 1978.

3. National Weather Service, Application of Probable Maximum Precipitation Estimates - U.S. East of the 103rd Meridian, Hydrometeorological Report No. 52, 1981.

4. National Weather Service, Interim Report - Probable Maximum Precipitation in California, Hydrometeorological Report No. 36, 1961 with revisions of OCtober 1969.

5. National Weather Service, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, 1981.

6. National Weather Service, Probable Maximum Precipitation, Colorado River and Great Basin Drainage, Hydrometeorological Report NO. 49, 1977.

7. National Weather Service, Probable Maximum Precipitation Estimates - United States Between the Continental Divide and the 103rd Meridian, Hydrometeorological Report No. 55A, 1988.

8. National Weather Service, Probable Maximum and TVA Precipitation Estimates with Areal Distribution for Tennessee River Drainage Less Than 3000 Square Miles in Area, Hydrometeorological Report No. 56, 1986.

9. Newton, D. W., Realistic Assessment of Maximum Flood Potentials, Journal of Hydraulic Engineering, ASCE, Vol. 109, No. 6, June 1983, pp. 905-918.

10. Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, U.S. Department of Agriculture, 1972.

11. U.S. Army Corps of Engineers, HMR52 Probable Maximum Storm - Users Manual, March 1984.

12. Wang, B. H., and Javed, K., Transformation of PMP to PMF: Case Studies, Journal of Hydraulic Engineering, ASCE, Vol. 112, No. 7, July 1986, pp. 547-561.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I90-II-4

FROM: MADISON McCULLOCH
Director of Technical Support Peter M. Turni

SUBJECT: Impounding Structures Safety Design Procedures: Pressure Testing Spillway Conduits

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the fourth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
Leakage problems have occurred in a number of pipe installations. Both infiltration and exfiltration have been observed. As a result, MSHA requires pressure testing of all pressure conduit spillways. Joints also need to be tested in some non-pressure situations where conditions are such that loss of backfill or slurry could occur, due to infiltration or leakage along the pipe. For guidance on this subject, specifications from other organizations have been examined and those that appear applicable are listed in this procedure instruction letter.

The Soil Conservation Service (SCS) has two specifications, one for pressure pipe and one for non-pressure pipe. In the National Engineering Handbook, Section 20, "Construction Specification 42: Concrete Pipe Conduits and Drains," the SCS, for non-pressured applications, states:

> Prior to the placement of concrete or earthfill around the conduit, the conduit shall be tested for leaks in the following manner: The ends of the conduits shall be plugged and a standpipe with a minimum diameter of two (2) inches shall be attached to the upstream plug. The conduit shall be braced at each end to prevent slippage. The conduit and the standpipe shall be filled with water. The water level

in the standpipe shall be maintained, by continuous pumping, a minimum of 10 feet above the invert of the upstream end of the conduit for a period of not less than two hours. Any leaks shall be repaired and the conduit shall be retested as described above. The procedure shall be repeated until the conduit is watertight.

The pipe joints shall show no leakage. Damp spots developing on the surface of the pipe will not be considered as leaks.

For pressure applications, the SCS states in Engineering Memorandum-27 (Rev.), "Conduit joints will be designed and constructed to remain watertight under maximum anticipated hydrostatic head and maximum probable conditions of joint opening . . . including the effects of joint rotation and a margin of safety where required." A similar statement can be found in Earth Dams and Reservoirs - Technical Release No. 60. Also in Technical Release No. 60, "All conduits under earth embankments are to . . . withstand the internal hydraulic pressures without leakage under full external load and settlement."

The American Water Works Association (AWWA) suggests in their concrete pressure pipe manual that, "Leakage allowances are generally specified in the range of 10-50 gallons per inch diameter per mile of pipe per 24 hours. This assigned value is intended only to give the contractor some allowance for apparent leakage, since any observed leaks must be repaired." Prior to testing, "The line should be filled at a slow rate to prevent air entrapment and should be left with a low pressure for 24 hours prior to testing. This will saturate the concrete lining and reduce the apparent leakage attributable to absorption by the pipe walls." The AWWA further suggests that, "Test pressures are commonly specified as some value slightly greater than the operating pressure, such as 120 percent of operating pressures."

The U.S. Bureau of Reclamation has apparently adopted the AWWA approach with regard to field testing siphons. In Typical Specifications, Item 5.1.4, the reader can find, "After a siphon is completed, it shall be tested for watertightness by being filled with water to the elevation of the floor at the downstream end of the outlet . . . The total amount of leakage from the siphon during this 24-hour period shall not exceed 50 gallons per inch of diameter per mile of siphon." The Bureau does not address apparent leakage, but most if not all siphons designed and constructed by the Bureau are concrete.

Considering the foregoing specifications, plans should require that all pressure conduits be pressure tested to at least the expected maximum design hydrostatic pressure. The test period

should range from 2 to 24 hours depending on pipe material and jointing. Joints should be visually inspected for leakage, whenever possible. An apparent leakage of 50 gallons per inch diameter per mile of pipe will be considered acceptable for concrete pipe provided that all obvious leaks are repaired. All other types of pipe, i.e., corrugated metal, smooth-wall steel, high-density polyethylene, and polyvinyl chloride, should be watertight. When testing plastic pipe with water, manufacturer's specifications should be consulted to determine test duration and allowance for pipe expansion. In testing with air, no pressure loss is acceptable during testing, regardless of the pipe, because the loss cannot be measured. Where welding is required, the welder should be certified.

Pipes are normally pressure tested prior to backfilling so that any leaks can be readily repaired. Designers need to consider, however, especially for flexible pipes with mechanical couplings, that joints may not remain watertight after the pipe has been buried under fill and deflects. Plans need to address this concern.

For non-pressure applications using corrugated metal pipe (CMP), hugger bands with gaskets should be used as a minimum; dimple bands are not acceptable. Furthermore, all corrugated metal pipe should be the welded seam variety; lock seam and riveted CMP are not acceptable unless adequate leakage control measures are provided.

While the watertightness of joints is a definite concern in pressure flow situations, joint tightness may also be a concern in non-pressure flow cases. This occurs when the backfill around a pipe is potentially erodible material, such as a fine sand or silt, which would tend either to infiltrate the pipe or to be washed out by exfiltration of water from the pipe. The former situation is a particular concern when settled slurry, which forms the foundation for an upstream construction stage, can potentially infiltrate a pipe. When conditions are such that infiltration or exfiltration could affect the safety of the dam, plans should include (even in non-pressure flow designs) a minimum pressure testing requirement. Testing joints to a nominal pressure will provide some assurance that the joints were properly constructed, are soil tight, and will not allow significant leakage.

All pressure testing must be conducted in a safe manner. All installations should be equipped with a pressure gauge and pressure relief valve during the test procedure. Internal and external temperatures should also be monitored to provide pressure/temperature data in the event calculations become necessary.

REFERENCES

1. American Iron and Steel Institute, Handbook of Steel Drainage and Highway Construction Products, Third Edition, 1983.

2. Bureau of Reclamation, Typical Specifications, U.S. Department of the Interior.

3. Soil Conservation Service, Earth Dams and Reservoirs - Technical Release No. 60, U.S. Department of Agriculture, Revised October 1985.

4. Soil Conservation Service, Engineering Memorandum-27 (Rev.), Re: Earth Dams, U.S. Department of Agriculture, March 19, 1965.

5. Soil Conservation Service, National Engineering Handbook, Section 20, "Construction Specification 42," U.S. Department of Agriculture, April 1986.

6. Standards Committee on Concrete Pressure Pipe, AWWA Manual M9, Concrete Pressure Pipe, American Water Works Association, 1979.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I90-II-5

FROM: MADISON McCULLOCH
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Conduit Seepage Control Measures

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the fifth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
Many public and private dam design and construction groups either permit or install conduits through embankment dams. However, most designers agree that closed hydraulic conveyances should be placed in stronger abutment soils or rock where less settlement and horizontal spreading will occur. Designers have long recognized that pipe installations provide an opportunity for seepage along the conduit. To preclude seepage along the conduit, designers have included impediments such as anti-seepage collars, cutoff walls and collars, and anti-seepage diaphragms. These diaphragms protrude circumferentially from around the conduit into the surrounding dam embankment material. The purpose of such protrusions is to increase the length of the potential seepage path along the pipe from the inlet to the outlet by a specific amount. This reduces the hydraulic gradient at the exit. The lowering of the hydraulic gradient reduces internal erosion or piping potential next to the conduit. The required extension of the seepage path evolved empirically over the past 80 years or so. After many years of trial and error, an increase of 15 to 20 percent is accepted as reasonable and prudent. Bureau of Reclamation engineers using the weighted-creep method of design commonly used percolation path increases on the order of 20 to 30 percent through the inclusion of projecting fins or collars.

The increased percolation path concept was standard practice industry-wide prior to about 1965. Since the late 1960s, an increasing number of practitioners have advocated the use of drains and filters to control the expected seepage along pipes for a variety of reasons. It was not until the early to mid-1980s that large Federal dam design agencies such as the Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service altered their standard specifications to preclude the use of anti-seepage collars and require inclusion of graded granular filters and drains.

Many of the design applications submitted to MSHA have included provisions for the construction of conduits with anti-seepage diaphragms. Some designs have included drain and filter systems. Materials for the anti-seepage collars have included concrete, steel, and polyethylene. The granular diaphragm material generally conforms to gradations specified under ASTM C-33. MSHA will accept either method or design philosophy. All design submittals should address conduit seepage control measures.

Dam designers submitting specification drawings and supporting documentation to the agency are advised to examine the accompanying reference list. One must be cognizant that the construction of pipes with anti-seepage collars is labor intensive and that additional testing and inspection may be required. Also, the designer should pay particular attention to connection detail in order to preclude seepage, diaphragm location respective to joints, and potential stress concentrations which may harm the conduit. Where a pipe passes through a rigid collar, provisions should be made for relative movement. In flexible pipes, the connection detail must allow for the anticipated pipe deflection while maintaining a watertight connection. Graded granular materials, on the other hand, must meet sizing requirements and be placed at specific well-defined locations under approved density specifications. Granular materials are to be compatible with surrounding soils and must not be contaminated during placement.

REFERENCES

1. Bureau of Reclamation, Design of Small Canal Structures, U.S. Department of the Interior, 1974.

2. Bureau of Reclamation, Guidelines for Controlling Seepage Along Conduits Through Embankment, U.S. Department of the Interior, 1987.

3. Corps of Engineers, Deletion of Concrete Seepage Cutoff Collars for Outlet Conduits, ETL 1110-2-180, U.S. Army, January 31, 1974.

4. Corps of Engineers, Earth and Rockfill Dams General Design and Construction Considerations, EM 1110-2-2300, U.S. Army, May 10, 1982.

5. Decker, R.S., Nickel, S.H., and McMeekin, M.P., Dammed If You Do and Dammed If You Don't, paper presented at ASCE Meeting, St. Louis, Missouri, October 27, 1981.

6. Highway Task Force, Handbook of Steel Drainage and Highway Construction Products, American Iron and Steel Institute, 1st Printing, 3rd Edition, April 1983.

7. Sherard, J.L., and Dunnigan, L.P., Seepage and Leakage from Dams and Impoundments, "Filters and Leakage Control in Embankment Dams," Geotechnical Division - American Society of Civil Engineers, Proceedings edited by R.L. Volpe and W.E. Kelly, May 5, 1985.

8. Soil Conservation Service, Earth Dams and Reservoirs - Technical Release No. 60, U.S. Department of Agriculture, June 1976.

9. Soil Conservation Service, Earth Dams and Reservoirs - Technical Release No. 60 (Revised), U.S. Department of Agriculture, October 1985.

10. Soil Conservation Service, Technical Note - Dimensioning of Filter-Drainage Diaphragms for Conduits According to TR-60, U.S. Department of Agriculture, April 2, 1985.

11. Soil Conservation Service, Technical Note W-21 - Filter and Drainage Diaphragm Dimensions, U.S. Department of Agriculture, August 1985.

12. Talbot, J.R., and Ralston, D.C., Seepage and Leakage from Dams and Impoundments, "Earth Dam Seepage Control, SCS Experience," Geotechnical Division - American Society of Civil Engineers, Proceedings edited by R.L. Volpe and W.E. Kelly, May 5, 1985.

13. The Committee on Failures and Accidents to Large Dams of the United States Committee on Large Dams, Lessons from Dam Incidents USA, ASCE/USCOLD, 1975.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I90-II-7

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Frequency of Moisture-Density Testing to Verify Compliance with Compaction Specifications

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the seventh letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
Tests need to be performed during the construction of a dam to determine compliance with moisture-density specifications in accordance with the approved plan and to detect any significant changes in the material properties over the construction period. The operator or the operator's agent should have such tests conducted at the following minimum frequencies:

a. one field test for every 2,000 cubic yards of compacted structural fill, with at least one test per lift;

b. one field test for every 200 cubic yards of compacted backfill in trenches or around structures, with at least one test per lift (Note: With small diameter pipes, where the total volume of pipe backfill may be small, more frequent tests than indicated by this criterion should be performed.);

c. one test any time there is suspicion of the effectiveness of compaction; and

d. supplementary laboratory compaction curves for at least every 20 field density tests.

Field tests should be performed at random locations in the fill. Records of the test results, as well as the test locations, should be kept at the mine.

In cases where a record of consistent test results is established, or in cases involving low-hazard dams, less frequent testing may be considered if justification is provided. Any time there is reason to suspect that the characteristics of the construction material have changed, reasons such as a change in preparation plant processing or unusual compaction test results the material should be further investigated. Grain-size, compaction, shear-strength, and other tests should be performed as warranted.

REFERENCES

1. Bureau of Reclamation, Earth Manual, U.S. Department of the Interior, 1974.

2. Naval Facilities Engineering Command, Design Manual - Foundations and Earth Structures, NAVFAC DM-7.2, Department of the Navy, 1982.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I91-II-1

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Use of Geotextiles as a Filter

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the eighth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
To perform acceptably as a filter in a drainage application, a geotextile must function as follows:

1. retain the protected soil to prevent piping;

2. have sufficient permeability to prevent the build-up of water pressure;

3. not become clogged; and

4. have sufficient strength to survive the construction procedures.

Impoundment plans in which a geotextile is proposed as a filter must include the basis for specifying the particular fabric or fabric characteristics. This should include showing that design criteria with respect to soil retention, permeability, clogging, and constructability have all been considered and met. (References No. 5 and No. 8 are good sources of information on design criteria.)

Plans also should require that critical geotextile installations be observed by a representative of the designer who is knowledgeable about geotextiles and filter requirements, and familiar with the placement procedures specified in the plan.

In high hazard dams where problems with the filter could lead to failure of the dam, the following are necessary:

1. The evaluation of clogging potential needs to include a soil-fabric interaction test.

2. A sufficient number of piezometers need to be included in the design to allow the drain's performance to be monitored.

Designers are cautioned that testing performed by the U.S. Bureau of Mines, although inconclusive, indicated a potential for plugging of the fabric when used as a filter in a coal waste embankment. Concerns for the formation of a precipitate, or the growth of bacteria on the cloth, have been raised. Because of the potential for clogging, filter fabric cloth should be selected with the largest opening size that provides the maximum flow capacity while maintaining the soil retention requirements.

A high percentage of the problems that have occurred with filter fabric installations have been attributed to incorrect or poor construction procedures. This is why all critical installations need to be observed by a representative of the designer who is knowledgeable about the important function that the geotextile serves.

Special attention needs to be given to preventing damage or disturbance of the fabric during installation. The recommendations of Task Force No. 25, which are cited in Geotextile Engineering Manual (see Reference No. 8), should be consulted although they are not intended to replace site-specific evaluation, testing, and design. In general, the manufacturer's recommendations for installation should be followed. Particular attention should be given to the following items:

1. Fabrics should be secured by sewing, pins, staples, or weights as necessary to prevent disturbance by construction operations or wind. Where seams are to be formed by overlapping, the overlap should be at least 2 to 3 feet and the specific conditions should be evaluated to ensure that the fabric will not open up under load.

2. In preparing surfaces for fabric placement, depressions, holes, and voids should be filled so that the fabric will not have to bridge them and possibly be torn when cover material is placed. Fabric should not be placed over sharp or angular rocks that could tear or puncture it. An intermediate layer of compatible finer material should be placed over such rocks to protect the fabric.

3. In placing material or using equipment on a fabric, care must be taken to avoid punctures or tears. Fabrics must be specified that have adequate puncture and burst strength for the conditions and construction procedures that will be encountered. Where applicable, specifications should limit the size of rock to be placed on the fabric and the drop height. Generally, stones greater than 250 pounds should be placed with no free-fall. Field trials should be made to ensure that no damage will occur due to the construction procedures. Depending on site conditions, a cushion layer of finer material may be required to protect the fabric.

REFERENCES

1. Carroll, Robert, "Geotextile Filter Criteria," Engineering Fabrics in Transportation Construction, Transportation Research Board, 1983.

2. Gabler, R.C., Properties of Filter Cloths for Seepage Control in Coal Mine Waste Embankments, RI 8871, U.S. Bureau of Mines, 1984.

3. Giroud, J.P., Filter Criteria for Geotextiles, Second International Conference on Geotextiles, Volume 1, pages 103-108, 1982.

4. Hoare, David, "Synthetic Fabrics as Soil Filters: A Review," Journal of the Geotechnical Engineering Division, October 1982.

5. Koerner, Robert, Designing with Geosynthetics, Second Edition, Prentice-Hall, 1990.

6. Koerner, Robert, and F.K. Ko, Laboratory Studies on Long-Term Drainage Capability of Geotextiles, Second International Conference on Geotextiles, Las Vegas, Nevada, 1982.

7. Rankilor, P.R., Membranes in Ground Engineering, John Wiley and Sons, 1982.

8. STS Consultants, Geotextile Engineering Manual, Parts 1 and 2, prepared for the Federal Highway Administration, 1985.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I91-II-2

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Design of Pipes for External Loading

Scope

This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose

Design and construction plans for active and proposed impounding structures are submitted by coal mine operators to MSHA for review and approval. It is MSHA's intent to maintain its design and construction requirements to the latest proven principles of "current, prudent engineering practices."

Mine waste dams and impoundments have some features that may differ from typical earth dams. When proposed design plans deviate from standard design criteria for dam safety, the plans and supporting documentation must clearly indicate the reason for the deviation, and provide a technical basis for the proposed design. While this information is presented to guide the reviewer, it remains the responsibility of the designer to keep abreast of changes in technology for impoundment structures and to design accordingly.

This letter is the ninth in a series addressing important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation. The issues addressed have been selected based on MSHA's experience with reviewing submitted plans. They represent items of particular concern or points of contention. They do not address all of the issues which must be considered in designing an impounding facility. MSHA intends to update and expand on the issues as needed.

The following information presents MSHA's current consensus on an important design issue.

Procedure Instructions

When a pipe is to be installed under or through a dam, plans must demonstrate through analyses and calculations that adequate factors of safety are provided against the various potential structural failure modes. Potential structural failures include wall crushing, wall buckling, and excessive deflection or wall strain. Parameters used in the various analyses must be adequately substantiated in the submitted plan.

The recommendations contained in the literature of pipe manufacturers, such as tables for the allowable cover over a pipe, must be used with caution. In using such design aids, designers need to ensure that the parameters used in their development are appropriate, and that each potential failure mode is taken into account. For dams with high hazard potential, manufacturers' tables should generally be used for preliminary design purposes only. Detailed analyses and calculations should be included in the plan.

Designers should note that technical literature contains some significant differences of opinion on the best structural design for flexible pipes. Particular points of contention concern the calculation of deflection and values of the soil modulus or the soil/pipe interaction modulus. For these reasons, the applicability of a manufacturer's recommended design procedure needs to be verified for the particular conditions found at a site. This is especially true for deep burial situations, as the emphasis for most pipe products has been on relatively shallow cover conditions, such as sewer installations. Until performance data is established for high cover situations, conservative design methods need to be used. Factors of safety of at least 2.0 should be specified. Where applicable, deflections should be checked using the Iowa Formula, with conservative values for the modulus of soil reaction. Because of the limitations of traditional, empirical design methods, use of a finite element analysis, such as the CANDE-89 program, is now considered by some to represent the best available method of design. For flexible pipes, in addition to the deflection caused by fill loading, installation deflection also needs to be taken into account in determining whether total deflection will be within acceptable limits.

Consideration should be given to limiting fill height by installing new pipes at higher elevations and grouting deeply buried pipes.

In high fill applications, due to uncertainty about pipe/soil interaction and the lack of performance data, the performance of the pipe may need to be verified by a monitoring device such as a

deflectometer, a "go-no go" device, or a TV camera. Also, contingency measures to repair or replace the pipe may be required in the event that monitoring shows that structural performance limits are exceeded.

The "imperfect ditch" or "induced trench" method of pipe installation should not be used in dams due to the potential for creating a seepage path and the uncertainty of the arching action under saturated conditions.

REFERENCES

1. American Association of State Highway and Transportation Officials (AASHTO), Standard Specification for Highway Bridges, Section 18, Soil-Thermoplastic Pipe Interaction Systems, 1989.

2. American Iron and Steel Institute, Handbook of Steel Drainage and Highway Construction Products, 1983.

3. American Water Works Association, Concrete Pressure Pipe, Manual M9, 1979.

4. American Water Works Association, Steel Pipe Design and Installation, Manual M11, 1964.

5. Federal Highway Administration, CANDE-89 Culvert Analysis and Design Computer Program: User Manual, Publication No. FHWA-RD-89-169, June 1989. (Note: this is the personal computer version of CANDE.)

6. Gumbel, J. E., O'Reilly, M. P., Lake, L. M., and Carder, D. R., The Development of a New Design Method for Buried Flexible Pipes, Europipe '82.

7. Howard, A. K., Modulus of Soil Reaction Values for Buried Flexible Pipe, Journal of Geotechnical Division, ASCE, Vol. 103, January 1977.

8. Katona, M. G., Smith, J., Odello, R., and Allgood, J., CANDE - A Modern Approach for the Structural Design and Analysis of Buried Culverts, Federal Highway Administration, Publication No. FHWA-RD-77-5, October 1976.

9. Schrock, Jay, Proceedings of the International Conference on Underground Plastic Pipe, ASCE, 1981.

10. Spangler, M. G. and R. L. Handy, Soil Engineering, Harper and Row, 1982.

11. Transportation Research Board, Plastic Pipe for Subsurface Drainage of Transportation Facilities, Report 225, 1980.

12. Watkins, R. K., Szpak, E. and Allman, W. P., Structural Design of Polyethylene Pipes Subjected to External Soil Loads, Engineering Experiment Station, Utah State University, 1974.

13. Young, O. C., and Trott, J. J., Buried Rigid Pipes: Structural Design of Pipelines, Elsevier Applied Science Publishers, 1984.

Authority
30 CFR 77.216 through 77.217.

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PROCEDURE INSTRUCTION LETTER NO. I91-II-3

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Phreatic Surface

Scope

This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose

This is the tenth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions

All design plans submitted for MSHA approval must include minimum slope stability factors of safety as required by 30 CFR 77.216-2(a)(13) before approval will be granted. An integral part of any slope stability analysis is the phreatic surface which is assumed to be present. The assumed phreatic surface used in the stability analyses should be either conservatively depicted or substantiated with appropriate seepage analyses.

Piezometers should be used in embankments to monitor the phreatic surface so potential instability problems can be quickly identified. However, piezometers by themselves should not be used to determine if the phreatic surface used in the design process is acceptable. The seepage analysis should be used in the design process to determine the maximum anticipated phreatic surface. The piezometers are then used to monitor the phreatic surface during the life of the embankment and verify the phreatic surface used in the design. If piezometer readings above the phreatic surface used in the stability analysis are obtained and appear to be accurate, then the stability of the embankment should be reassessed using the higher phreatic surface.

The long-term stability analysis for each stage should be based on a phreatic surface in the embankment which is at or above the anticipated phreatic surface for the long-term steady-state seepage condition. The designer may choose to determine the phreatic surface which results in the minimum acceptable stability factors of safety. A seepage analysis should then be provided to indicate that the maximum anticipated phreatic surface is below the phreatic surface used to obtain the minimum acceptable stability factors of safety. The long-term, steady-state seepage condition should be determined by assuming the pool water surface elevation at the lowest ungated water outlet. This is usually the invert elevation of the lowest ungated principal spillway or, if an ungated principal spillway is not provided, the invert elevation of the lowest open channel spillway. The fine refuse beach formed on the upstream face of most coal refuse embankments is conservatively assumed to present no hydraulic head loss in the seepage analysis, due primarily to inherent uncertainties in determining its degree of consolidation, density, gradation, and coefficient of permeability.

Where applicable, the phreatic surface for a rapid reservoir drawdown condition should be evaluated for use in the rapid drawdown condition stability analysis. In many instances, the phreatic surface for the rapid reservoir drawdown condition will not be appreciably higher than the phreatic surface for the long-term steady-state seepage condition because the higher phreatic surface usually does not have sufficient time to fully develop or the upstream embankment soil is relatively free draining. Cedergren (Reference 6) provides a quick method for estimating the phreatic surface for drawdown conditions.

Many different methods are currently available for estimating the maximum anticipated phreatic surface for steady-state conditions within an embankment. The Corps of Engineers, Seepage Analysis and Control for Dams, EM-1110-2-1901 (Reference 9) provides an excellent summary of the available methods. Practically all methods are based on the LaPlace equations and Darcy's law of laminar flow through porous media. The complexity of the embankment in terms of permeability and anisotropic conditions, and the familiarity of the designer with a specific method usually dictates which method is used. Perhaps the most common methods are the flow net construction methods presented by Casagrande (Reference 5), Corps of Engineers (Reference 9), Cedergren (Reference 6), and the computerized finite element methods. The finite element methods are becoming increasingly more popular and are particularly useful for evaluating the effects of different conditions. However, no matter which method is used, extreme care must be exercised to ensure that the assumptions inherent in the method and procedures are fully satisfied or do not significantly affect the results.

The coefficients of permeability used in the seepage analysis should be either conservatively chosen or should be determined by using laboratory permeability tests (References 1, 4, 7) or field permeability tests (References 3, 4, 6, 9). The obtained coefficients of permeability are generally regarded as accurate to only one order of magnitude. This accuracy should be kept in mind for all seepage analyses.

It is well documented that compacted embankments usually demonstrate a coefficient of permeability in the horizontal direction which is greater than the coefficient of permeability in the vertical direction. A term called the "permeability ratio" is commonly used to express the horizontal coefficient of permeability to the vertical coefficient of permeability. The available literature shows a wide range of permeability ratios, from less than 1 to over 100, for earthen embankments. MSHA has examined the guidelines of other recognized agencies experienced in dam design and construction, most notably the Corps of Engineers (Reference 8) and the Bureau of Reclamation (Reference 3) and other published permeability ratios, and has concluded that all embankment plans should be designed assuming a minimum permeability ratio of 9. Although the published information supports this ratio, lower permeability ratios may be allowed provided they are adequately substantiated and documented.

Many types of drains are commonly incorporated in embankments to lower the phreatic surface, control internal seepage, and help stabilize the embankment. These drains must be designed for material compatibility and relative permeability with respect to surrounding soils as provided in MSHA's Procedure Instruction Letter Nos. I90-II-2 (Graded Filters) and I91-II-1 (Geotextiles as a Filter) to prevent piping yet provide adequate drainage capacity. Any drains used in the seepage analysis to determine the maximum anticipated phreatic surface should have calculations substantiating their capacity to carry at least 10 times the anticipated seepage flow. This drain capacity factor of safety is needed because of the potential inaccuracy of the coefficients of permeability and potential inadequacies in proper placement of the drain. A drain capacity factor of safety above 10 may even be warranted for conditions involving semi-turbulent and turbulent flow conditions. The Corps of Engineers (Reference 9), Cedergren (Reference 6), and Leps (Reference 10) provide information for determining flow rates for semi-turbulent and turbulent flow conditions where Darcy's law is invalid. Drains should be a size that will ensure that the phreatic surface is directed into the drain instead of over it. The drains should have adequate thickness, usually at least 3 feet, and the material be properly placed to prevent segregation.

REFERENCES

1. ASTM D2434, Standard Test Method for Permeability of Granular Soils (Constant Head), Annual Book of ASTM Standards, Sec. 4, Vol. 04.08, Soil and Rock; Building Stones, American Society of Testing and Materials, Philadelphia, 1984.

2. Bureau of Mines, RI8875 Estimating Horizontal Drain Design by the Finite-Element and Finite-Difference Methods, U.S. Dept. of the Interior.

3. Bureau of Reclamation, Chapter 8 Seepage Analysis and Control, U.S. Dept. of the Interior, Engineering and Research Center, Design Standards No. 13, Embankment Dams, 1987.

4. Bureau of Reclamation, Earth Manual, A Water Resources Technical Publication, U.S. Dept. of the Interior, 2nd Ed., 1985.

5. Casagrande, A., Seepage Through Dams, New England Water Works Association, Vol. II, No. 2, June 1937.

6. Cedergren, H. R., Seepage, Drainage, and Flow Nets, John Wiley & Sons, 1989.

7. Corps of Engineers, Laboratory Soils Testing, EM-1110-2-1906, Appendix VII, U.S. Dept. of the Army, 1986.

8. Corps of Engineers, Recommended Guidelines for Safety Inspection of Dams, Appendix D, U.S. Dept. of the Army, Guidelines issued pursuant to the National Dam Inspection Act, Public Law 92-367.

9. Corps of Engineers, Seepage Analysis and Control for Dams, EM-1110-2-1901, U.S. Dept. of the Army, 1986.

10. Leps, T.M., "Flow Through Rock Fill", Embankment-Dam Engineering-Casagrande Volume, John Wiley & Sons, 1973.

Authority
30 CFR 77.216 through 77.217.

Filing Instructions
MSHA personnel should file this letter behind the tab marked "Procedure Instruction Letters" in the binder for Program Policy Handbooks and Procedure Instruction Letters.

U.S. Department of Labor

Mine Safety and Health Administration
4015 Wilson Boulevard
Arlington, Virginia 22203-1984

EFFECTIVE DATE: 08/25/91 EXPIRATION DATE: 03/31/93

PROCEDURE INSTRUCTION LETTER NO. I91-II-4

FROM: MADISON McCULLOCH
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Special Considerations for Short-Term Conditions

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the eleventh letter in a series of MSHA's coal mine impounding structures review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
Coal waste disposal operations that are of sufficient size to fall within MSHA design criteria are best described as being in a constantly changing mode. The availability of embankment building material is generally dependent upon the rate of coal production and the percentage of waste material present in the mine's production. Mine waste impounding structures will grow quickly during periods of high mine production, such as those due to favorable market conditions, and remain stagnant during low mine production periods, such as those due to unfavorable market conditions, unless other types of embankment material are utilized. This is contrary to typical dam construction activity. When an impounding facility is built by other agencies or private industry, construction is usually continuous until completion of the facility. The operator of a refuse disposal facility should recognize that MSHA may require that a refuse dam be completed with other materials to maintain the operational safety of the structure.

The mining industry is confronted with conditions that are unique to waste disposal operations. In light of these conditions, MSHA will consider accepting a design storm of less magnitude than the full design storm during unavoidable short-term construction periods. Unavoidable refers to periods of time when application

of the full design storm criteria in the design of the structure is virtually impossible. These periods are normally associated with initial start-up conditions and abandonment. Normally, short-term criteria only applies during the first 2 years after the initial start-up of the facility, and within 2 years from the final abandonment of the site. There can be other times where unavoidable circumstances occur, but these circumstances should be very short-term. A smaller storm should never be used in the design just for convenience or to reduce the final cost of the structure.

A maximum time of 2 years is considered adequate for a mining company to resolve any conditions that would prevent the implementation of long-term criteria. This does not mean that in every case a full 2 year delay in implementation is appropriate. Generally, the timeframe will be much less than 2 years. It should always be kept to the lowest timeframe reasonably possible. With proper planning and diligent effort, most delays can be completely eliminated. Some examples of short-term conditions are as follows.

1. Short-term conditions may be necessary during initial construction of a new impounding structure. During this time, the embankment height is being raised to the design height to provide the necessary storage, surcharge, and freeboard to control the design storm. For coal refuse facilities, this time should not exceed a period of 6 months to 1 year.

2. In conditions where the company is changing from an open channel spillway to a storage type configuration, there could be a time period where the full design storm cannot be passed. This time must be as short as possible, and a very positive plan for the sequence of change must be provided.

3. During the period that an operating impounding facility is being changed to a non-impounding facility, the company must eliminate the available storage and/or surcharge by excavating the spillway deeper or by filling the impoundment with coarse refuse.

REFERENCE

E. D'Appolonia Consulting Engineers, Inc., Engineering and Design Manual - Coal Refuse Disposal Facilities, U.S. Department of the Interior, Mining Enforcement and Safety Administration (MESA), 1975, U.S. Government Printing Office.

U.S. Department of Labor

Mine Safety and Health Administration
4015 Wilson Boulevard
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EFFECTIVE DATE: 11/15/91 EXPIRATION DATE: 3/31/93

PROCEDURE INSTRUCTION LETTER NO. I91-II-5

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Effects of Mining on Dams and Impoundments

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the twelfth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
In designing a dam, an important factor to be considered is the location of present, and possible future, underground mining near the proposed site. One of the requirements for a safe dam is that deformations be minimized so that cracking of the dam is eliminated and an adequate freeboard is maintained. Another requirement is that seepage through a dam and its foundation be minimized and controlled. Mine subsidence and mining-induced strains can jeopardize these dam safety requirements.

When mine subsidence occurs, tensile strains are induced and zones of tension are created at the surface. As a result, cracks can occur in soils and mine waste materials because such materials have low resistance to tensile stress. Openings can occur in the foundation rock due to cracks or when tensile strains become concentrated along existing joints. Conduits that pass through a dam can be pulled apart or otherwise damaged by differential movements.

A crack in a dam, an open rock joint in its foundation, or a damaged conduit can result in piping due to the concentration of seepage in that area. Piping is a process of internal erosion where the amount of seepage progressively increases as more and more material is carried away with the flow. This process can lead to the eventual failure of the dam. A prime example of this is the Teton Dam failure in Idaho in 1976. Piping can occur

through the foundation soil or through the dam itself. The embankment or foundation materials may be carried into and through openings in the rock foundation. Piping can also occur along or in damaged conduits. Over 30 percent of all dam failures occur due to seepage or piping problems.

Differential movements resulting from subsidence can cause other problems by affecting the function of internal design features such as filters and drains. These problems can result in higher pore water pressures than the dam was designed for, and can cause slope failure. Subsidence also can reduce the amount of freeboard, and could result in the dam being overtopped during a storm.

For these reasons, a site that has been undermined or under which mining is planned may not be suitable for the construction of a dam. Designers should be sure to investigate alternative sites. Where use of an undermined site must be proposed, designers should realize that a more comprehensive foundation investigation is called for, that extensive remedial measures may be required to make the site acceptable, and that additional safety features are normally required in the dam's design.

Establishment of "Safety Zone"

The most prudent and recommended design approach is to locate dams far enough from mining that they will not be affected by subsidence. To do this, the area of mining influence should be delineated. One method of doing this is to determine a draw angle. This establishes a "safety zone" beneath and around the dam. No mining is permitted within this zone. The extent of the "safety zone" should be conservatively estimated, based on the specific site conditions and local experience, and considering that tensile strains as low as .1% to .3% are sufficient to cause cracks in some earthen materials.

All information used in determining how close to the dam the mining can safely occur, or the location of the "safety zone," needs to be fully documented in the impoundment plan submitted to MSHA for approval. Substantiation should include detailed geologic sections and mine maps. The analysis of the subsidence potential should take into account local subsidence experience and local conditions, and needs to include the technical basis for the proposed extent of the safety zone.

The information contained in References No. 1 and 3 should be consulted for information concerning "safety zones."

Uncertainties of Subsidence Effects

The problem in dealing with undermined sites is the difficulty in determining how subsidence has affected the foundation and in predicting how it will affect the dam. The effect that underground mining has on the surface depends primarily on the type of mining, the percent extraction and the amount and type of overburden. In room and pillar mining (first mining only), with adequately sized pillars and with competent roof and floor rock, there may be no significant impact at the surface. However, the surface may be affected if the pillars are too small; if they deteriorate with time; or if the floor is too weak, or becomes soft due to moisture, resulting in the pillars punching into it. At shallow depths, sinkholes can extend to the surface regardless of pillar size if entries are driven too wide. Full extraction mining methods will affect the surface in virtually all cases., with the surface strains generally increasing as the mining depth decreases.

With full extraction methods, uncertainty stems from the inability to predict and determine the tensile strain distribution at and near the surface. In room and pillar mining, there is the unknown long-term behavior of the roof/pillar/floor structural unit. In both cases, methods are lacking to establish the response of the dam and foundation materials to the potential strains or movements. Determining the true extent of disturbance to the foundation, and how it will behave under full reservoir head, is difficult even with an extensive foundation testing program. For these reasons, a thorough consideration of alternative sites should be made.

Design Features to Compensate for Mining Effects

If there are no alternatives, and a dam is proposed on a site that is already undermined, then a comprehensive foundation investigation is called for. Specific features must be incorporated into the dam's design to allow it to safely withstand any potential effects of the mining.

Design measures that should be considered in such cases include but are not limited to the following:

1. conducting a more extensive foundation investigation to locate openings and zones of high permeability;

2. taking special precautions during foundation preparation to ensure that any open joints or cracks in rock foundations are adequately sealed off, such as by grouting, or that a protective filter zone is provided;

3. backfilling or grouting the mine openings in critical support areas to minimize or reduce the amount of movement which can occur;

4. specifying a very wide dam cross-section and crest width to provide increased mass and greater resistance to piping failure;

5. maintaining an ample amount of freeboard to compensate for the maximum likely subsidence;

6. specifying larger drain and filter cross-sections, so that these internal features would continue to be functional with the maximum likely subsidence;

7. locating any decant pipes over unmined or backfilled areas;

8. compacting materials at water contents slightly wet of optimum to increase their ability to deform without cracking;

9. incorporating design features, such as a grout curtain and impermeable embankment zone, to minimize the amount of seepage through the dam and its foundation;

10. incorporating design features, such as a chimney drain, to collect seepage and discharge it in a controlled manner;

11. using wide zones of materials with "self-healing" characteristics, to act as crack stoppers; and

12. specifying a comprehensive monitoring program for the dam to provide for the early indication of a potential problem.

Proposed safety measures must be fully documented in the plan that is submitted to MSHA for approval. Plans should include detailed geologic information, mine maps showing present mine layout and mining projections, an evaluation of pillar and floor stability, analyses of subsidence and sinkhole potential, and an evaluation of the cracking and piping potential of the embankment and foundation materials. The subsidence analysis should describe all existing and anticipated movements and strains, how they were evaluated, and what specific design measures were incorporated to compensate for present and potential subsidence effects.

In general, a designer should include redundancy in the design so that the disruption or failure of any one feature would not jeopardize the safety of the dam. Required features must be selected and evaluated on a case-by-case basis depending on specific site conditions, especially the hazard potential. Plans that involve undermining and that are submitted without

conservative defensive measures, or without an adequate justification based on an appropriate level of testing and technical analyses, should not be approved.

Pillar/Floor/Roof Evaluations

The stability of the roof, pillars, and floor must be evaluated in cases where a dam is proposed over existing room and pillar mining, and in cases where a limited number of entries might be proposed under a dam. Analyses must show that pillars have a conservative factor of safety with respect to crushing. The factor of safety should be greater than 2.0 for the long-term support of critical areas. Since different methods of evaluating pillar strength can indicate a significant variation in safety factors, consideration of several methods is suggested and the use of a conservative method is called for. Where existing pillars are found to be inadequate, additional support, such as by grouting, needs to be provided. If the area is accessible, the possibility of providing support from underground should be considered.

The potential for subsidence due to pillars punching into the floor needs to be analyzed. In this regard, experience in the mine and the potential for softening of the floor due to moisture must be evaluated. Where the cover is shallow, the potential for sinkhole development also must be analyzed and accounted for in the design. In any of these analyses, the engineering properties of the coal and rock need to be determined by testing.

Mining Near Existing Dams

After a dam has been constructed, any mining that is to occur near it must be carefully planned. Due to the uncertainty of long-term support, the development of entries near or under dams needs to be avoided. Only under favorable conditions and where entry development is essential for ventilation or haulage safety should limited mining be considered under an existing dam.

Since full extracting mining methods, e.g., longwall mining and pillar extraction, affect the surface in virtually all cases, such mining is normally not acceptable either under a dam, or within a zone of influence of the dam.

Auger Holes or Mine Openings in Abutment

Where mine openings or auger holes occur in an abutment, plans need to include analyses showing that potential problems due to deformation and seepage have been accounted for in the design. In such cases, plans normally include provisions to provide support by backfilling the openings, and to control seepage by the placement of filters and drains along the openings.

Monitoring

In any case where mining induced deformations could have an adverse effect on the dam, the performance of the dam should be monitored. The monitoring of horizontal and vertical movements, piezometric levels, and seepage quantity is normally required.

Effects on the Mine

The possibility of a hazard to underground miners due to an inrush of water or slurry into the mine is another concern whenever there is mining near an impoundment. Plans should include a complete evaluation of this potential, including such items as:

1. the potential for an inrush into the mine due to sinkhole development;

2. the likelihood of increased mine water inflow due to higher overburden permeability;

3. the possibility of inflow due to disturbance to geologic discontinuities;

4. the potential inflow rates and volumes;

5. the possible flow paths and water depths within the mine;

6. the effects of inflow on mine ventilation and escapeways; and

7. the measures to be taken underground to handle inflow.

Regulations pertaining to mining under bodies of water are contained in 30 CFR 75.1716 through 75.1717. These regulations should be consulted prior to the commencement of such mining operations.

REFERENCES

1. Babcock, C. O. and V. E. Hooker, Results of Research to Develop Guidelines for Mining Near Surface and Underground Bodies of Water, IC 8741, U.S. Bureau of Mines, 17 pp., 1977.

2. Bieniawski, Z. T., Rock Mechanics Design in Mining and Tunneling, 1984.

3. Engineers International, Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining, Open File Report 45-81, U.S. Bureau of Mines, 364 pp., 1979.

4. Neito, A. S., Evaluation of Damage Potential to Earth Dam by Subsurface Coal Mining at Rend Lake, Illinois, Proceedings of Tenth Ohio River Valley Soils Seminar, Lexington, Kentucky, October, 1979.

5. Peng, S. S., Coal Mine Ground Control, John Wiley & Sons, 1978.

6. Whittaker, B. N., and D. J. Reddish, Subsidence; Occurrence, Prediction and Control, Elsevier Science Publishers, 1989.

Authority
30 CFR 77.216 through 77.217.

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EFFECTIVE DATE: 11/15/91 EXPIRATION DATE: 3/31/93

PROCEDURE INSTRUCTION LETTER NO. I91-II-6

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures: Erosion Protection for Spillways

Scope
This procedure instruction letter has been prepared to guide MSHA personnel who are responsible for reviewing impoundment plans. It is MSHA's intent that this information also be shared with the operators and designers of coal mine impounding structures.

Purpose
This is the thirteenth letter in a series of MSHA's coal mine impounding structure review guidelines regarding important design issues. MSHA's goal is that these issues be thoroughly considered so that plans have a sound engineering basis, with proper documentation.

Procedure Instructions
The integrity of open channel emergency spillways during a storm event must be ensured. Topographic constraints in the mining industry often necessitate that open channel spillways be placed immediately adjacent to or on the impounding structure. A failure of the spillway in this location could jeopardize the entire facility. The serious consequences of failure dictate that the same rationale used in the selection of the design storm event must apply to the design criteria for emergency spillways.

The preferred design of an open channel is to cut it through competent rock. When this is not possible, the design and construction of spillway linings for erosion protection must be accomplished in a manner that will ensure the maximum protection of the lining against the forces resulting from the peak design flow velocity.

Riprap has been used as channel lining material; however, its stability under high velocities is a serious concern. The various design methods that are available will yield a wide range of required rock sizes for a given set of conditions. These inconsistencies raise questions as to the application of those methods to the design of emergency spillway linings. Most riprap design methods were developed by Federal and State agencies for particular public works projects. Typical projects that might use riprap protection include highway embankments, bridge

abutments, flood channels, canals, and stilling basins. The type of project to be protected and the experience of each agency greatly influence the design method chosen. The failure of the riprap protection in these projects generally will not create a life-threatening situation. The failure of riprap lining in an emergency spillway could cause the breach of an impounding facility resulting in death and significant property damage. Therefore, the use of riprap in emergency spillways subjected to high velocities is strongly discouraged, unless special considerations are addressed. Plans proposing riprap must include calculations to support the proposed stone sizes. Riprap specifications should address stone gradation, layer thickness, bedding requirements, and stone durability.

Gabions, which consist of wire baskets filled with rock, are considered by many to solve some of the problems related to the use of riprap. Properly designed, the wire mesh can successfully contain a much smaller-sized rock when exposed to high velocity flow. This type of system has the limited ability to change shape without failure when unstable ground conditions occur. The problems associated with some of the hydraulic forces are eliminated because gabions are permeable.

Rigid linings are a potential solution to the limitations associated with the use of riprap or gabions. The list of rigid linings includes grouted riprap, concrete, and formed concrete products such as Armorform or Fabriform. Many rigid linings are destroyed due to flow undercutting the lining, channel headcuttings, or hydrostatic pressure behind the channel walls or floor. If a section of a rigid lining fails, then the remaining sections could fail in a rapid succession. Positive under-seepage cutoffs and weep holes are design measures that should therefore be used.

Formed concrete products are seeing application as spillway linings under certain conditions. Non-reinforced cement grout bags must be treated as rigid linings. As rigid linings, these systems present some concerns due to a lean concrete mix, a lack of aggregate in the mix, and an absence of embedded steel reinforcement. Also, the bag will deteriorate over time, allowing the cracked sections to move freely and independently. Recent advances have been made in increasing the strength and stability of uniform sections and articulated products. Steel or plastic fibers can be mixed with the cement grout to provide an increase in tensile and bending strength. Transverse and longitudinal cables of steel or nylon can be inserted to prevent excessive movement and separation.

Linings, consisting of synthetic grass-reinforcement materials, have been successfully used in some low hazard outlets and diversion channels where the anticipated velocities are low and loss of the structure would not be expected. These products are

still considered experimental and their use should be limited to low hazard facilities on a site-by-site basis.

The selection of the type of lining is critical to the overall facility design. Seeking design support from the manufacturer in making this decision is important. Manufacturers should be made thoroughly aware of the intended use of the product and the consequence of system failure.

The loss of lining protection cannot be allowed in an emergency spillway. Several concerns must be thoroughly addressed if such a protection system is being considered. The foundation is of primary importance. Erodible materials must be protected from the forces of high velocity flow. The design should include comprehensive foundation preparation and an appropriate base, which might include a geotextile and an underfilter. Additionally, the integrity of the lining material must be ensured. Damage is most likely during peak design storm conditions when the outflow is highest and maintenance access is unlikely. The impact of debris impingement and the resulting displacements must be considered. It is, therefore, critical that a positive means of lining protection or anchorage be developed. Systems that could satisfy this criteria might include an anchored wire mesh or grouted rock bolts to minimize movement, and a float device that would prevent debris from entering the spillway.

Regardless of the type of lining selected, a hydraulic analysis is needed to determine the maximum flow depths and velocities, the duration of such flows, and a complete water surface profile. This information will be used to determine the magnitude of the forces (e.g., hydrodynamic lift and drag, tractive and critical shear stress) that the particular lining will be exposed to. The plan submitted to MSHA should include a complete technical analysis demonstrating that the proposed lining is capable of withstanding these forces. The plan also must include detailed specifications on liner material and placement.

A significant consideration with any spillway, whether cut into rock or lined, is periodic examination. Exposure to the elements will cause deterioration to occur and, thus, evaluation of its extent and potential impact on performance is critical. Impoundment plans should include specific provisions addressing this concern.

REFERENCES

1. American Society of Civil Engineers, Review of Slope Protection Methods, Soil Mechanics and Foundation Division - Earth Dams - Slope Protection - Reports, June 1948, pp. 845-866.

2. Cameron, C. P., Cato, K., McAneny, C., and May, J., Geotechnical Aspects of Rock Erosion in Emergency Spillway Channels, Technical Report REMR-GT-3, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, August 1986.

3. Colorado State University, Hydraulic Test to Develop Design Criteria for the Use of Reno Mattresses, Civil Engineering Department, Fort Collins, Colorado, March 1984.

4. Federal Highway Administration, Design of Stable Channels with Flexible Linings, HEC 15, October 1975.

5. Simons, D. B., and Senturk, F., Sediment Transport Technology, Water Resources Publications, Fort Collins, Colorado, 1977.

6. State of California, Bank and Shore Protection in California Highway Practice, Division of Highways, Department of Public Works, November 1970.

7. U.S. Army Corps of Engineers, Practical Riprap Design, Waterways Experiment Station, Vicksburg, Mississippi, June 1978.

8. Walters, W. H., Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments, U.S. Dept. of Commerce, NTIS, August 1982.

Authority
30 CFR 77.216 through 77.217.

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EFFECTIVE DATE: 04/01/92 **EXPIRATION DATE: 03/31/94**

PROCEDURE INSTRUCTION LETTER NO. I92-II-1

FROM: MADISON McCULLOCH Madison McCulloch
Director of Technical Support

SUBJECT: Impounding Structures Safety Design Procedures

Scope
This procedure instruction letter (PIL) applies to MSHA personnel who review impoundment plans, and mine operators and designers of coal mine impounding structures.

Purpose
The purpose of this letter is to revalidate the information contained in the following PILs:

I90-II-1	Compaction Specifications
I90-II-2	Graded Filters
I90-II-3	Reservoir Evacuation by Pumping
I90-II-4	Pressure Testing Spillway Conduits
I90-II-5	Conduit Seepage Control Measures
I90-II-6	Probable Maximum Flood (PMF)
I90-II-7	Frequency of Moisture-Density Testing to Verify Compliance with Compaction Specifications
I91-II-1	Use of Geotextiles as a Filter

Although these PILs have an expiration date of March 31, 1992, the information is still relevant and should be retained and used.

Background
Design and construction plans for active and proposed impounding structures are submitted by coal mine operators to MSHA for review and approval. MSHA is addressing important design issues in a series of coal mine impounding structure guidelines. Although the procedure instruction letters have expiration dates, the information should continue to be used until instructions to the contrary are issued. MSHA intends to update and expand on the issues as needed until all guidelines have been issued.

Authority
30 CFR 77.216 through 77.217.

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APPENDIX C

DEPARTMENT OF LABOR

Mine Safety and Health Administration

30 CFR Part 77

RIN 1219-AA49

Safety Standards for Refuse Piles and Waste Impoundment Dams at Surface Coal Mines and Surface Work Areas of Underground Coal Mines

AGENCY: Mine Safety and Health Administration, Labor.

ACTION: Final rule.

SUMMARY: This final rule revises the Mine Safety and Health Administration's (MSHA) safety standards that address refuse piles and impoundment structures used at coal mines to dispose of refuse or to contain water, sediment, or slurry. These revisions address reports and certifications for refuse piles and impoundment structures, frequency of inspections of impoundments, and the method of abandoning impoundments and impounding structures. The final rule affects surface coal mines and surface areas of underground coal mines.

EFFECTIVE DATE: May 1, 1992

FOR FURTHER INFORMATION CONTACT: Patricia W. Silvey, Director, Office of Standards, Regulations and Variances, MSHA, (703) 235-1910.

SUPPLEMENTARY INFORMATION:

I. Background

On June 15, 1990, MSHA published a proposed rule in the Federal Register (55 FR 24526) to revise reporting and recordkeeping requirements for impoundment structures and

refuse piles. The proposal also addressed the frequency of inspections for impoundments, and the method of abandoning impoundments and impounding structures. The public comment period for this proposal was scheduled to close on September 21, 1990, but in response to a request from the mining community, the comment period was extended until October 19, 1990 (55 FR 39300). MSHA held a public hearing on December 13, 1990, in Pittsburgh, Pennsylvania (55 FR 48806). A transcript of the hearing was made available for public inspection. Following the hearing, MSHA allowed commenters to submit supplementary statements and data until the record closed on January 18, 1991. MSHA received written and oral statements on the proposed rule from both labor and industry. The Agency developed this final rule after a full evaluation of the entire rulemaking record.

II. Discussion of Final Rule

Impoundments are structures that are used to impound water, sediment, slurry, or any combination of these materials. Refuse piles are deposits of coal mine waste that are removed during mining operations or separated from mined coal and deposited on the surface. The failure of impoundment structures can flood and devastate downstream communities. To avoid or minimize these disasters, MSHA's existing safety standards in 30 CFR 77.214 through 77.217 address the construction and maintenance of impoundments and refuse piles.

The revisions in this final rule clarify existing paperwork requirements or provide alternative procedures for inspecting and

abandoning impoundments. The final rule reduces reporting and recordkeeping burdens on the mining industry by reducing the frequency of recordkeeping and reporting requirements in appropriate instances. Reports are replaced by certifications except when actual or potential hazardous conditions exist. The final rule preserves the effectiveness of the existing requirements and does not lessen the protection afforded to miners.

III. Section-by-Section Discussion

Section 77.215-2 Refuse piles; reporting requirements.

Existing § 77.215-2 requires mine operators to submit certain information concerning refuse piles to MSHA's District Manager. Paragraphs (b)(4) through (b)(8) require the operator to report the following information: a topographic map; whether or not the refuse pile is burning; a description of measures taken to prevent water from being impounded or contained within the refuse pile; a diagram with cross sections of the refuse pile; and any other information pertaining to the stability of the refuse pile which may be required by the District Manager. Paragraph (c) requires this information to be reported every twelfth month once a refuse pile has been declared a hazard. There is no provision for cessation of such reports if the hazardous conditions are eliminated. Under the existing standard, the annual reporting requirement ceases only when the site is abandoned according to an approved plan.

The final rule, like the proposal, clarifies and revises § 77.215-2(c). It continues to require reports on refuse piles to be submitted to MSHA's District Manager every twelfth month once a refuse pile has been declared a hazard, but only if the refuse pile continues to present a hazard. The revision allows MSHA's District Manager to determine if a site should no longer be considered hazardous.

Several commenters were in agreement with the standard as proposed. However, one commenter stated that if a site had been considered hazardous and is still active, it is susceptible to change and could easily become hazardous and that the reporting requirement should remain in effect until the site is abandoned. This commenter objected to the District Manager determining when a site is no longer considered hazardous, stating the District Manager does not possess the expertise to make this determination and should not be given such authority.

In response to this commenter, MSHA emphasizes that all refuse piles remain active until they are properly abandoned, and while they are active they are inspected by MSHA at regular intervals. If any hazard recurs or a new hazard is found, the reporting requirements would again apply. In addition, District Managers, with the help of other MSHA personnel, regularly determine if hazardous conditions exist at coal mines. Specifically, the existing standard recognizes that the District Manager has the expertise to identify if a refuse pile can

present a hazard and the authority to declare that the hazard no longer exists.

This revision will not lessen the protection afforded miners since a report will continue to be required as long as the refuse pile presents a hazard.

Section 77.215-3 Refuse piles; certification.

Existing § 77.215-3(a) requires certification by a registered engineer that a hazard associated with a refuse pile has been addressed. The certification is required within 180 days following written notice by the District Manager that a refuse pile can present a hazard. The final rule, like the proposal, revises § 77.215-3(a) to allow operators to certify that a refuse pile that has been identified as hazardous is being constructed in accordance with current prudent engineering practices. The existing standard does not recognize the possibility that elimination of a hazard could take more than 180 days. The wording of the final rule recognizes that in some cases it may take more than 180 days to eliminate the hazard on a refuse pile.

As proposed, MSHA is also revising § 77.215-3(b) to require a certification every twelfth month once a refuse pile has been declared a hazard only for as long as the refuse pile presents a hazard. The existing standard does not provide a mechanism to terminate the certification requirements after the hazard has been eliminated unless the site is abandoned through an approved plan, a process that could take many years.

Several commenters agreed with the standard as proposed, while one commenter suggested retaining the existing recordkeeping requirement. This revision will not reduce the protection provided miners since the reporting requirement will remain in effect as long as the refuse pile can present a hazard. The final rule will allow the reporting requirement to be terminated when the hazard is eliminated.

Section 77.216-3 Water, sediment, or slurry impoundments and impounding structures; inspection requirements; correction of hazards; program requirements.

Under existing § 77.216-3(a), impoundments and impounding structures must be inspected at intervals not exceeding 7 days for appearances of structural weakness and other hazardous conditions. All instruments must also be monitored at intervals not exceeding 7 days. As proposed, MSHA is revising existing § 77.216-3(a) to allow for inspection frequencies other than the 7 days. Under the final rule, the District Manager may approve alternative inspection frequencies based on the hazard potential of the impoundment as well as its demonstrated performance history. The final rule also includes a requirement for immediate inspection after a specified rain event approved by the District Manager.

This revision allows the District Manager some flexibility to vary the frequency of required inspections and minimizes recordkeeping requirements for impoundments that have a demonstrated record of safety and present low hazard potential.

Unless the District Manager approves an alternative inspection frequency, the required inspection period for impounding structures remains every 7 days. However, when the District Manager allows an alternative inspection frequency, the final rule provides an equally safe, if not safer, alternative because a specified rain event will trigger an immediate inspection regardless of when the previous inspection occurred.

Reasons for extending the time between inspections would include both a low hazard potential for the structure and a demonstrated history of performance. The potential for extension of inspection time periods will encourage operators to install instrumentation with the knowledge that once the structure has a demonstrated record of safe performance, less frequent inspections and instrument readings would be possible. Under the existing rule, operators sometimes avoided installing instrumentation since all instrumentation is required to be monitored every 7 days.

The revised standard would also reduce the number of unnecessary inspections as well as the need for miners to travel in remote areas when it has been demonstrated that the structure has very little hazard potential. Before the impoundment standards were originally promulgated on September 9, 1975 (40 FR 41776), MSHA did not require engineering plans for impoundments at coal mines. However, since 1975 all impoundments at coal mines have been required to be constructed in accordance with engineering plans approved by MSHA. There has been general

compliance with this requirement. This successful use of engineering controls makes it less important to rely so heavily on frequent inspections and gives the Agency more information with which to determine when less frequent inspection is warranted.

One commenter agreed with the proposal stating that it recognizes that each impoundment has a different level of safety that is based on design, construction, and location. Several other commenters stated that the proposed language provides a needed flexibility in determining the appropriate inspection intervals and recordkeeping requirements for impoundments. Further, these commenters stated that the only relief from the current inspection requirements has been the petition for modification procedure, which can be a time consuming and burdensome process.

Another commenter expressed concern that the condition of some impoundments can change rapidly with adverse weather conditions. In such situations, a 7 day inspection would be too infrequent. This commenter recommended that more frequent inspections be required in times of adverse weather conditions, such as rainy weather.

In response to these commenters, the final rule requires immediate inspection after a specified rain event approved by the District Manager. Such a rain event may differ for each impoundment depending on factors such as design, size, type of construction and hazard potential of the impoundment. It will

also vary depending on geographical location of the impoundment and regional weather patterns. The Agency intends that the event be defined as a specific amount of rainfall over a period of time. This change will ensure a greater degree of protection to persons, while at the same time providing greater flexibility to allow longer inspection intervals for impoundments that have proven stable and are functioning as designed. It should also be noted that if a potentially hazardous condition develops at an impoundment, existing § 77.216-3(b)(4) requires the operator to examine the structure and monitor the instrumentation at least once every 8 hours, or more often, as required by an authorized representative. This provision remains unchanged.

Section 77.216-4 Water, sediment, or slurry impoundments and impounding structures; reporting requirements; certification.

Under existing § 77.216-4, mine operators must submit an annual report to the District Manager describing any changes to the impoundment. The report must be certified by a registered engineer that all work was done according to an approved plan. Under the final rule, if an impoundment or impounding structure has not undergone any changes in the previous year, the mine operator only submits a certification by a registered professional engineer that there have been no changes. The final rule requires reports if the engineer's examination reveals indications of structural weakness, hazardous conditions, or other changes to the structure. This provision reduces the reporting requirements for operators whose impoundments have not

changed during the reporting period. This revision would continue to provide for submission of records that allow for comparison of changing conditions and the identification of potentially unsafe situations.

One commenter expressed concern over MSHA's burden hour estimate regarding the average time required to prepare a report, suggesting that the potential time saving that could be realized is much greater than estimated. Another commenter stated and MSHA agrees that the revision would result in a more useful record and would enhance the ability of the operators to focus on potentially unsafe situations.

One commenter opposed the proposed revision, stating that water impoundments pose a great risk to the communities in many areas. Another commenter stated that MSHA should require a yearly inspection by an engineer or a professional specialist to ensure the safety of the structure. In response to these commenters, paragraph (a)(7) requires a registered professional engineer to certify that the impoundment has undergone no changes in the previous year. This revision does not reduce the protection provided by the existing standard. Although it eliminates a reporting requirement when there are no changes to report, it maintains the requirement whenever a change occurs to the impounding structure. Paragraph (b) also requires that a report be submitted at least every 5 years for impoundments that have not been changed. This provision was not proposed but has been incorporated into the final rule. In addition, the

certification provision does not affect the requirements for regular inspections under § 77.216-3.

Another commenter requested clarification of the statement "changes in the impoundment during the reporting period." This commenter questioned whether the term "changes" refers to normal sediment deposition or modification of the structure. The Agency intends that natural sediment deposition, in itself, does not constitute a reportable change unless it occurs to the extent that it affects the design performance of the structure and appurtenances. For purposes of clarification, reportable changes would include modifications to the structure during the reporting period and changes that affect the stability or operation of the impoundment.

Section 77.216-5 Water, sediment or slurry impoundments and impounding structures; abandonment.

Under existing § 77.216-5, in order to abandon an impoundment, the operator must preclude the possibility of future impoundment of water. This provision prevents several functional and recreational uses for impounding structures such as water storage, flood control, farming, or maintenance of recreational lakes or ponds for fishing, boating, or swimming. As proposed, the final rule revises § 77.216-5 to allow operators to obtain MSHA approval of an impoundment abandonment plan that does not preclude the future impoundment of water. Under the revised standard, the abandonment plan still requires District Manager approval.

MSHA will allow approval of an abandonment plan without provisions to preclude the future impoundment of water only when certain requirements are met. Under paragraph (b), these requirements include certification by a registered engineer knowledgeable in dam design that the structure conforms to the design drawings and has no apparent defects, certification from the owner or prospective owner that there is a willingness and ability to assume the responsibility to operate and maintain the structure, and a requirement that the owner obtain a permit or approval for the structure from the appropriate State or Federal regulatory authority. For purposes of clarification, the term "knowledgeable," which describes the level of expertise required of the certifying engineer, has been changed from the term "familiar" in the proposed rule.

Further, since promulgation of the existing standards in 1975, other agencies have become involved in the regulation of impounding structures associated with mining. The Surface Mining Control and Reclamation Act of 1977 established the Office of Surface Mining (OSM) in the Department of Interior. OSM has promulgated extensive surface regulations that include the control of fresh water, waste, and sediment structures. The OSM regulations also reference MSHA standards for impoundments under §§ 77.216 through 77.216-3.

OSM's regulations on impoundments (30 CFR 816.49) permit the operator to have a permanent impoundment. The requirements for permanent impoundments are part of OSM's "Post-Mining Land Use

Plan." As part of this plan, the operator's permit is based on the following criteria:

1. The impoundment must be adequate for its intended purpose.

2. Final grading must provide adequate safety.

3. The spillway must be designed as the regulatory authority may require.

MSHA's final rule includes a provision that would require the current or prospective owner to obtain a permit for post-mining use of impoundments from the State or Federal regulatory authority. For purposes of clarification the term "Federal" has been added to the standard to recognize that in some States a Federal agency may issue the necessary permit.

The term "prospective owner" has also been added to this section in order to address the situation where the operator may wish to leave the impoundment in place at the request of a third party who may have an interest in the continued existence of the structure. If the plan for the structure is to transfer it to a third party, the Agency needs assurance of the willingness and ability of the third party to operate and maintain the structure. The Agency intends that the responsible party be capable of operating as well as maintaining the structure, therefore the term operation has been added to the final rule. Under the safeguards provided in the final rule, the Agency believes that the flexibility to allow for post-mining uses of some impounding

structures is warranted, does not reduce safety, and has a beneficial societal impact.

Several commenters agreed with the proposed standard. They stated that allowing impounding structures to remain after abandonment will provide a valuable public service in that many of these impoundments can be used for water storage, flood control, wildlife habitat, and recreation. However, one commenter disagreed with the proposed standard, stating that most water impoundments retain the water that has been used in the coal cleansing process because the water is laden with toxic chemicals which would pose a hazard to people and could not possibly sustain any form of life.

A review of the approximately 750 impounding structures inspected by MSHA at coal mines indicates that about 50 percent of these structures were designed for sediment storage or as fresh water reservoirs. In addition, MSHA finds that some benefits can be attained when impounding structures associated with coal mining are left in place. Such structures can continue to perform sediment control and other beneficial functions after the slurry input has stopped and the quality of water improves. However, MSHA anticipates that impounding structures constructed of coal mine waste or designed to impound coal mine waste will generally not receive permits to be left in place. The reason for this is that 30 CFR 816.84(b)(1), an OSM regulation, does not currently allow such structures to be permanently left in place.

MSHA anticipates that this revision will primarily apply to small, low hazard, earthen structures that do not have the potential for loss of life or substantial property damage. Through the flexibility provided in the final rule, impoundments that do not present a hazard to miners or to the public could be left intact where they will serve future societal uses.

IV. Executive Order 12291 and the Regulatory Flexibility Act

This rule will not result in major cost increases nor have an incremental effect of $100 million or more on the economy. Therefore, this rule does not fall within the criteria of a major rule and Executive Order 12291 does not require a Regulatory Impact Analysis to be prepared. MSHA estimates that compliance with this final rule will result in a cost reduction of $1,919,000.

The final rule revises the existing rule and reduces the recordkeeping and reporting burden by about 64,000 hours, from 175,000 hours to 111,000 hours. Specifically, the revisions to §§ 77.215-2 and 77.215-3, which provide a mechanism to terminate the annual reporting requirement after the hazard has been eliminated, will decrease the total number of reports to be completed from 50 to 25, reducing the burden from 100 to 50 hours and resulting in a cost reduction of $1,500. It is estimated that the revision to § 77.216-3, which allows flexibility to reduce the frequency of inspections (thereby, the recordkeeping requirements) for impoundments that have a demonstrated record of safety, will decrease the total burden from about 94,000 to

31,000 hours and result in a cost reduction of $1,890,000. Finally, the revision to § 77.216-4, which requires a report only when there are indications of structural changes or hazardous conditions, will decrease the total number of reports to be completed from 750 to 300, reducing the burden from 1,500 to 600 hours and resulting in a cost reduction of $27,000.

The Regulatory Flexibility Act requires that agencies evaluate and include, whenever possible, compliance alternatives that minimize adverse impacts on small businesses. MSHA has determined that this final rule will not have a significant impact on a substantial number of small entities. Accordingly, a regulatory flexibility analysis is not required.

V. List of Subjects in 30 CFR Part 77

Mine safety and health, Refuse piles, impoundments and impounding structures.

William J. Tattersall
Assistant Secretary for
Mine Safety and Health

Date

Accordingly, subchapter O, chapter I, title 30 of the Code of Federal Regulations is amended under 30 U.S.C. 811 as follows:

Part 77--MANDATORY SAFETY STANDARDS--SURFACE COAL MINES AND SURFACE WORK AREAS OF UNDERGROUND COAL MINES

1. The authority citation to 30 CFR part 77 continues to read as follows:

Authority: 30 U.S.C. 811, 957 and 961.

2. Section 77.215-2 is amended by revising paragraph (c) to read as follows:

§ 77.215-2 Refuse piles; reporting requirements.

* * * * *

(c) The information required by paragraphs (b)(4) through (b)(8) of this section shall be reported every twelfth month from the date of original submission for those refuse piles which the District Manager has determined can present a hazard until the District Manager notifies the operator that the hazard has been eliminated.

3. Section 77.215-3 is amended by revising paragraphs (a) and (b) to read as follows:

§ 77.215-3 Refuse piles; certification.

(a) Within 180 days following written notification by the District Manager that a refuse pile can present a hazard, the person owning, operating, or controlling the refuse pile shall submit to the District Manager a certification by a registered engineer that the refuse pile is being constructed or has been modified in accordance with current, prudent engineering practices to minimize the probability of impounding water and failure of such magnitude as to endanger the lives of miners.

(b) After the initial certification required by this section and until the District Manager notifies the operator that the hazard has been eliminated, certification shall be submitted every twelfth month from the date of the initial certification.

* * * * *

4. Section 77.216-3 is revised by amending paragraph (a) to read as follows:

<u>§ 77.216-3 Water, sediment, or slurry impoundments and impounding structures; inspection requirements; correction of hazards; program requirements</u>.

(a) All water, sediment, or slurry impoundments that meet the requirements of § 77.216(a) shall be examined as follows:

(1) At intervals not exceeding 7 days, or as otherwise approved by the District Manager, for appearances of structural weakness and other hazardous conditions.

(2) All instruments shall be monitored at intervals not exceeding 7 days, or as otherwise approved by the District Manager.

(3) Longer inspection or monitoring intervals approved under this paragraph (a) shall be justified by the operator based on the hazard potential and performance of the impounding structure, and shall include a requirement for inspection immediately after a specified rain event approved by the District Manager.

(4) All inspections required by this paragraph (a) shall be performed by a qualified person designated by the person owning, operating, or controlling the impounding structure.

* * * * *

5. Section 77.216-4 is revised to read as follows:

§ 77.216-4 Water, sediment or slurry impoundments and impounding structures; reporting requirements; certification.

(a) Except as provided in paragraph (b) of this section, every twelfth month following the date of the initial plan approval, the person owning, operating, or controlling a water, sediment, or slurry impoundment and impounding structure that has not been abandoned in accordance with an approved plan shall submit to the District Manager a report containing the following information:

(1) Changes in the geometry of the impounding structure for the reporting period.

(2) Location and type of installed instruments and the maximum and minimum recorded readings of each instrument for the reporting period.

(3) The minimum, maximum, and present depth and elevation of the impounded water, sediment, or slurry for the reporting period.

(4) Storage capacity of the impounding structure.

(5) The volume of the impounded water, sediment, or slurry at the end of the reporting period.

(6) Any other change which may have affected the stability or operation of the impounding structure that has occurred during the reporting period.

(7) A certification by a registered professional engineer that all construction, operation, and maintenance was in accordance with the approved plan.

(b) A report is not required under this section when the operator provides the District Manager with a certification by a registered professional engineer that there have been no changes under paragraphs (a)(1) through (a)(6) of this section to the impoundment or impounding structure. However, a report containing the information set out in paragraph (a) of this section shall be submitted to the District Manager at least every 5 years.

6. Section 77.216-5 is revised to read as follows:

<u>§ 77.216-5 Water, sediment or slurry impoundments and impounding structures; abandonment</u>.

(a) Prior to abandonment of any water, sediment, or slurry impoundment and impounding structure which meets the requirements of 30 CFR § 77.216(a), the person owning, operating, or controlling such an impoundment and impounding structure shall submit to and obtain approval from the District Manager, a plan for abandonment based on current, prudent engineering practices. This plan shall provide for major slope stability, include a schedule for the plan's implementation and, except as provided in paragraph (b) of this section, contain provisions to preclude the probability of future impoundment of water, sediment, or slurry.

(b) An abandonment plan does not have to contain a provision to preclude the future impoundment of water if the plan

is approved by the District Manager and documentation is included in the abandonment plan to ensure that the following requirements are met:

(1) A registered professional engineer, knowledgeable in the principles of dam design and in the design and construction of the structure, shall certify that it substantially conforms to the approved design plan and specifications and that there are no apparent defects.

(2) The current owner or prospective owner shall certify a willingness and ability to assume responsibility for operation and maintenance of the structure.

(3) A permit or approval for the continued existence of the impoundment or impounding structure shall be obtained from the Federal or State agency responsible for dam safety.

[FR Doc. 92-4678 Filed 2-28-92; 8:45 a.m.]

Mine Safety & Health Administration's
Safety Standards for
Refuse Piles & Impoundments at Coal Mines

PART 77-MANDATORY SAFETY STANDARDS, SURFACE COAL MINES AND SURFACE WORK AREAS OF UNDERGROUND COAL MINES

Subpart A-General

Sec.

77.1 Scope.

77.214 Refuse piles; general.

77.215 Refuse piles, construction requirements.

77.215-1 Refuse piles; identification.

77.215-2 Refuse piles; reporting requirements.

77.215-3 Refuse piles; certification.

77.215-4 Refuse piles; abandonment.

77.216 Water, sediment, or slurry impoundments and impounding structures; general.

77.216-1 Water, sediment or slurry impoundments and impounding structures; identification.

77.216-2 Water, sediment, or slurry impoundments and impounding structures; minimum plan requirements; changes or modifications; certification.

77.216-3 Water, sediment, or slurry impoundments and impounding structures; inspection requirements; correction of hazards; program requirements.

77.216-4 Water, sediment or slurry impoundments and impounding structures; reporting requirements; certification.

77.216-5 Water, sediment or slurry impoundments and impounding structures; abandonment.

77.217 Definitions.

Subpart A-General

§ 77.1 Scope.

This Part 77 sets forth mandatory safety standards for bituminous, anthracite, and lignite surface coal mines, including open pit and auger mines, and to the surface work areas of underground coal mines, pursuant to section 101(i) of the Federal Mine Safety and Health Act of 1977.

[36 FR 9364, May 22, 1971, as amended at 43 FR 12320, Mar. 24, 1978]

§ 77.214 Refuse piles; general.

(a) Refuse piles constructed on or after July 1, 1971, shall be located in areas which are a safe distance from all underground mine airshafts, preparation plants, tipples, or other surface installations and such piles shall not be located over abandoned openings or steamlines.

(b) Where new refuse piles are constructed over exposed coal beds the exposed coal shall be covered with clay or other inert material as the piles are constructed.

(c) A fireproof barrier of clay or inert material shall be constructed between old and new refuse piles.

(d) Roadways to refuse piles shall be fenced or otherwise guarded to restrict the entrance of unauthorized persons.

[36 FR 9364, May 22, 1971, as amended at 36 FR 13143, July 15, 1971]

§ 77.215 Refuse piles; construction requirements.

(a) Refuse deposited on a pile shall be spread in layers and compacted in such a manner so as to minimize the flow of air through the pile.

(b) Refuse shall not be deposited on a burning pile except for the purpose of controlling or extinguishing a fire.

(c) Clay or other sealants shall be used to seal the surface of any refuse pile in which a spontaneous ignition has occurred.

(d) Surface seals shall be kept intact and protected from erosion by drainage facilities.

(e) Refuse piles shall not be constructed so as to impede drainage or impound water.

(f) Refuse piles shall be constructed in such a manner as to prevent accidental sliding and shifting of materials.

(g) No extraneous combustible material shall be deposited on refuse piles.

(h) After October 31, 1975 new refuse piles and additions to existing refuse piles, shall be constructed in compacted layers not exceeding 2 feet in thickness and shall not have any slope exceeding 2 horizontal to 1 vertical (approximately 27°) except that the District Manager may approve construction of a refuse pile in compacted layers exceeding 2 feet in thickness and with slopes exceeding 27° where engineering data substantiates that a minimum safety factor of 1.5 for the refuse pile will be attained.

(i) Foundations for new refuse piles and additions to existing refuse piles shall be cleared of all vegetation and undesirable material that according to current, prudent engineering practices would adversely affect the stability of the refuse pile.

(j) All fires in refuse piles shall be

extinguished, and the method used shall be in accordance with a plan approved by the District Manager. The plan shall contain as a minimum, provisions to ensure that only those persons authorized by the operator, and who have an understanding of the procedure to be used, shall be involved in the extinguishing operation.

(The requirements contained in paragraph (j) were approved by the Office of Management and Budget under control number 1219-0074)

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957), Pub. L. No. 96-511, 94 Stat. 2812 (44 U.S.C. 3501 et seq.))

[36 FR 9364, May 22, 1971, as amended at 40 FR 41776, Sept. 9, 1975; 47 FR 14696, Apr. 6, 1982]

§ 77.215-1 Refuse piles; identification.

A permanent identification marker, at least six feet high and showing the refuse pile identification number as assigned by the District Manager, the name associated with the refuse pile and the name of the person owning, operating or controlling the refuse pile, shall be located on or immediately adjacent to each refuse pile within the time specified in paragraphs (a) or (b) of this section as applicable.

(a) For existing refuse piles, markers shall be placed before May 1, 1976.

(b) For new or proposed refuse piles, markers shall be placed within 30 days from acknowledgment of the proposed location of a new refuse pile.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))
[40 FR 41776, Sept. 9, 1975]

§ 77.215-2 Refuse piles; reporting requirements.

(a) The proposed location of a new refuse pile shall be reported to and acknowledged in writing by the District Manager prior to the beginning of any work associated with the construction of the refuse pile.

(b) Before May 1, 1976, for existing refuse piles, or within 180 days from the date of acknowledgment of the proposed location of a new refuse pile, the person owning, operating or controlling a refuse pile shall submit to the District Manager a report in triplicate which contains the following:

(1) The name and address of the person owning, operating or controlling the refuse pile; the name associated with the refuse pile; the identification number of the refuse pile as assigned by the District Manager; and the identification number of the mine or preparation plant as assigned by MSHA.

(2) The location of the refuse pile indicated on the most recent USGS 7 1/2 minute or 15 minute topographic quadrangle map, or a topographic map of equivalent scale if a USGS map is not available.

(3) A statement of the construction history of the refuse pile, and a statement indicating whether the refuse pile has been abandoned in accordance with a plan approved by the District Manager.

(4) A topographic map showing at a scale not to exceed 1 inch=400 feet, the present and proposed maximum extent of the refuse pile and the area 500 feet around the proposed maximum perimeter.

(5) A statement of whether or not the refuse pile is burning.

(6) A description of measures taken to prevent water from being impounded by the refuse pile or contained within the refuse pile.

(7) At a scale not to exceed 1 inch=100 feet, cross sections of the length and width of the refuse pile at sufficient intervals to show the approximate original ground surface, the present configuration and the proposed maximum extent of the refuse pile, and mean sea level elevations at significant points.

(8) Any other information pertaining to the stability of the pile which may be required by the District Manager.

(c) The information required by paragraphs (b)(4) through (b)(8) of this section shall be reported every twelfth month from the date of original submission for those refuse piles which the District Manager has determined can present a hazard and which have not been abandoned in accordance with a plan approved by the District Manager.

(Approved by the Office of Management and Budget under control numbers 1219-0015 and 1219-0060)

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957), Pub. L. No. 96-511, 94 Stat. 2812 (44 U.S.C. 3501 et seq.))

[40 FR 41776, Sept. 9, 1975, as amended at 47 FR 14696, Apr. 6, 1982]

§ 77.215-3 Refuse piles: certification.

(a) Within 180 days following written notification by the District Manager that a refuse pile can present a hazard, the person owning, operating, or controlling the refuse pile shall submit to the District Manager a certification by a registered engineer that the refuse pile is constructed or has been modified in accordance with current, prudent engineering practices to minimize the probability of impounding water and failure of such magnitude as to endanger the lives of miners.

(b) After the initial certification required by this section, certifications shall be submitted every twelfth month from

the date of the initial certification for all refuse piles which have not been abandoned in accordance with a plan approved by the District Manager.

(c) Certifications required by paragraphs (a) and (b) of this section shall include all information considered in making the certification.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))

[40 FR 41776, Sept. 9, 1975]

§ 77.215-4 Refuse piles; abandonment.

When a refuse pile is to be abandoned, the District Manager shall be notified in writing, and if he determines it can present a hazard, the refuse pile shall be abandoned in accordance with a plan submitted by the operator and approved by the District Manager. The plan shall include a schedule for its implementation and describe provisions to prevent burning and future impoundment of water, and provide for major slope stability.

(Approved by the Office of Management and Budget under control number 1219-0074)

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957), Pub. L. No. 96-511, 94 Stat. 2812 (44 U.S.C. 3501 et seq.))

[40 FR 41776, Sept. 9, 1975, as amended at 47 FR 14696, Apr. 6, 1982]

§ 77.216 Water, sediment, or slurry impoundments and impounding structures; general.

(a) Plans for the design, construction, and maintenance of structures which impound water, sediment, or slurry shall be required if such an existing or proposed impounding structure can:

(1) Impound water, sediment, or slurry

to an elevation of five feet or more above the upstream toe of the structure and can have a storage volume of 20 acre-feet or more; or

(2) Impound water, sediment, or slurry to an elevation of 20 feet or more above the upstream toe of the structure; or

(3) As determined by the District Manager, present a hazard to coal miners.

(b) Plans for the design and construction of all new water, sediment, or slurry impoundments and impounding structures which meet the requirements of paragraph (a) of this section shall be submitted in triplicate to and be approved by the District Manager prior to the beginning of any work associated with construction of the impounding structure.

(c) Before May 1, 1976, a plan for the continued use of an existing water, sediment, or slurry impoundment and impounding structure which meets the requirements of paragraph (a) of this section shall be submitted in triplicate to the District Manager for approval.

(d) The design, construction, and maintenance of all water, sediment, or slurry impoundments and impounding structures which meet the requirements of paragraph (a) of this section shall be implemented in accordance with the plan approved by the District Manager.

(e) All fires in impounding structures shall be extinguished, and the method used shall be in accordance with a plan approved by the District Manager. The plan shall contain as a minimum, provisions to ensure that only those persons authorized by the operator, and who have an understanding of the procedures to be used, shall be involved in the extinguishing operation.
(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))

[40 FR 41776, Sept. 9, 1975]

§ 77.216-1 Water, sediment or slurry impoundments and impounding structures; identification.

A permanent identification marker, at least six feet high and showing the identification number of the impounding structure as assigned by the District Manager, the name associated with the impounding structure and name of the person owning, operating, or controlling the structure, shall be located on or immediately adjacent to each water, sediment or slurry impounding structure within the time specified in paragraph (a) or (b) of this section as applicable.

(a) For existing water, sediment or slurry impounding structures, markers shall be placed before May 1, 1976.

(b) For new or proposed water, sediment, or slurry impounding structures, markers shall be placed within 30 days from the start of construction.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))

[40 FR 41777, Sept. 9, 1975]

§ 77.216-2 Water, sediment, or slurry impoundments and impounding structures; minimum plan requirements; changes or modifications; certification.

(a) The plan specified in § 77.216, shall contain as a minimum the following information:

(1) The name and address of the persons owning, operating or controlling the impoundment or impounding structure; the name associated with the impoundment or impounding structure; the identification number of the impounding structure as assigned by the District Manager; and the identification number of the mine or preparation plant as assigned by MSHA.

(2) The location of the structure indicated on the most recent USGS 7 1/2 minute or 15 minute topographic quadrangle map, or a topographic map of equivalent scale if a USGS map is not available.

(3) A statement of the purpose for which the structure is or will be used.

(4) The name and size in acres of the watershed affecting the impoundment.

(5) A description of the physical and engineering properties of the foundation materials on which the structure is or will be constructed.

(6) A statement of the type, size, range, and physical and engineering properties of the materials used, or to be used, in constructing each zone or stage of the impounding structure; the method of site preparation and construction of each zone; the approximate dates of construction of the structure and each successive stage; and for existing structures, such history of construction as may be available, and any record or knowledge of structural instability.

(7) At a scale not to exceed 1 inch=100 feet, detailed dimensional drawings of the impounding structure including a plan view and cross sections of the length and width of the impounding structure, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection, in addition to the measurement of the minimum vertical distance between the crest of the impounding structure and the reservoir surface at present and under design storm conditions, sediment or slurry level, water level and other information pertinent to the impoundment itself, including any identifiable natural or manmade features which could affect operation of the impoundment.

(8) A description of the type and purpose of existing or proposed instrumentation.

(9) Graphs showing area-capacity curves.

(10) A statement of the runoff attributable to the probable maximum precipitation of 6-hour duration and the calculations used in determining such runoff.

(11) A statement of the runoff attributable to the storm for which the structure is designed and the calculations used in determining such runoff.

(12) A description of the spillway and diversion design features and capacities and calculations used in their determination.

(13) The computed minimum factor of safety range for the slope stability of the impounding structure including methods and calculations used to determine each factor of safety.

(14) The locations of surface and underground coal mine workings including the depth and extent of such workings within the area 500 feet around the perimeter, shown at a scale not to exceed one inch=500 feet.

(15) Provisions for construction surveillance, maintenance, and repair of the impounding structure.

(16) General provisions for abandonment.

(17) A certification by a registered engineer that the design of the impounding structure is in accordance with current, prudent engineering practices for the maximum volume of water, sediment, or slurry which can be impounded therein and for the passage of runoff from the designed storm which exceeds the capacity of the impoundment; or, in lieu of the certification, a report indicating what additional investigations, analyses, or improvement work are necessary before such a certification can be made, including what provisions have been made to carry out such work in addition to a schedule for completion of such work.

(18) Such other information pertaining to the stability of the impoundment and

impounding structure which may be required by the District Manager.

(b) Any changes or modifications to plans for water, sediment, or slurry impoundments or impounding structures shall be approved by the District Manager prior to the initiation of such changes or modifications.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))

[40 FR 41777, Sept. 9, 1975]

§ 77.216-3 Water, sediment, or slurry impoundments and impounding structures; inspection requirements; correction of hazards; program requirements.

(a) All water, sediment, or slurry impoundments which meet the requirements of § 77.216(a) shall be examined by a qualified person designated by the person owning, operating or controlling the impounding structure at intervals not exceeding seven days for appearances of structural weakness and other hazardous conditions. All instruments shall be monitored at intervals not exceeding seven days by a qualified person designated by the person owning, operating, or controlling the impounding structure.

(b) When a potentially hazardous condition develops, the person owning, operating or controlling the impounding structure shall immediately:

(1) Take action to eliminate the potentially hazardous condition;

(2) Notify the District Manager;

(3) Notify and prepare to evacuate, if necessary, all coal miners from coal mine property which may be affected by the potentially hazardous conditions; and

(4) Direct a qualified person to monitor all instruments and examine the structure at

least once every eight hours, or more often as required by an authorized representative of the Secretary.

(c) After each examination and instrumentation monitoring referred to in paragraphs (a) and (b) of this section, each qualified person who conducted all or any part of the examination or instrumentation monitoring shall promptly record the results of such examination or instrumentation monitoring in a book which shall be available at the mine for inspection by an authorized representative of the Secretary, and such qualified person shall also promptly report the results of the examination or monitoring to one of the persons specified in paragraph (d) of this section.

(d) All examination and instrumentation monitoring reports recorded in accordance with paragraph (c) of this section shall include a report of the action taken to abate hazardous conditions and shall be promptly signed or countersigned by at least one of the following persons:

(1) The mine foreman;

(2) The assistant superintendent of the mine;

(3) The superintendent of the mine;

(4) The person designated by the operator as responsible for health and safety at the mine.

(e) Before May 1, 1976, the person owning, operating, or controlling a water, sediment, or slurry impoundment which meets the requirements of § 77.216(a) shall adopt a program for carrying out the requirements of paragraphs (a) and (b) of this section. The program shall be submitted for approval to the District Manager. The program shall include as a minimum:

(1) A schedule and procedures for examining the impoundment and impounding structure by a designated qualified person;

(2) A schedule and procedures for monitoring any required or approved instrumentation by a designated qualified person;

(3) Procedures for evaluating hazardous conditions;

(4) Procedures for eliminating hazardous conditions;

(5) Procedures for notifying the District Manager;

(6) Procedures for evacuating coal miners from coal mine property which may be affected by the hazardous condition.

(f) Before making any changes or modifications in the program approved in accordance with paragraph (e) of this section, the person owning, operating, or controlling the impoundment shall obtain approval of such changes or modifications from the District Manager.

(g) The qualified person or persons referred to in paragraphs (a), (b)(4), (c), (e)(1), and (e)(2) of this section shall be trained to recognize specific signs of structural instability and other hazardous conditions by visual observation and, if applicable, to monitor instrumentation.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))
[40 FR 41777, Sept. 9, 1975]

§ 77.216-4 Water, sediment or slurry impoundments and impounding structures; reporting requirements; certification.

Every twelfth month following the submission of information specified in § 77.216-2(a) the person owning, operating, or controlling a water, sediment, or slurry impoundment and impounding structure that has not been abandoned in accordance with an approved plan, shall submit to the District Manager a report describing any changes in the geometry of the impounding structure;

instrumentation; average and maximum depths and elevations of the impounded water, sediment, or slurry; storage capacity of the impounding structure; the volume of water, sediment, or slurry impounded; and any other aspect of the impounding structure affecting its stability which has occurred during such reporting period. The report shall also contain a certification by a registered engineer that all work was performed in accordance with the approved plan.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))
[40 FR 41778, Sept. 9, 1975]

§ 77.216-5 Water, sediment or slurry impoundments and impounding structures; abandonment.

Prior to abandonment of any water, sediment, or slurry impoundment and impounding structure which meets the requirements of § 77.216(a), the person owning, operating, or controlling such an impoundment and impounding structure shall submit to and obtain approval of the District Manager a plan for abandonment based on current, prudent engineering practices which shall contain provisions to preclude the probability of future impoundment of water, sediment, or slurry, provide for major slope stability, and include a schedule for the plan's implementation.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))
[40 FR 41778, Sept. 9, 1975]

§ 77.217 Definitions.

For the purpose of §§ 77.214 through 77.216-5, the term:

(a) ''Abandoned'' as applied to any refuse pile or impoundment and impounding structure means that work on such pile or structure has been completed in accordance with a plan for abandonment approved by the District Manager.

(b) ''Area-capacity curves'' means graphic curves which readily show the reservoir water surface area, in acres, at different elevations from the bottom of the reservoir to the maximum water surface, and the capacity or volume, in acre-feet, of the water contained in the reservoir at various elevations.

(c) ''Impounding structure'' means a structure which is used to impound water, sediment, or slurry, or any combination of such materials.

(d) ''Probable maximum precipitation'' means the value for a particular area which represents an envelopment of depth-duration-area rainfall relations for all storm types affecting that area adjusted meteorologically to maximum conditions.

(e) ''Refuse pile'' means a deposit of coal mine waste which may contain a mixture of coal, shale, claystone, siltstone, sandstone, limestone, and related materials that are excavated during mining operations or separated from mined coal and disposed of on the surface as waste byproducts of either coal mining or preparation operations. ''Refuse pile'' does not mean temporary spoil piles of removed overburden material associated with surface mining operations.

(f) ''Safety factor'' means the ratio of the forces tending to resist the failure of a structure to the forces tending to cause such failure as determined by accepted engineering practice.

(Secs. 101, 508, Pub. L. 91-173, 83 Stat. 745, 803 (30 U.S.C. 811, 957))

APPENDIX D

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