DESIGN GUIDELINES FOR COAL REFUSE PILES AND WATER, SEDIMENT, OR SLURRY IMPOUNDMENTS, AND IMPOUNDING STRUCTURES (AMENDMENT TO IR 1109)

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These recommended design guidelines for coal waste structures were prepared to outline principal design factors to be weighed in developing plans to be submitted to MSHA for approval. The establishment of rigid design criteria or standards is not intended. Designs must be evaluated in the light of peculiarities and local conditions at each structure. This can only be done by competent, experienced engineering judgment, which the guidelines are intended to supplement and not supplant. These guidelines will be continually updated as the state-of-the-art for the safety and orderly deposition of coal waste is advanced.

HYDROLOGIC AND HYDRAULIC CONSIDERATIONS

1. Current, prudent engineering practices require a conservative approach to provide maximum flood protection for water retention structures located where failure may cause loss of life or serious property damage. MSHA's recommended minimum design storm criteria for impoundments is contained in table I. To determine the hazard potential for use in table I, the total volume, including all water, sediment, and slurry which can be impounded must be considered. In obtaining precipitation design criteria, the U.S. Department of Commerce publications are considered the most current rainfall information available and are used by MSHA in reviewing the design.

Design engineers that utilize properly designed open channel spillways as the primary method for routing the design storm through an impoundment can use storms of 6-hour duration. Normally, impoundments with open channel spillways will be able to handle storms of any duration when the 6-hour storm is used for design.

To attain an equal degree of hydrological safety, designers that utilize surcharge reservoir storage and a drawdown system as the primary method for handling the design storm, should extend the storm to at least 36 hours and when appropriate, to the limits contained in current hydrometeorlogical reports for the probable maximum precipitation (PMP) and to 24 hours or longer for the 1 percent probability (OPP) precipitation. The designer should use these extended storms to develop the probable maximum flood event that is reasonable for the region and for the operational conditions at the site.

Although most of the time, flow through a decant system is insignificant during a flood routing analysis, a decant system with properly designed trashracks and antivortex devices, where appropriate, can be considered in any flood routing beginning at the start of the storm. Gated discharge facilities cannot be included in the total discharge when routing the flood through the impoundment.

With regard to reservoir drawdown criteria, the discharge facilities must be able to discharge, within 10 days, 90 percent of the storm water volume stored above the normal maximum operating water level. The 10-day drawdown criteria should begin at the time the water surface reaches the maximum elevation attainable from the design storm.

Although a 20 percent reduction factor in the PMP for areas smaller than 10 square miles has been allowed by MSHA for impoundments located east of the 105th meridian because of imperfect "fit" of storm isohyetal patterns, current practice among Federal agencies (USBR, COE, and NWS) eliminates the use of this reduction factor due to the lack of substantive hydrological justification. Therefore, any future reductions in the PMP must be substantiated by a study using current hydrometerological reports and hydrological practices.

Submittals with design storms of lesser magnitude than PMP must include information substantiating such a decision. Documentation should include a description of the downstream area which could be affected by the failure. If the hazard potential is not obvious, a breach analysis may be required. A 100-year frequency storm (1 percent probability) is the minimum storm permitted in the design of any impounding facility.

Although a pump system may not be considered as an aid in routing storm runoff through an impoundment, pumps can be used to meet the drawdown requirements. Use of pumps to meet drawdown requirements should be evaluated on a site by site basis, taking into consideration power source, backup pump availability, and maintenance program. Pump capacity should be verified in the field. Each pump should be activated weekly to ensure dependability.

2. The design freeboard is the vertical distance between the lowest point on the crest of an impounding structure after all settlement has taken place, and the maximum design water surface elevation. So there is no possibility of an embankment overtopping as a result of the design storm, sufficient documentation should be provided to verify the adequacy of the freeboard. Items which should be considered in determining freeboard requirements include: frequency of the design storm, duration of high water level in the impoundment, effective wind fetch, water depth, potential wave run-up on the embankment slope, and the ability of the embankment to resist erosion. Without documentation, a freeboard of 3 feet is generally accepted for impoundments with a fetch of less than 1 mile. Freeboard should also be considered in the design of any diversion ditch or spillway channel.

3. The top of the refuse pile should be sloped so as not to impound water nor impede flow both during construction and upon abandonment. In most cases, diversion ditches have been employed to control surface runoff around a refuse site.

4. Diversion ditches around an impoundment can be used in conjunction with the impoundment outlet structure to calculate storm outlet flow only when the diversion ditch has been designed to carry no less than that of the design storm for the impounding structure and is designed, constructed, and maintained to standards no less than that of an open channel spillway. Diversion ditches are sometimes used to reduce small intensity storm inflow into the impoundment. These ditches cannot be used for reservoir flood routing.

5. Consideration should be given to prevent piping along conduits extending through an embankment. Designs for conduits should also address: clogging, corrosion, conductivity, differential settlement, and where appropriate, pressure testing. Conduit joint design should be appropriate for the material upon which the pipe will be founded. Special design considerations should be given to the type and method of protection for

conduits that are exposed to highly corrosive elements. The criteria given in Technical Release No. 60 of the Soil Conservation Service (August 1981) provides substantial technical information concerning conduit design.

6. Surfaces of channels and diversion ditches should be capable of withstanding the expected maximum velocity of the design flow without undue erosion or scour.

GEOTECHNICAL CONSIDERATIONS

1. Provided sufficient design data has been obtained, the stability of an impounding structure should normally have minimum static and seismic factors of safety of at least 1.5 and 1.2, respectively, under maximum anticipated phreatic conditions. A sufficient number of failure surfaces must be analyzed to show that the minimum factor of safety has been bracketed. To appropriately evaluate the seismic potential of high hazard sites geologic conditions, especially recent faulting and historical siesmicity, should be considered. High hazard dams located in seismic zones 3 and 4 on the Algermissen zone map may require the use of suitable dynamic procedures and analyses in lieu of "pseudo-static" methods.

2. Filters, drainage blankets, etc., that are so thin that a small amount of contamination during construction would reduce the size below design requirements are not generally considered adequate. When the performance of filter cloth, such as in internal drains, is critical to the stability of an impounding structure, piezometers should be installed to verify its effectiveness. The use of filter cloth in inaccessible portions of dam structures should be viewed with caution due to the potential for clogging, and the lack of long-term performance records on the use of filter cloth in drainage applications.

3. When a coal company has requested approval to raise the height of an embankment by upstream construction over slurry sediment it is required that suitable tests be performed on the slurry (subsurface investigation) to prove that the slurry has sufficent strength for stability and support of the added material and that the construction of the dam addition be engineer-controlled and suitably compacted in layers.

4. Closed-circuit coal waste, improperly mixed or at high moisture content, is a poor structural material, and its use for embankment construction should be viewed with caution. Normally, the material contains a considerable amount of water and therefore should be regarded as a fluid with no structural integrity. If closed-circuit coal waste is to be used as a structural component in an embankment, the embankment should be designed using engineering properties determined for that particular coal waste material.

5. The long-term stability of impounding structures should be evaluated using effective stress methods. In addition to rotational-type failure surfaces, wedge, or irregular type failures should be analyzed where

conditions warrant. Stability should also be considered during construction, at end-of-construction, and for rapid drawdown, whenever such conditions may be critical.

6. The method used to determine the location of the phreatic surface for use in stability calculations should be fully explained and documented in the submitted plan and should include consideration of the ratio of horizontal to vertical permeability. Piezometers are generally required to monitor and verify the phreatic surface for moderate and high hazard sites.

7. In designing an impounding structure, settlement and seepage must be considered and adequate measures taken to control or safely compensate for their effects. Such measures should be fully explained and documented via appropriate testing in the submitted plan.

8. If underground workings are beneath or within close proximity of the dam or impoundment, sufficient information to evaluate possible detrimental effects to the dam and underground workings should be included in the submittal.

9. Sufficient substantiation of soil parameters used in the stability analysis should be submitted. Complete test data verifying strength parameters should be included.

TABLE I

RECOMMENDED MINIMUM DESIGN STORM CRITERIA

HAZARD POTENTIAL		IMPOUNDMENT SIZE	
		< 1000 AF and < 40 ft. deep	≥ 1000 AF or ≥ 40 ft. deep
LOW Facilities located in rural or agricultural areas where failure would cause only slight damage, such as to farm buildings, forest, or agricultural land, or minor roads.	SHORT TERM	OPP	OPP
	LONG TERM	OPP	1/2 PMP
MODERATE Facilities located in predominately rural areas where failure may damage isolated homes, main highways, or minor railroads, disrupting services or relatively important facilities.	SHORT TERM	OPP	1/2 PMP
	LONG TERM	1/2 PMP	PMP
HIGH Facilities located where a failure could be reasonably expected to cause loss of life, serious damage to houses, industrial and commercial buildings, important utilities, highways, and railroads.	SHORT TERM	1/2 PMP	1/2 PMP
	LONG TERM	PMP	PMP

(1) When determining impoundment size and hazard potential in the event of failure, the total volume and depth of the impoundment should include all water, sediment, and slurry which could be impounded.

(2) Short-term criteria may be used for unavoidable construction conditions, normally associated with initial start-up and abandonment. Construction requirements for controlling the short-term design storm are generally expected to be completed and fully operational within 1 year.

(3) The long-term storm criteria should be met within 2 years. Construction, including delays, must be prudently scheduled and completed in a manner which will minimize the time required to meet the long-term criteria.

(4) Probable maximum flood criteria shall be used when other factors such as antecendent conditions can significantly increase runoff above the amounts obtained from the PMP.

(5) Facilities west of the 105th meridian that require the PMP for design purposes should also be evaluated for the 1-hour thunderstorm and the most critical of the two should be used for design purposes.

(6) Future downstream development may increase a site's hazard potential and necessitate an upgrading of the structure's capability to handle a design storm consistent with the new hazard rating.

COMMENTS CONCERNING THE USE OF TABLE I

Design Storms (Long-Term Conditions)

Numerous design storm criteria are used by the engineering profession and governmental agencies for hydrologic analyses of water retention earth embankment dams. The common factor associated with most of these criteria is that differentiations are based on the size of the possible impoundment, height of the dam, and on the magnitude of potential hazard should failure occur. Impounding coal waste disposal facilities are considered to possess the same potential for loss of life and property as earth embankment dams, and therefore require hydrologic design parameters consistent with state-of-the-art technology. Size of impoundment capability, height of dam, and hazard potential should therefore be considered when establishing a long-term design storm criteria.

Disposal Operations and Short-term Conditions

Process plant waste disposal operations are constantly changing entities. The availability of embankment building material is generally dependent upon the rate (tons/day) of coal production and the percent of waste material present in the mine's production. Both of these conditions are unique to the mining industry and are not associated with routine earth embankment dam building operations.

Recognizing that the mining industry is confronted with conditions that are unique to waste disposal operations, MSHA will consider design storms of less magnitude than normally required for long-term conditions for unavoidable short-term construction periods, normally associated with initial start-up and abandonment. A time period not in excess of 2 years is generally considered adequate for a mining company, with prudent planning and diligent effort, to resolve any conditions which would prevent the implementation of long-term design criteria.

It is stressed that the short-term criteria are not intended as less costly design alternatives, but are allowed on a case-by-case basis in recognition of the unique problems encountered in mine waste disposal operations.

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