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## **200 GENERAL**

Normally, the first stage of roadway construction is clearing and grubbing of the roadway area. The Inspector should review the Project Plans, Standard Specifications, and Special Provisions covering this phase and make certain that the work is performed as required. Particular attention should be given to keeping the Contractor's activities confined within the limits of the slope stakes. The disposal of the resulting materials should be as directed in the contract documents. However, if disposed of off site, a letter granting permission should be in the project files.

The Resident Engineer and Inspector should be thoroughly familiar with the Project Plans and Special Provisions, soil profile, all right-of-way (ROW) agreements, and borrow pits before grading operations are started. Together, the Resident Engineer (RE) and Inspector should make a plans-in-hand inspection of the project noting the following:

- clearing limits shown on the Project Plans versus clearing actually needed;
- typical sections shown on the Project Plans;
- soil profile, cut slopes, and shrink and swell factors indicated;
- drainage profiles (check that existing drainage has not changed, proposed drainage does not flow off the right-of-way, and natural drainage isn't changed to adversely affect landowners or structures upstream and downstream);
- utilities, fences, or other obstructions to be moved or protected;
- private property boundaries and other restricted areas;
- vegetation, survey monuments, archaeological sites, or other physical features to be protected, preserved, or relocated;
- borrow sources and access roads;
- unusual soil/moisture conditions such as springs, seeps, or swamps;
- construction traffic control requirements;
- subgrade/embankment stabilization requirements; and
- ROW infringements or unresolved ROW agreements.

As noted above, the Resident Engineer should inspect the drainage of lands adjacent to the highway and make certain that all drainage structures, inlets, outlets, channel, and dikes are properly located. The Resident Engineer should determine the need for any additional drainage facilities.

Special care should be given to locations of material sources in streambeds. The impact of changes in the stream flow conditions on structures and other developments must be carefully considered. Impacts can extend a considerable distance from the point of disturbance so it is often necessary to consult with the hydraulics specialists before approving work in streambeds.

Highway construction projects have been identified as one of the primary sources of soil erosion and sedimentation. Construction of highways typically disturbs large areas of natural vegetation that can result in an accelerated rate of soil erosion. During the course of the grading and draining, frequent inspections should be performed to determine that the sequence of operations is such that damage to any of the work will be kept to a minimum in case of heavy rains (see Subsection 104.09).

For roadway excavation, the Inspector should review the soil profile while inspecting the work and should note radical variations in the actual soil conditions compared with those on the soil profile. Major differences in the soils encountered from those indicated could justify changes in the design. Should wide differences be found, it would be advisable to request a review of the conditions by the Materials Group. This is especially critical at

finish subgrade elevation. The plasticity index (PI) and amount passing the #200 (75 $\mu$ m) sieve of the final subgrade material are checked against the design values to determine whether adjustments to the pavement structural section are necessary. This must be done as soon as possible since any increase in pavement section could mean extra surveying and additional work by the Contractor, both may have an impact on the Contractor's schedule. (See Subsection 203-3.03(D), Unsuitable Materials.)

For embankment construction, the entire subgrade must be proof rolled with a loaded water truck or any other heavy piece of equipment. The Inspector should see that any unstable spots in the natural ground are corrected before any embankment lifts are placed.

The Inspector must be familiar with the location of approved borrow pits and the quantity and quality of materials to be removed.

The Inspector is responsible for seeing that the grade is constructed in accordance with the Project Plans to the limits indicated by the slope stakes. If there is any question concerning the placement or markings of a slope stake, the Inspector should contact the Contractor's survey party chief for clarification.

### **Construction of Detours**

Many construction projects require detours prior to building the roadway. Usually, the need for such detours is foreseen, and detailed information about detour construction is given in the Project Plans or referred to in the Standard Drawings. An on-site inspection of all proposed detours should be made. Any recommendations that might serve to add to the safety of the traveling public should be referred to the Resident Engineer.

When changes are made to the detours shown on the Project Plans or new detours are added, the changes are to be reviewed by the Regional Traffic Engineer and documented by change order.

The Department recognizes its obligation to provide safe, easy-to-drive detours. This, along with minimal delay, is a benefit to our public relations.

Proper signing, marking, and lighting of detours are extremely important. All detours should be signed and marked as directed in Part IV of the MUTCD with the ADOT Supplement.

After the completion of detour construction including signing, striping, and lighting, the Resident Engineer should make a daytime and nighttime inspection of the detour. The traffic control coordinator for the project should do frequent re-inspections and documentation of the detour.

It is beneficial to have someone who is not involved in the design of traffic control accompany the Resident Engineer during his or her inspection of traffic control. An independent observation can be very beneficial in finding problems. Arrange to drive through the project with a local police officer, county deputy, or Department of Public Safety officer. Deficient detour conditions must be remedied as soon as possible. There may be instances when the Contractor's work will need to be suspended until detour safety is satisfactory.

A complete record including diagrams, plans, photographs and/or video recordings must be kept showing all traffic control devices and the detour including any changes to either. Plans and diagrams should show the type, location, and sizes of all signs, barricades, and any other traffic control device. The photographs and video recordings should be taken to provide a sequence of pictures showing the detour from beginning to end.

## **201 CLEARING AND GRUBBING**

### **201-1 Description**

Normally this operation is the first phase of construction. It consists of clearing the area within the project limits of all obstructions and vegetation in accordance with the specifications prior to commencing any earth-moving activity. During the clearing and grubbing operations, care should be taken to limit the activity of the Contractor to an area within the slope stake boundaries as much as possible. The intent is to preserve as much vegetation outside the slope stake limits as possible. When clearing limits are staked by the Contractor, care must be taken to assure the slope rounding details in the Standard Drawings are followed and the additional distance for slope rounding is cleared.

When the Contractor provides a material source, plant site, or equipment yard, he or she will be required to prepare an environmental analysis addressing the usage (refer to Subsections 107.11 and 1001-4). In addition, the Contractor must notify the Arizona Commission of Agriculture and Horticulture prior to any clearing operation. The purpose of this notice is to provide the opportunity for salvage and preservation as provided in the Arizona Native Plant Law. The Resident Engineer should bring these requirements up at the preconstruction conference if it is applicable to the project. This applies to privately owned land as well as publicly owned land. Environmental conditions often restrict operations in watershed areas.

The Standard Specifications provide for saving all trees and shrubs found suitable for roadside improvement and beautification if they will not interfere with construction. In order that the Contractor might know which trees and shrubs are to be saved, the Resident Engineer (with the assistance of one of ADOT's Landscape Supervisors) shall mark such trees and shrubs in a distinguishable manner. The Contractor should be informed of this marking.

When sufficient clearing and grubbing has been done to permit the start of grading operations, an inspection of the area shall be made and, if found acceptable, the Contractor can be allowed to proceed.

### **201-3 Construction Requirements**

#### **201-3.02 Removal and Disposal of Materials**

Disposition of cleared materials requires careful attention. All cleared and grubbed material must be removed and disposed of before earthwork operations can begin.

The Standard Specifications provide that all debris from the clearing and grubbing operations shall be removed from the project and disposed of. All disposal is to be made outside of the right-of-way, and the Contractor must obtain written permission from the land owner (not the tenant) for such use of the land. A copy of such written consent must be given to the Resident Engineer.

The use of any disposal site and haul roads, public or private, may require an Environmental Analysis. The Resident Engineer should carefully inspect disposal sites to judge the impact such use will have on the surrounding property. Remember that impacts of activities off the project can be in conflict with the project environmental analysis on which the project approval is based.

**201-5 Basis of Payment**

Clearing and grubbing may be paid for as a lump sum or by the area. Measurements of the actual areas to be cleared should be made before the clearing operation begins. Quantities should be computed and the Contractor advised so that a verification of the quantity can be made if required before the area is disturbed.

If clearing and grubbing are not paid for directly, the clearing limits should still be documented.

## **202 REMOVAL OF STRUCTURES AND OBSTRUCTIONS**

### **202-3 Construction Requirements**

#### **202-3.01 General**

This work consists of the removal and satisfactory disposal of all buildings, fences, structures, old pavements outside the slope staked areas, abandoned pipe lines, and any other obstructions that are not designated or permitted to remain, unless they are covered by another portion of the contract. Normally, the items to be removed under this section are indicated under the miscellaneous removal item of the contract. Salvageable material that will be retained by the Department should be removed with care and inventoried in order to preserve its usefulness. Complete the "Receipt For Salvaged Materials" form to document salvaged materials.

Before any removal work begins, a value should be established for each of the removed items. This is necessary to properly document the amount of work performed as a percentage of the pay item in the contract. The Resident Engineer and the Contractor should mutually agree upon the value. Blue Stake the area to determine exact location of underground utilities that may conflict with removal items.

It is recommended that a photographic or videotape log of all existing conditions on the project be established before work commences. This can be a valuable record of existing conditions.

All items to be removed, listed or unlisted in the Project Plans and Special Provisions, should be documented to show what was removed and when the removal was accomplished.

When the natural ground is disturbed by the removal of structures and obstructions, all depressions are to be refilled and compacted according to Standard Specifications before any embankment is placed over the area.

## **203 EARTHWORK**

### **203-2 General**

An excellent description of construction equipment can be found in the *Caterpillar Performance Handbook*

The inspector should check the Special Provisions for pre-wetting requirements when cuts are deeper than 3 feet (1 meter). The inspector should review subsection 206-3 of the Standard Specifications when the contractor decides to pre-wet pay items that will be measured and paid on the basis of weight.

#### **203-2.02 Contractor Quality Control**

When the Special Provisions require that the Contractor perform quality control, the Contractor will be responsible for quality control measures necessary to provide acceptable quality in the production, hauling, and placement of materials.

### **203-3 Roadway Excavation**

Roadway excavation involves loosening, digging, loading, hauling, placing, compacting, finishing, and disposal of the excess materials in the roadway cut sections as specifically described in the Standard Specifications and Special Provisions. Before beginning this operation, the Resident Engineer should have a discussion with the Contractor on the removal and disposition of material excavated from specific areas within the project. There should be an agreement as to the placement of excavated materials.

#### **203-3.03 Construction Requirements**

##### **(A) General**

The Standard Specifications do not allow payment for materials excavated beyond the limits of the roadway, except in certain instances. If at any time the Contractor excavates outside the slope stake limits, below finished subgrade elevation, gouges, or undercuts slopes (except as required by the Project Plans), the Contractor shall be notified in writing that this material will not be paid for. When the Contractor excavates outside the require limits, the material will be replaced with a material of equal or better quality and compacted to an acceptable density at the Contractor's expense.

Undercutting below subgrade elevation might be ordered for the purpose of correcting an unstable condition, diverting water, or providing a more gradual change from cut to fill. Observation of numerous fill settlements in areas of abrupt changes indicates a need for undercutting at these locations. Other problems at grade cut points are caused by topsoil being an inferior subgrade material.

Any undercutting which the Resident Engineer has authorized should be measured for payment as roadway excavation unless there are extenuating conditions that warrant performance of the work as extra work. (See Subsection 109.04). However, if the undercutting was the result of the Contractor's operation, no additional payment should be made.

Before the work is accepted, the roadway section affected by such undercutting shall be corrected to true plans grade and section.

In cut sections, cut ditches may be constructed to prevent the pooling of water. The outlet ends of these ditches should be constructed so that the water will be discharged onto natural ground and not against the embankment slope. Cut ditch sections are staked in conjunction with the roadway excavation.

## **(B) Slopes**

The Contractor's selection of the type of equipment for finishing of slopes is predicated upon steepness, access, and type of material.

Rounding of slopes at the top and ends of cut sections are normally done as the excavation progresses, because of more ready access to those areas. Slopes should be trimmed and shaped as much as possible during the progress of the excavation operation.

Slope rounding is not always shown on the typical roadway section in the Project Plans since the typical section refers to Standard Drawings that do specify slope rounding.

There are some instances where slope rounding is not required. These areas are usually described in the Project Plans or Special Provisions.

## **(C) Blasting**

### **(1) General**

Overshooting, or blasting which loosens solid rock formations outside the limits of the planned slopes, may cause slides and overbreakage. The Contractor can avoid overshooting by plotting the depth and direction of the drill holes and determining their relation to the slope line to ascertain that they are not beyond the slope line. The Contractor should evaluate the amount and type of explosive and the spacing of the holes. The Resident Engineer should closely observe the drilling and shooting operations. If the method used results in overshooting or damage to the adjacent property, the Contractor should modify the blasting plan. The Resident Engineer will not assume responsibility for the Contractor's methods or procedures, but should become familiar with the properties, uses, and action of explosives and detonators used by the Contractor. ADOT Geotechnical Services may be contacted for technical assistance. Each project office located on a job where blasting will be done should obtain information pertaining to the use and safety of commercial explosive material. Refer to the Reference and Additional Information section at the end of this chapter for publications available.

The Resident Engineer should see that good records are kept of blast hole patterns, loading rates, types of blasting agents used, and comments on the results of the blast. Did it throw a lot of rock outside the slopes; was there overbreakage, etc.? Good records of the blasting operations are often useful in resolving disputes about overbreakage and alleged changed conditions.

If blasting is near a developed area, a joint inspection should be made of the surrounding properties prior to blasting to assist in verifying any damage which may occur from the blasting. Photographs or a video recording of the area during this inspection should be made.

It is very important that the Resident Engineer review the blasting plan to ensure that the Contractor has followed all requirements for a blasting permit. All required permits must be obtained prior to any blasting.

### **(2) Controlled Blasting**

The Contractor shall provide a written blasting plan prior to beginning any blasting work. This plan must be reviewed by the Resident Engineer to verify it contains the following minimum requirements:

- the method for transporting the blasting agent to the site;
- the type of blasting agent used;
- the size and depth of holes;
- size and loads of blast pattern;
- type of stemming material;
- ignition source;
- method of storage on site;
- procedures in case of a misfire;
- type of firing device (electrical, etc.);
- type of security that will be used; and
- name of blasting company or person doing the blasting, and copies of their certifications or license with issuing agency.

The Inspector should review all requirements for transporting and storage of the blasting agent and review the Contractor's operation for compliance.

In an attempt to control the fracture of the rock along the slope line, presplitting is often required on many rock cuts. Presplitting or preshearing can be defined as the establishment of a free surface or shear plane by the controlled use of explosives and blasting accessories in appropriately aligned and spaced drill holes. Preshearing involves a single row of holes drilled along the neat excavation slope line. Presplitting involves a series of charges fired simultaneously in adjoining holes. Collision of the shock waves between holes places the web between the holes in tension and shears the rock between the holes. With proper hole spacing and charge to suit the type of material being blasted, the fracture zone between the holes will be a narrow sheared area through which the subsequent primary blasts can break.

The presheared plane reflects some of the shock waves from the primary blasts that follow, which prevents them from being transmitted into the finished wall and minimizes shattering and overbreak.

### **(3) Radio Frequency Hazards**

Radio Frequency (RF) transmitters, which include AM and FM radio, cellular phones, television, and radar, create powerful electromagnetic fields, decreasing in intensity with distance from the transmitter antenna. If the electric detonator wires are in a strong RF field (near a transmitter that is radiating RF power) the unshielded leg wires or circuit wires, whether connected to a blasting machine or not, will act as an antenna similar to that on a radio or TV set. The RF field will induce electric current in the circuit wiring that will flow through the electric detonator connected to it and sufficient RF energy may be induced in the wires to fire the electric detonator. Tests have demonstrated that electric detonator wires, under certain circumstances, may pick up enough electric energy from such fields to cause them to explode.

Commercial Amplitude Modulated (AM) transmitters are potentially the most dangerous. They combine high power and low frequencies so that there is little loss of RF. Low frequencies induce more current than high frequencies so the potential to induce a current in the blasting wire is high.

Frequency-Modulated (FM) and TV transmitters are unlikely to create a hazardous situation. Although their power is extremely high and antennas are horizontally polarized, the high frequency currents are rapidly attenuated in detonators or lead wires. Also, these RF sources usually employ antennas on top of high towers and this has an additional effect of reducing the electromagnetic field at ground level.

Mobile radio transmitter units must be rated as a potential hazard because they enter directly into the blasting area. The Citizen Band radio is an unusual problem for several reasons.

1. There are millions of units being used by the general public.
2. The operating frequency of these units is in the range that is considered to be the worst case for typical electric blasting circuits.
3. Some irresponsible operators use illegal linear amplifiers to increase their power output.

Federal regulations require the posting of signs within 1000 feet (300 meters) of construction sites warning that two-way radios should be turned off because of blasting. Observance of the posted signs will provide the necessary degree of safety if the units are operating within the legal power output. Exhibit 203-3.03-1 shows tables of distances designed for the convenience of the commercial blaster. The selected groupings include all the obvious types of RF transmitters that may be encountered around blasting areas.

The safe distances recommended are for the FCC approved units; it is not possible to specify safe distances for the illegal units because they do not operate within any limits. When planning to blast electrically at a new location, the Resident Engineer should inspect the area for RF transmitters before blasting is started and follow the recommendations of Exhibit 203-3.03-1.

**Recommended Distances of Mobile Transmitters  
Including Amateur and Citizens' Band  
Minimum Distance (feet)**

Transmitter <sup>(1)</sup> Power (Watts)	MF 1.6 to 3.4 MHz Industrial		HF 28 to 29.7 MHz Amateur		VHF 35 to 36 MHz Public Use 42 to 44 MHz Public Use 50 to 54 MHz Amateur		VHF 144 to 148 MHz Amateur 150.8 to 161.6 MHz Public Use		UHF 450 to 470 MHz Public Use Cellular Automobile Telephones Above 800 MHz	
	(Feet)	(Meters)	(Feet)	(Meters)	(Feet)	(Meters)	(Feet)	(Meters)	(Feet)	(Meters)
	5	30	10	70	22	60	19	20	6	10
10	40	12	100	31	80	25	30	10	20	6
50	90	28	230	70	180	55	70	22	40	12
100	120	37	320	98	260	80	100	31	60	19
180 <sup>(2)</sup>	170	52	430	132	350	107	130	40	80	25
250	200	61	500	153	410	125	160	49	90	28
500 <sup>(3)</sup>	280	86	710	217	480	177	220	68	120	37
600 <sup>(4)</sup>	300	92	780	238	640	195	240	74	140	43
1,000 <sup>(5)</sup>	400	122	1,010	308	820	250	310	95	180	55
10,000 <sup>(6)</sup>	1,240	378	3,200	976	2,600	793	990	302	560	171

**Citizens Band, Class D Transmitters, 26.96-27.41 MHz**

Type	Recommended Minimum Distance			
	Hand-Held	Hand-Held	Vehicle-Mounted	Vehicle-Mounted
Double Sideband - 4 watts maximum transmitter power	5 ft.	2 m	65 ft.	20 m
Single Sideband - 12 watts peak envelope power	20 ft.	7 m	110 ft.	34 m

<sup>(1)</sup> Power delivered to antenna.

<sup>(2)</sup> Maximum power for two-way mobile units in VHF (150.8 to 161.6 MHz range) and for two-way mobile and fixed station units in UHF (450 to 460 MHz range).

<sup>(3)</sup> Maximum power for major VHF two-way mobile and fixed station units in 35 to 44 MHz range.

<sup>(4)</sup> Maximum power for two-way fixed station units in VHF (150.8 to 161.6 MHz range).

<sup>(5)</sup> Maximum power for amateur radio mobile units.

<sup>(6)</sup> Maximum power for some base stations in 42 to 44 MHz band and 1.6 to 1.8 MHz band.

There may be instances where the use of two-way radios will increase the overall safety of a blasting operation by providing instant communication. When radios are used for this purpose, the minimum separations specified, in Exhibit 203-3.03-1 for a particular transceiver, should be maintained.

Due to static electricity, firing of explosives should not be carried out during a thunderstorm or when one is approaching. During such a period, leading wires should be short-circuited and all persons should move to a safe distance. Short-circuiting is a safeguard; however, it may not prevent the firing of a charge if the wires are struck by lightning.

Safety should be the concern of all individuals in the blasting area. Shattered windows, flying boulders, moved railroad tracks, damaged forest and highways, and injured people could be the result of a poor blasting operation. Blasting is an extremely dangerous activity, and the Contractor must have the proper respect for the havoc that negligence or errors can cause. Before blasting, the Contractor should inform the local law enforcement agencies, inform neighbors in the area, post "Blasting Ahead—Turn Off 2-Way Radio" signs, purchase necessary permits, and use necessary personnel to cordon off the area.

The ADOT Safety and Health Section can assist in resolving safety issues related to blasting. In addition, each project office should have a current copy of the OSHA Safety and Health Standards for the Construction Industry.

#### **(D) Unsuitable Materials**

Unsuitable materials are defined as those materials that may adversely affect the stability of the roadbed. Any soils that may cause instability or have some other detrimental effect should not be used unless adequately treated to make them satisfactory. If unsuitable materials are encountered, they should be removed and replaced with acceptable material, or should be processed and placed in a manner that will make the material acceptable.

The design of a pavement structure is influenced by many variables. One of the most important variables is the strength of the subgrade soils. Our present design method characterizes the subgrade soils by use of the "R" value test, or Resilient Modulus. In the AASHTO Test Manual, the "R" value test method is described as a "procedure for testing both treated and untreated laboratory compacted soils or aggregates with the stabilometer and expansion pressure devices to obtain results indicative of performance when placed in the base, subbase, or subgrade of a road subjected to traffic loads." The "R" value test takes three days to complete and requires specialized equipment. For that reason, all the "R" value tests are performed by the Materials Group. For design purposes, the design "R" value is determined from calculated "R" values, using the Plasticity Index (PI) and the percent passing the #200 (75 $\mu$ m) sieve (PC) of the subgrade materials as well as from actual "R" value tests. Using this PI and material passing the #200 (75 $\mu$ m) sieve (PC) information, a subgrade acceptance chart is developed (an example is shown Exhibit 203-3.03-2). This chart is used to determine whether the subgrade is suitable for the proposed design. The subgrade acceptance chart is included in the Final Materials Design Report distributed to the District and the project. When borrow is required to construct subgrade, the project Special Provisions will include the equation, "PC+(2.83xPI) shall not exceed XXX", to determine its acceptability based on the PI and PC. If the chart or formula is not available at the District, a copy may be obtained by contacting Materials Group, Pavement Section.

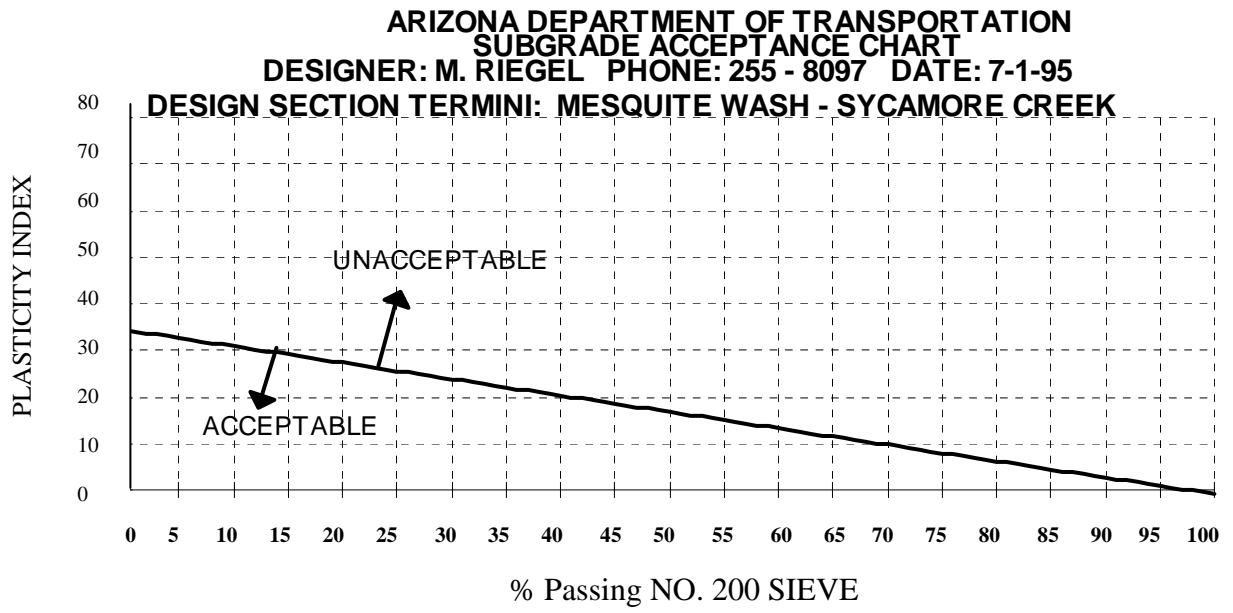


Exhibit 203-3.03-2. Subgrade Acceptance Chart

If during subgrade acceptance testing (other than borrow), the PI and materials passing a #200 (75 $\mu$ m) sieve of the sample fall within the unacceptable region of the subgrade acceptance chart, Materials Group should be contacted. The design may be affected by these results, necessitating a redesign of the pavement structural section. Meanwhile, efforts should be made to isolate the area of unacceptable material.

Isolating the area of unacceptable material is normally done by sampling on each side of the unacceptable material in increments of 100 feet (30 meters) until acceptable samples are obtained. Using this information, Materials Group will determine the best method of dealing with the unacceptable subgrade material.

If borrow material fails to meet the requirements of the formula, the Contractor will be required to locate another source of borrow.

Subgrade acceptance samples will normally be taken from the upper 3 feet (1 meter) of subgrade. In certain circumstances the sampling will extend to a greater depth if the conditions could affect the structural design.

### **(E) Surplus Material**

Some projects may have an excess of excavated material after the required embankment work is completed. If this is known beforehand, a designated disposal site may be provided on the Project Plans. If no designated disposal site is provided, then it becomes the responsibility of the Contractor to provide an acceptable means of disposing of this material. The Resident Engineer may approve of disposing of this excess material within the project limits. If the Contractor intends to provide a disposal site, an Environmental Analysis may be required.

When left to remain on the project, surplus material should be used in widening embankments, constructing berms, emergency turnouts, view points, and dikes. If a large amount of waste appears to be developing due to errors in estimating shrinkage and swell factors or for any other cause, the District Engineer should be notified as soon as possible so that necessary steps may be taken for proper disposal of the surplus material. Unightly waste piles of surplus material should not be allowed.

Waste material that is used for roadway items such as widening embankments, widening berms, turnouts, viewpoints, dikes, etc., will be placed in accordance with Specification 203-10. End dumping over the side of a fill will not be allowed. Widening of fills from the top will cause the fill to be unbalanced—a condition that can cause the fill to slide or crack from the unequal loading. This type of failure becomes more severe on steep side slopes.

Material shall not be wasted without the permission and direction of the Resident Engineer. When working within US Forest Service lands, US Forest Service officials must approve waste sites.

### **203-4 Drainage Excavation**

It is important that much consideration be given to adequate drainage around and through the roadway prism. Expenditure for drainage control may prove to be well justified due to potential maintenance savings and protection of adjacent properties.

Evaluate not only what condition exists, but also what might occur during the life of the project. Bank protection is often overlooked when evaluating drainage channels, as is nearby urban development. Urban development reduces natural ground surface area, which dramatically increases precipitation runoff. Possible scour or erosion of streambeds is very important in determining proper grades for construction of bank protection. Always try to plan drainage so that no abrupt directional changes are made, but rather gradual changes that will allow the water to run its course with minimal erosion.

Occasionally, properly engineered drainage will require work outside of the established right-of way. In such cases, additional drainage easement areas or construction easements will have to be secured from the ADOT Right-of-way Group.

Detailed staking of drainage work is required to ensure "puddling" does not occur on abutting private property. This is especially important in developed areas.

Channel changes that will direct the flow into a drainage structure should be completed by the time the structure is completed. To minimize embankment damage during construction, channel changes for the purpose of directing the water flow away from the roadway section should be constructed before completion of embankment. Adequate protection should be provided to prevent erosion due to diversion of water through new channels.

When failure to complete the needed channels and dikes endangers the work or other property, the Contractor should be notified in writing. The condition should be well documented and photographed when the Contractor does not take timely action to correct the situation.

Inlet or outlet channels to culverts should present a neat appearance upon completion and should be open and ready for use upon completion of the structure. The Contractor is responsible for any damage and repair necessary due to inlets and outlets at structures not working properly.

### **Inspection of Drainage Facilities**

After completion of all drainage structures, drainage ditches, and channels, the Resident Engineer should make an inspection of the entire project for the purpose of locating any areas where water might collect. If such areas are encountered, the necessary corrections should be made. Rainstorms during construction afford an excellent means of checking the adequacy of constructed drainage. Take advantage of them.

## **203-5 Structural Excavation and Structure Backfill**

### **203-5.03 Construction Requirements**

#### **(A) Excavation**

In most types of soil it is necessary to provide shoring, or slope the ground beyond the neat lines shown in the Project Plans or Standard Drawings in order to avoid caving. The contractor's slope, shoring and trenching plan must be approved by the Resident Engineer. Side slopes must conform to the Occupational Safety and Health Administration (OSHA) standards. Therefore, all excavations will automatically be referred to the OSHA Standards for excavation. It is very important that the Inspector have a copy of the latest OSHA Standards for excavation when working in these areas. See Subsection 501-3 of this manual for a discussion of OSHA Standards for trenching.

When plans indicate the structure is to rest on rock, then excavate to a depth sufficient to expose sound material. The rock surface shall be rough, and approximately level, or stepped. Rock seams should be pressure grouted.

It is essential that the subgrade foundation under a structure be uniform and firm under the entire bearing surface. When unsuitable material is at the excavation planned grade then it must be removed and replaced with structure backfill material. When a portion of the structure is on yielding material and the other portion is on unyielding material, or rock then remove the rock to a minimum depth of 2 feet (0.6 meter) below grade, and replace with structure backfill material in accordance with Specification 203-5.03(B). If it can be avoided,

culverts should not be placed partly on filled ground and partly on undisturbed natural ground because of the probability of unequal settlement. If any portion of a culvert must be placed on filled material, the filled material should be placed in accordance with Specification 203-10 Embankment Requirements.

When concrete is to be placed on material other than rock, special care must be taken not to disturb the bottom of the excavation. When suitable material in the bottom of the excavation is disturbed or over excavated, that portion of the foundation shall be restored by the contractor in accordance with Specification 203-5.03 (B) to a firm foundation without payment.

### **(B) Backfill**

Specification 203 permits the Contractor some latitude in selecting the material while still requiring a material that is free of frozen lumps, chunks of clay, or other objectionable material, and conforms to gradation, plastic index, and resistivity requirements.

The material should be placed in layers not to exceed 8 inches (200 millimeters) in depth before compaction. It is advisable to mark the wall or area being compacted in 8 inch (200 mm) increments as each lift is placed in order to assure proper lift thickness. Care should be taken to extend the compacted area as far as necessary in order to notch into firm material.

The Standard Specifications require cutting into compacted material both laterally and longitudinally, with all material to be compacted.

The minimum frequency of density testing should be in accordance with the Sampling Guide in the Materials Testing Manual. At the start of operations on a project, it is advisable to perform more frequent tests to evaluate the effectiveness of compaction methods, material, and moisture content, as well as the variability of the entire backfill and compaction process. The tests should be timely so that there is a minimum of delay to the Contractor's operations.

Backfill material should not be placed adjacent to a concrete structure until the concrete has developed the minimum strength specified for that structure. Standard requirement is a minimum compressive strength of 2,000 PSI (15 MPa) and in no case backfill before 72 hours after casting. Field cure cylinders and strength history are the basis for determining compressive strength. When placing backfill material around concrete structures care must be taken to bring the backfill material up uniformly on both sides of the structure. Backfill placement on one side must never be more than 2 feet (0.5 meter) above backfill placed on any other side.

Geocomposite Wall Drains conforming to Specification 1014-6 shall be installed on the soil side of abutment walls, wing walls, retaining walls, and culvert side walls. Care must be exercised to insure Geocomposite Wall Drains are installed properly in accordance with Specification 203-5.03(C). If the drain fails to function properly it could cause the structure to fail. There will be no measurement for payment of Geocomposite Wall Drains, unless specified otherwise.

As an option the Contractor may use a slurry backfill material that conforms to the requirements of Specification 203-5.03(B)(2). The slurry should be placed in uniform layers not to exceed 4 feet (1 meter) in depth before compaction. It is advisable to mark the wall or area being compacted in 4 foot (1 meter) increments as each lift is placed in order to assure proper lift thickness. The water content should not exceed 40 gallons per ton (150 liters per metric ton) of backfill material. Internal vibrators should be used for compacting slurry in accordance with Standard 601-3.03(D). Have the contractor excavate holes in the slurry so compaction can be tested at random depths. Direct the contractor to refill and compact test holes. Subsection 501-3.04 of this manual and the Specifications have additional information on the applications and use of slurry backfill.

### **203-5.04 Method of Measurement**

The pay limits for structural excavation and structure backfill are shown on the Standard Drawings (or in rare instances, the Project Plans). These quantities are not meant to represent the actual quantity necessary to complete the work. Over excavation may be permitted, but no payment will be made for excavation due to slides, cave-ins, silting, or filling due to lack of side support, the action of the elements, or contractor carelessness. No deduction will be made when the contractor elects not to excavate material within the pay limits, but excavation that does not extend to these limits should not be permitted if it interferes with the setting of forms and braces or the proper backfilling, compacting, and testing operations. Footings that must be over excavated deeper than plan depth shall be measured as structural excavation up to 3 feet (1 meter) deeper than the Standard pay limit.

### **203-6 & 203-7 Grader Ditch & Crown Ditches**

Grader ditches should be constructed as shown on the Project Plans or as directed by the Resident Engineer. Care as to size and general appearance should be exercised in the cutting of grader ditches. Ditches constructed through rock formations should be shaped and trimmed to leave a reasonably pleasing appearance.

Grader ditches will be constructed to the length staked in the field, but it is often advisable to let an experienced blade operator determine the alignment between stakes in order to provide proper drainage.

A properly placed crown ditch or grader ditch may not ordinarily parallel the centerline of the roadway. All ditches should be constructed to approximate natural contour lines. When it becomes necessary to go beyond the limits of the right-of-way to provide proper drainage, no work shall be performed off the right-of-way until the Right-of-way Group has obtained an easement. This need would normally be coordinated through the District Engineer.

### **203-8 Crown Dikes**

Crown dikes are usually formed from material obtained from roadway, structural, drainage excavation, or borrow. The same precautions described in Section 203-6 should be considered in constructing crown dikes.

Placing and finishing of crown dikes shall be as shown in the Project Plans or Standard Drawings.

### **203-9 Borrow**

When the excavation does not develop enough material to complete the embankment, a borrow source may be provided to make up the difference. The need for borrow is usually evident during the design phase, but may develop from unforeseen conditions.

When borrow is required, it shall be obtained from approved sources in accordance with requirements of Specification 1001. One of the major factors affecting the acceptability of a borrow source is the requirements placed on the material by the structural design of the pavement. Requirements for borrow placed within the top 3 feet (1 meter) of subgrade will be specified in the Special Provisions.

Borrow is measured in the original, or final space it occupies depending upon the pay item description shown in the contract. Borrow (Pit) items are measured in the original space occupied,

whereas Borrow (In Place) is measure in the final space occupied. All roadway, drainage, or structural excavation shall be incorporated into the roadway embankment prior to the importing of borrow unless the Resident Engineer has given written permission to the Contractor to do otherwise.

There will normally be no payment for either roadway or structural excavation that is wasted when borrow has been used, unless specified in the contract documents.

On projects with Borrow (In-Place), or projects with over 5,000 cubic yards (3,800 meters cubed) of earthwork, the Resident Engineer should consult with the Roadway Designer or Project Manager to determine if the existing ground line should be re-measured. The primary consideration should be reasonable accuracy and validity of the existing topographic information prior to beginning earthwork operations.

If a question or disagreement regarding quantities arises, then additional measurements can be performed covering that appropriate stage of construction. If there are no problems with quantities in the earthwork operation, no measurement will be necessary beyond the initial work except for Borrow (In-Place). Arrangements to have aerial photography taken for the project should be made at least 30 days prior to beginning any earthwork operation. If a survey crew can make remeasurement, the request should be made with enough lead time to obtain the necessary crew. Borrow sources may need to be measured before and after excavation when borrow is used for miscellaneous purposes such as shoulder widening or flattening.

Changes in borrow placement that result in:

1. a material with different properties being used;
2. a substitution for excavated material; or
3. a change from a specified source, are all changes to the contract requiring a supplemental agreement.

Always remember written approval is required to change the borrow placement from that shown in the Project Plans.

## **203-10 Embankment**

### **203-10.02 Embankment Materials**

It is very important for the Inspector to ensure that no large rocks, boulders, broken concrete, or other large debris are placed in areas where piling and drilled shafts are to be constructed (i.e., in embankment for a bridge abutment). Subsection 203-10.02, and Subsection 203-10.03 limit the size and type of material that can be placed in these areas. Subsection 203-10.03 includes all drilled shaft, metal pile, abutment, wing wall, and anchor slab locations. The same precautions should be taken at locations for guardrail, underground conduit, and light and signal pole foundations. Some projects build embankment for other projects, so the Inspector needs to be aware of other the impacts the Contractor's embankment work could have on a future project.

Steel H-piles will corrode in disturbed soils that have a low resistivity or an extreme pH value. Subsection 203-10.02 places limits on embankment soil resistivity and pH for that reason. The key to understanding this specification is that embankment soils are disturbed soils. An undisturbed native soil, which the pile is driven through, may have a resistivity and pH value outside the specifications. As long as the soil is undisturbed, it is usually not a problem for the pile. It is only disturbed soils used for fill, embankment and structure backfill that threaten a pile with long-term corrosion (refer to Subsection 203-5.03[B]).

Two final points about piling and earthwork concern 1) the completion of all embankment work before piling driving begins (Subsection 603-3.04 [A]) and 2) the requirement of excavating to the top of the pile when the embankment has already been completed (203-5.03[A]). The first requirement is discussed further in Subsection 603-3.04 of this manual. The second requirement eliminates the risk of damaging or loosening of the piles as a result of exposing, cutting, and removing excessive lengths of piling.

### **203-10.03 Embankment Construction Requirements**

#### **(A) Placement**

Embankment placed within top 3 feet (1 meter) of the finished subgrade elevation will have different requirements than embankment placed at greater depth. It is very important for the Inspector to ensure that material in the top layer meet all the standard requirements. Sampling and testing will be required in areas where embankment is covered by pavement or penetrated by bridge structures.

The Contractor should not begin the removal and placement of borrow until all roadway, structural, and drainage excavation has been removed and incorporated into the embankment, unless otherwise authorized by the Resident Engineer.

The long-term smoothness of a road depends to a large degree on the proper preparation of the area upon which the embankment is to be placed (the embankment foundation). The presence of slippage planes, areas of unstable material, or water from irrigation, seepage, springs or just surface water retained in a clay basin, are some of the detrimental conditions that may be encountered. The presence of localized areas of heavier, lush vegetation is an indication of the presence of water. Such areas should be investigated with consultation of the Materials Group. If it is feasible, areas containing standing or running water should be removed, drained, or otherwise corrected before embankment is placed. In swamp areas where the subgrade is close to the ground line, it may be necessary to raise the grade. Corrective measures not included in the Project Plans or Special Provisions will require a supplemental agreement.

If the existing ground surface is highly irregular, the surface should be smoothed or otherwise restored to a reasonably regular surface.

When constructing embankments on steep slopes, attention should be given to preventing a slippage plane. Benching is required in such locations (see Subsection 2.03-10.03). Where embankments 5 feet (1.5 meter) or less in height are to be constructed. The top 6 inches (150 millimeter) of the ground on which the embankment is to be placed must be watered, processed, and compacted to 95% of maximum density in accordance with the Standard Specifications.

Earth embankments should be constructed in successive layers, not more than 8 inches (200 millimeter) thick before compaction. Thinner layers usually compact more readily. Roots and other unsuitable material should be removed before compaction. Layers of embankment on hillsides should be placed part width, beginning at the low side and decreasing in width as the embankment is raised. Earth embankments are generally built with scraper type equipment that haul, spread, and compact the embankment material.

Operators of large heavy equipment very rarely compact right to the outer edge of the embankment. They prefer to travel in a compacted area away from the edge. This leaves an uncompacted area several feet wide. The Inspector should watch for these areas and other areas where large equipment cannot maneuver, and require supplemental compaction. If supplemental compaction is not provided, the Resident Engineer should be informed and density tests should be taken in the uncompacted area.

When embankment slopes are to be seeded, surface cultivation to the specified depth is critical for minimizing erosion and achieving favorable seed germination. A minimum tillage of 6 inch depth is required on fill slopes and a minimum tillage of 12 inch depth is required on cut slopes. The seeding contractor generally doesn't have the equipment to accomplish desired tillage. This is best achieved through the general contractor, who has access to larger equipment. The soil should be left in a loose, evenly roughened condition, free of clods or large stones with the entire width of the tillage cultivated to the specified depth. This may require passing the equipment over the same area parallel to the contours several times to provide thorough soil cultivation. All tillage should result in furrows no more than 12 inches apart and directional along the contours.

Embankments should be constructed in such a manner that there will be no ponding of water that will soak into and soften the lower levels of the embankment.

Embankments can be constructed in cold weather, but the inspector must ensure no snow, or frozen chunks of earth are placed in the embankment. Snow and ice will eventually melt and cause the embankment to settle unevenly.

Changes in borrow placement that result in:

- material with different properties,
- substitution for excavated material, or
- a change from a specified source

are all changes to the contract and may require a supplemental agreement. Written approval is required to change the borrow placement from that shown on the Project Plans.

### **Subgrade Finishing**

After all approved materials have been incorporated into the subgrade and compacted to the required density, "blue top" grade stakes, wire control line, or another method approved by the engineer shall be used to provide the finished subgrade elevation. Before the placement of any further materials, the Inspector shall verify that the roadway has been trimmed or slight fills made to bring the subgrade to desired grade and section. The final subgrade density tests must be performed and tests made on the subgrade materials (PI and materials passing a #200 (75 $\mu$ m) sieve) before any base material is placed on the roadway.

The subgrade is to be finished in conformity with the elevations called for in the Project Plans. When asphalt or concrete pavements are placed directly on the subgrade, without select or aggregate base, it is very important to construct the subgrade to the proper cross slope and grade. Subgrade tolerances are shown in the Standard Specifications.

### **(B) Compaction**

#### **(1) Earth**

Ideal conditions for obtaining compaction with the least effort would be a material that contains uniform moisture content near optimum. Often, maintaining the moisture slightly below optimum works better. With the use of heavy rolling equipment, moisture at optimum or slightly above may cause the material to be unstable.

Most soils compact more readily in thin layers. This is the reason for maximum lift requirements that appear in the Standard Specifications. In some cases it may be in the Contractor's interest to further reduce the lift thickness.

Embankment placed near a bridge abutment must conform to special compaction requirements that will prevent settlement of approach slabs and anchor slabs.

Prewetting of roadway excavation and borrow pits is common practice among Contractors: distribution of water is usually better, dust is controlled, loading of scrapers is aided, and compaction can be obtained easily with a minimum of loss by evaporation. (See Subsection 206-3 for the method of computing the weight of materials to which water has been added.)

The amount of watering and rolling required in the construction of rock embankments depends on the amount and character of fine material contained between the rock fragments. Close observation of the placement of the material and good judgment will determine the amount of water and type of compaction needed. Normally, if the fine material does not fill the voids between the rocks, watering and rolling will not be effective. Since compaction tests can seldom be performed in rock embankments, the Inspector must give this type of work more attention than normally required for other embankments.

Stability and support of soils is directly affected by the degree of compaction. The lower the compaction, the lower the support, especially when moisture is present.

As mentioned in the discussion of embankment, the Inspector should keep the Contractor advised of possible problem areas involving drainage and the roadway prism.

Saturated areas are to be drained, dried out, and compacted before being covered. Sometimes it is more efficient to just replace the material.

Filling in with dry material is usually not an acceptable method of stabilizing wet earth because complete mixing of the wet and dry material seldom occurs. The mixed area will look stable and may temporarily support construction equipment, but it will eventually fail under repeated loading.

Do not allow the Contractor to bridge over a soft spot by covering the spot with dry, stable material. Soft, unstable areas do not meet specifications and must be corrected.

The removed material can be wasted in areas outside the roadway prism, or if sufficient embankment is available, it can be spread out to dry in thin lifts. Before being placed within 3 feet (1 meter) of finished subgrade elevation, the material is to be tested to be sure it meets subgrade acceptance requirements.

The Inspector needs to keep good records of the areas needing corrective work and how the work was accomplished.

Soils will vary widely as to the amount of effort necessary to achieve a uniform degree of compaction. It is the Contractor's responsibility to provide the equipment needed to obtain the required density.

Compaction tests should be performed so that they represent any area where it is suspected that there may be inadequate compaction (such as near outside edges of roadway or near structures). The outside edges of fills should be given extra attention to assure density. Each lift of material placed must be tested and approved before placing additional lifts.

The Contractor should be immediately advised of the results of the compaction tests.

Testing equipment (such as "speedy" moisture testers, scales, molds, proctor hammers, nuclear gauges, and volume measuring devices) is to be checked or recalibrated before the start of each project, and at suitable intervals during the life of the project.

## **(2) Rock**

Rocky fill material should not be deposited in large piles and leveled off. Dumping the material on top of the layer being built and shoving it ahead with a dozer can obtain a more uniform arrangement of the different rock sizes. This method will provide a more effective placement of the material in the fill so that there will be a minimum of voids. When possible, rock should be placed, spread, and leveled in 24 inch (0.6 meter) thick layers. The ideal layer will cover the full width of embankment and contain sufficient earth or other fine material to fill the interstices between rocks. The top layer of the rock embankment should be built with the most care since this layer serves as the subgrade. Where suitable material is available within the cut area, it may be set aside for finishing the final layer. However, such material should be used only after tests have been performed to prove that its use is acceptable per Section 203-10. The use of material containing clay or frozen earth must be avoided for plating rocky subgrade. If satisfactory quality plating material is not available, it is better to use a greater thickness of subbase material for filling any irregularities in the surface of the subgrade.

In rocky material the Inspector should seek out areas that can be tested. There is a tendency to easily dismiss the need for compactive effort simply because the material is rocky. Vibratory compaction is best for rocky soil, but almost any type of compactive effort will be beneficial.

**204 RESHAPING AND GRADING EXISTING IMPROVEMENTS**

Under this section all work is performed that is necessary to modify or restore existing features (such as embankment slopes, dikes, ditches, medians, and other features). Finishing the subgrade or existing surfacing is not included under this section.

The Project Plans are to be checked carefully to determine the extent of the work to be done under this section. A complete list of the work should be made to aid in tracking completed work and for the development of partial payments.

## **205 GRADING ROADWAY FOR PAVEMENT**

### **205-3 Construction Requirements**

The use of staged construction often makes it necessary to reshape a previously constructed subgrade or to modify a design pavement structural section. The Contractor should scarify the entire road surface within the roadway prism, if necessary, and rebuild, recompact, remove, or reshape it to the cross-section shown on the Project Plans.

The inspector should check the bid schedule to see if removals of existing concrete medians, curb and gutter, or other obstructions are included in payment for grading roadway for pavement.

Shifting of material may be necessary in some cases and in others it may become necessary to import additional materials. Complete and satisfactory compaction of the entire reshaped cross section must be achieved before placement of base material.

Where necessary, the surface material at approaches to structures shall be removed to a depth sufficient to allow the placement of the designed thickness of subbase, base, and pavement.

#### **205-3.04 Compacting and Finishing**

When asphaltic concrete or Portland cement concrete is to be placed directly on the subgrade, it will be necessary to finish the subgrade to specified tolerances. It may be necessary to import a select borrow material to obtain the degree of finishing needed. Finishing tolerances are the same as for subgrade discussed in Section 203-10. The finish should be as uniform as possible. This prevents nonuniform compaction and the uneconomical use of paving materials to fill in low spots.

## **206 FURNISH WATER SUPPLY**

### **206-1 Description**

Furnishing a water supply is a lump sum item and consists of providing a water supply sufficient for the needs of the project including the hauling and applying of all water required in the compacting of embankment, base, and surfacing material, special backfill, and other fill and backfill. The "Furnish Water Supply" bid item should be used on remote projects where it is difficult to obtain water. The furnishing of all water required for the control of dust and any water used in wetting cuts and pits must be included in the "Furnish Water Supply" item.

### **206-3 Construction Requirements**

The inspector should check the Special Provisions for pre-wetting requirements when cuts are deeper than 3 feet (1 meter). The inspector should review subsection 206-3 of the Standard Specifications when the contractor decides to pre-wet pay items that will be measured and paid on the basis of weight – the specification's intent is that the contractor be paid the weight of this material prior to pre-wetting.

### **206-5 Basis of Payment**

Generally payment for this item is made at the contract lump sum price. Occasionally, the Bidding Schedule omits "Furnish Water Supply" as a pay item. The Inspector should carefully review this item in the Standard Specifications and Special Provisions to ensure proper procedures are followed. Furnishing water for dust palliative and pre-wetting is included in payment for the items of work requiring water when the "Furnish Water Supply" pay item is omitted from the bid schedule.

## **208 SEPARATION GEOTEXTILE FABRIC**

### **208-2 Materials**

A Certificate of Compliance must accompany all geotextile fabric delivered to the project. If the delivered materials are not on the ADOT Materials Group pre-approved list, then the fabric must include a Certificate of Analysis along with supporting documentation. Each roll of fabric must be tagged, and the Engineer must approve each lot, or shipment before the materials are incorporated in the work.

The inspector should ensure all requirements of Standard Specification and Special Provision sub sections 208-2 and 1014 are met. Particular attention must be given to protecting the fabric from sunlight since ultraviolet rays will rapidly destroy the fabric.

### **208-3 Construction Requirements**

Detailed installation instructions are included in the Standard Specifications and Special Provisions. Additional installation instructions should be available from the manufacturer or local supplier. The Resident Engineer should obtain and review this information before construction begins.

Adequate anchoring is required to prevent haul trucks from pushing or shifting the fabric out of position. Always back dump on the fabric and spread the material over the fabric. Dump subsequent loads onto the leveled fill material and advance by spreading; do not mix material on the fabric.

Should the fabric be damaged in any way during or after installation, it may be repaired by patching. The recommended repair procedures are to remove the damaged area and place a piece of fabric of appropriate dimensions to cover the damaged area and extending 3 feet (1 meter) beyond in all directions.

## REFERENCES AND ADDITIONAL INFORMATION

### Section 200

*ADOT Erosion and Pollution Control Manual*, Arizona Department of Transportation, Intermodal Transportation Division, Phoenix, AZ

### Section 203

The INSTITUTE OF MAKERS OF EXPLOSIVES (IME) is the safety association of the commercial explosive industry in the United States and Canada. This non-profit, incorporated association is concerned primarily with safety in the manufacture, transportation, storage, handling, and use of explosive materials and other essential applications. The IME has a Safety Library comprised of publications pertaining to:

1. *Construction Guide for Storage Magazines*
2. *American Table of Distances*
3. *Suggested Code of Regulations*
4. *Warnings and Instructions for Consumers in Transporting, Storing, Handling and Using Explosive Materials.*
5. *Handbook for the Transportation and Distribution of Explosive Materials*
6. *Safety in the Transportation, Storage, Handling and Use of Explosive Materials*
7. *Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Detonators*

*Workbooks for Field Sampling and Testing for Earthwork (Course No. 101R)*, Arizona Department of Transportation, Phoenix, AZ

*Workbook for Excavation and Embankment Inspection (Course No. 102)*, Arizona Department of Transportation, Phoenix, AZ

*Workbook for Subgrade and Base Course Inspection (Course No. 104)*, Arizona Department of Transportation, Phoenix, AZ

*Caterpillar Performance Handbook*