



COCONINO COUNTY PUBLIC WORKS DEPARTMENT

EARTHWORK STANDARDS

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About these standards

All earthwork shall be placed and tested in accordance with this section, unless otherwise stated by the County engineer or his/her representative. For construction purposes, *the following precedence of standards will prevail*: Current Coconino County Public Works Department Standards (including: Earthwork, Concrete, and Paving Standards); current International Building Code (IBC), Project specific plans and specifications; geotechnical report; ADOT Standards; and MAG Standards.

Prior to the County accepting the project as completed, and within 30 days of completion of the earthwork project, the project engineering firm must submit a bound *report* to the County Engineering Department. The report shall comply with the subheading in this section titled “*reports*”.

The following standards shall be considered the minimum standards to be used on Coconino County earthwork projects. Additional recommendations and specifications may also be incorporated for construction if stated in a project geotechnical report, as shown on the project plans, or as directed by the County.

Prior to Site Grading *Earthwork shall not be performed without having a grading permit issued from the County Engineering Department that covers the work to be performed.* A completed set of grading plans, a geotechnical report and a Storm Water Protection Plan (SWPPP) shall be submitted to the Engineering Department for review, along with appropriate fee payment. Grading plans must be stamped/signed by a Civil Engineer registered in the State of Arizona. The geotechnical report must be signed by an Engineering Geologist, Civil Engineer, or Geotechnical Engineer. **All earthwork projects shall comply with current County, State, and Federal storm water protection standards.**

All recommendations set forth in the geotechnical report shall be consistent with the standards as defined in the first paragraph of these Earthwork Standards. The County Engineering Department must review and approve the grading plans, the geotechnical report, and Storm Water Protection Plan prior to issuing a grading permit.

Before any earthwork operations may begin on a project the SWPPP must be in place, and implementation must continue throughout grading and construction. **Straw waddles shall be utilized for sediment control** in lieu of hay bales.

A pre-construction meeting (pre-con) must also be held; minimum required attendees at the pre-con are representatives from the following: the County, the contractor, and the contractors’ QC. The Quality Control (QC) is responsible for performing all observation, field and lab testing, and inspections required per current Coconino County construction standards.

During Site Grading

Survey staking: All necessary reference staking shall be maintained for the duration of the project, for both grading and trenching operations. Staking shall be spaced at no greater separation than 100’ intervals. Staking shall have information including stationing, cuts/fills, offsets, and all other information required to complete grading or construction.

Hubs: Sequences of "blue top" hubs (wooden stakes denoting finished road elevation, often painted blue) shall be spaced at 50' intervals—one at each edge of pavement (EP) and one at roadway center. Cul-de-sacs shall have a minimum of one center hub and six evenly spaced around the perimeter.

Safety during construction is paramount; all construction equipment and supplies shall be fenced off from public access, and all applicable County, State and Federal regulations must be followed, including the subsection herein "Health and Safety", and "Traffic Control". **The County may stop a project at anytime due to safety concerns.**

Clearing and Grubbing Prior to fill placement, all surface vegetation shall be cleared to a minimum of 5' outside of fill areas, unless otherwise noted on plans. All vegetation, and any other debris removed from within the cleared area shall be hauled off site, unless otherwise specified by the County Engineering Department. The exposed surface shall then be prepared as described under "General Fill Placement".

General Fill Placement *All soil and rock material (aggregate base, millings, etc.) placed by the contractor shall be defined as fill.* All fill placed shall be observed and/or tested per these Earthwork Standards. All density tests shall be performed by either the Sand Cone method (ASTM D1556), or by the nuclear method (ASTM D6938). **The Modified Proctor (ASTM D1557) shall be used for all laboratory reference curves on all County projects.**

All references to % compaction in the County Earthwork Standards are to ASTM D1557 (not ASTM D698).

Compaction Equipment: Certain compaction equipment will work better for specific soil or material types, such as; vibratory equipment for granular soils, and non-vibratory sheepsfoot for clayey soils. The County Engineering Department or a geotechnical representative may disallow a type of compaction equipment that is not appropriate for the type of material being compacted. **A vibratory plate whacker (vibra-plate) shall not be used** for compacting loose lifts thicker than 2".

Prior To Placing Fill (including placement in over-excavated areas, roadway cut, and natural surfaces) **the existing surface shall be prepared by:** scarifying to a minimum depth of 6" and removing material larger than 3" size, then moisture conditioning to between -1% and +3% of optimum moisture (or as directed in the geotechnical report), and then compacting to a minimum of **90%**. All fill shall be placed in horizontal lifts. Loose lift thickness shall be limited to 8" maximum.

Material Size and Type: Fill shall contain **no material with dimensions greater than 3" size within the upper two feet** of final soil grade (finished subgrade). Fill placed in depths deeper than 24" below finished subgrade may contain material larger than 3" diameter; however, larger material will require observation and placement methods as described under the "Rock Fill Placement" section.

Clean cinders shall not be used as fill material; however, clean cinders that are blended with at least 25% of material finer than the #40 sieve and at least 10 % passing the #200 sieve may be approved by the County for use as fill material, but must be reviewed for use by the County prior to placement.

Expansive Soil: Soil with a Plasticity Index (PI) of 15 or greater shall be considered expansive, and shall not be used within 12" of concrete slabs, footings, walls or within the upper 6" of subgrade beneath pavement—unless recommended in the geotechnical report and approved by the County.

Density Tests: Any fill areas with a density test failure, or fill placed in a manner deemed unacceptable by the County, their representative, or the QC engineering firm, shall be reworked to meet County standards. Fill shall not be compacted over unacceptable fill, areas with outstanding density test failures, or unprepared native soil.

Testing Frequency

- General Fill shall be tested at a minimum of 1 test per every vertical foot, and within each horizontal grid of 300 feet.
- Trench backfill shall be tested at a minimum of 1 test each 2 vertical feet within every 100 lineal feet.
- Roadway finished subgrade and aggregate base shall be tested at a minimum of 1 test per 100 lineal feet.
- Slope faces shall be tested no less than 1 test each 100 lineal feet and 1 test every 5 vertical feet.

Import Material Import fill shall be free of organic material and debris, have maximum rock size of 3", be predominantly granular, and have a PI of less than 15. Import material must be approved by the County prior to use.

Roadway Fill The upper 6" of material immediately beneath the aggregate base (AB) section shall be defined as the "subgrade" section. The surface of the subgrade after passing string lining shall be considered the finished subgrade (FSG). Both the subgrade and the AB sections shall be compacted to a minimum of **95%**. Preparation and compaction shall be performed as described under "General Fill Placement".

All subgrade and aggregate base sections must be stable, and free of soft, segregated, nesting, or pumping areas. Stability of the subgrade and aggregate base sections shall be confirmed visually and by proof rolling, as necessary. Proof rolling shall be performed with a fully loaded water truck, or other acceptable means. **Aggregate Base (AB)** shall conform to the aggregate base standards listed under "Materials" section herein.

Tolerances: Finished grade compaction tests (both subgrade and AB) shall be completed, and submitted to the County for review prior to string lining. ***Both the finished subgrade and AB surfaces shall be string lined to be within a tolerance of $\pm 1/2$ "***. Subgrade and AB sections will not be accepted as complete until surfaces are within the aforementioned tolerances.

Roadway Cut All cut portions of roadway (including areas with exposed rock remaining after cuts and excavations) shall be scarified to a minimum of 6", and then all material larger than 3" size shall be removed. This scarified zone shall then be moisture conditioned and compacted, as described under "General Fill Placement".

Trench Fill Utility trenches shall be bedded below the pipe(s) with a 6" thick layer of approved material, and then compacted to a minimum of **90%**. Shading shall be placed around the haunches of pipes and conduits with a cover of 6" of shading over the top and compacted to a minimum of **90%**. Cinders may be utilized in the **shading and bedding** zones, and compacted to a minimum of **90%**. Shading and bedding material shall have a gradation no larger than ¾" size and a PI of less than 15.

The maximum total length of trench allowed open on a project at one time is 600 feet. All trenches and excavations accessible by the public shall be completely fenced or cordoned off with caution tape.

Clean cinders shall not be used for trench backfill; however, clean cinders that are blended with at least 25% of material finer than the #40 sieve and at least 10 % passing the #200 sieve may be approved by the County for use as fill material.

All trench backfill shall be compacted to a minimum of **90%**

Beneath existing paved and concrete areas, trench backfill shall consist of a County approved **2 sack** (chip or sand) **slurry**. The slurry shall be placed to the top of the trench, level with the top of the adjoining aggregate base section. Pavement shall then be placed per Coconino County Paving Standards to match existing pavement thickness on each side of the trench, or 3" thick, whichever is greater.

Outside of existing paved and concrete areas, trench backfill may match existing materials, and shall be compacted to a minimum of **90%**. If 2 sack slurry is used in lieu of soil backfill, the slurry shall be brought up to within 6" of finished subgrade.

Concrete Structural Fill A **4" layer of aggregate base** (conforming to aggregate base listed under "Materials" herein) **shall be placed immediately beneath all concrete structures**, including; Driveways, sidewalks, curb and gutter, catch basins, and other drainage structures, and then compacted to a minimum of **95%**.

Backfill within a 24" zone around concrete structures (excluding sidewalks and curbs) shall be considered structural fill and placed as described under the "General Fill Placement" section and compacted to a minimum of **95%**. Concrete structural fill shall consist of maximum particle size of 3" with a PI of less than 15.

Foundation Excavations Foundations shall not be founded on, in, or within 12" of expansive soil, unless otherwise designed for by a geotechnical engineer. **Expansive soil shall be defined as material having either a Plasticity Index (PI) of 15 or greater (per ASTM D4813), or an Expansion Index (EI) greater than 20 (per ASTM D4829).**

Prior to placement of steel, concrete, or other material into foundation bottoms, the foundation excavation must be observed and approved by a representative from the County Engineering Department, or a qualified representative from the QC engineering firm. **Prior to pouring concrete** the foundation must be free of loose material, water, snow, ice, debris, or any other unacceptable material. The foundation must be excavated to the width and depth per plan or project recommendations, and must be founded into dense native soil, bedrock, or fill compacted to **95%**.

Differential support conditions are a concern where foundations span cut and fill soils, or foundations cross native rock and engineered fill (transition zones). Footings, slabs, and other concrete structures will not be allowed when placed directly across transition zones. A geotechnical engineer will be required to determine if overexcavation or other methods are necessary to help mitigate differential settlement in transition zone areas.

Grouted Rip Rap When protection is required in ditches, **Grouted rip rap** shall be used, unless otherwise approved by the County. Rip rap for grouted purposes shall have a bulk specific gravity of 1.8 or greater. Grout shall be a 3,000 psi mix with 5% air ($\pm 1.5\%$), and pre-approved by Coconino County. Grout thickness shall be a minimum of 8"; individual rocks (rip rap) shall be seated into the grout with between $\frac{1}{2}$ and $\frac{1}{3}$ of the rock exposed. A minimum of 1 rock per sq. ft. shall be placed.

Use of 3,000 psi County approved concrete mix is acceptable in lieu of grout. Rip rap shall be between 6" and 12" in diameter. Grout, rip rap, and placement procedures must be approved by the County Engineering Department prior to placement.

Unless otherwise approved, all **grout or concrete used for rip rap shall be colored** to match the adjacent landscaping.

Non-grouted rip rap shall only be used with prior approval by the County and have a bulk specific gravity of 2.4 or greater (per ASTM C127), and all rock shall be angular. Rip rap shall range between 3" and 12" size, with 50% (by weight) larger than 6" size, unless otherwise specified by the County Engineering Department. A sample of rip rap must be submitted to the County for approval prior to placement.

Non-grouted rip rap placed in v-ditches shall be underlain by woven fabric such as TC Mirafi 500x or equivalent.

Fill Slope Construction Fill constructed against existing slopes **steeper than 5:1 (taller than 5')** shall have a **keyway** constructed at the slope toe. The keyway width shall be $\frac{1}{2}$ the slope height, or a minimum of $1\frac{1}{2}$ the width of the compaction equipment used. The key bottom shall be sloped into the slope at a minimum of 2%. The toe of the key shall be excavated into dense soil or bedrock formation to a minimum depth of 24", or as approved by the County Engineering Department. As slope fill is placed, **horizontal benches shall be cut into acceptable dense native soil or compacted fill.** Benches shall be placed at intervals of 3 to 5 vertical feet and shall be wide enough for compaction equipment to work efficiently. **No material with dimensions greater than 3" shall be placed within 1 foot of the slope face.**

Fill slopes shall be overbuilt during construction and the cut back to compacted finish grade—or compacted by a means that will achieve consistent density throughout the fill to the slope face. Fill slope density shall be a minimum of **90%** and placed as described under "General Fill Placement". **Fill slopes steeper than 3:1 (taller than 5') shall require review and approval by the County or a geotechnical engineer.**

Cut Slope Construction Cut slopes steeper than 3:1 (taller than 5') must have a geologist or geotechnical engineer's review and written approval. At anytime during the cutting or after a cut slope has been completed—should the County have concerns of its stability—the County may request evaluation by a geologist prior to accepting the slope as finished.

Rock Fill Placement “Rock Fill Placement” shall apply when more than 30% of the material (by weight) is greater than ¾" size, and therefore cannot be tested per ASTM D 1557. Rocks with diameters of 3" or more may be placed in fill areas deeper than 24" below finished subgrade, as approved by the County Engineering Department. The rock fill lift thickness will be governed by the largest acceptable size material within the fill. Due to the generally untestable nature of the rock fill material, no density testing shall be performed. However, during the placement and compaction of the rock fill, **full-time observation is required by the QC.**

Predominantly granular material must be used as matrix soil in rock fills (the matrix soil shall be defined as the material finer than ¾" size). The matrix soil shall have an SE of ≥ 32 (Sand Equivalency per ASTM D2419). The rock fill shall be placed so no voids are visible between the irreducible material, and no nesting is apparent. The matrix soil within the rock fill shall be compacted at 2% to 8% above optimum moisture.

Observation trenches shall be excavated as necessary (no less than one per every other lift) to visually confirm adequate densification and to help confirm that the rock fill is free of nested material and/or voids. Should voids, nesting, loose material, or improper moisture content be observed, the unacceptable portion of rock fill shall be remixed and recompacted.

Materials **Aggregate Base** (AB) gradation shall conform to either MAG Table 702-1 (Aggregate Base) or to Table 303-1 of ADOT Road and Bridge Construction Standards (Class 1, ¾" aggregate). AB shall have a minimum of 30% fractured faces (per ASTM D5821), and have a resistance to abrasion confirmed by a loss of no more than 40% of weight per 500 revolutions (per ASTM C131).

Miscellaneous Aggregates, geotechnical fabrics, and all other project specific materials (that are not specified in this Earthwork Standard) shall be as specified in the project geotechnical report, project plans, or special provisions (confirmed by testing as deemed necessary by the County); and must be specifically approved for use by the County *prior* to placement.

Quality Control (QC) It is mandatory that the contractor (or developer) hire an engineering laboratory (QC) to sample, test, and document the earthwork operations. **It is the QC's responsibility to understand current County standards, and communicate test results to the contractor and the County on a daily basis.** Field reports and field test data shall be submitted by the QC to the County daily during the project, unless otherwise agreed by the County. Construction that is dependent on field or lab results may be stopped by the County, until the necessary data has been submitted to the County.

The contractor shall stop placing, and/or remove any unacceptable material upon notification by the engineering lab (QC or QA) that the material is out of specifications, and shall not resume placement until the material is shown to the County to be back within specification.

The County Engineering Department reserves the right to hire an engineering laboratory of their choice to perform Quality Assurance (QA). Materials not meeting project requirements will be rejected, and shall be removed by the contractor immediately.

Reports Prior to the County accepting a project as complete, and within 30 days of completion of earthwork, a bound "final engineering report" shall be submitted to the County Engineering Department. This final engineering report shall be signed by a registered civil, geotechnical engineer, or a NICET Level IV technician, unless otherwise approved by the County Engineering Department.

Included in the bound final engineering report shall be the following information:

Density Test Results:

- ***Density tests shall be numbered consecutively***, beginning with the first test taken on the project, ending with the last test on taken on the project. Do not restart the numbering sequence with the number 1 each day; continue the sequence from the previous days testing.
- ***Each test failure must be retested*** at the same location and elevation. The retest number shall be designated by the original failure number, then with an "R" after the number (R designates retest, i.e.: 29 R would designate a retest of test 29).
- Test Date
- Location
- Elevation or depth
- Proctor number , with a ***soil description including the USCS*** (per ASTM D2487)
- Maximum density
- Field dry density
- Percent compaction (rounding to whole number is ok)
- Required compaction
- Pass / Fail (P or F is sufficient)
- Test locations must be shown on plot plans, with basic information such as a north arrow, street names, etc.

Lab Test Results:

- Test type, ASTM or other designation
- **Soil description, the USCS must be included**
- Location sample taken from (import or native)
- Each test must be reviewed and signed by Lab Manager

Reports shall include a statement that ***"all earthwork has been completed in general accordance with project plans and specifications"***. Any exceptions or non-compliances shall be stated in the report.

Sampling and Testing of Soil and Aggregate

Laboratory testing, field sampling and testing, and inspection or observations, shall be performed by ATTI or NICET or ICC certified personnel only, unless otherwise approved by the County Engineering Department.

All Engineering laboratories performing work on Coconino County projects shall hold current accreditation by AMRL as an approved AASHTO-R18 Lab, unless otherwise approved by the County. All sampling procedures for soil and aggregates shall be performed in accordance with current ASTM standard test methods, unless otherwise approved by the County Engineering Department, or noted below.

Accepted test methods are:

Lab

Classification of soils, USCS	D2487 / 4.08
Dry preparation of samples	D421 / 4.08
Wet preparation of samples	D2217 / 4.08
Moisture content of soils	D2216 / 4.08
Determining minus 200 material by washing	D1140 / 4.08
Particle size analysis (Hydro and sieve)	D422 / 4.08
Liquid and Plastic Limits of soil (PI)	D4318 / 4.08
Specific gravity of soil	D854 / 4.08
Moisture - density of soil (Modified Proctor)	D1557 / 4.08
Moisture - density relations of soil - cement mixtures	D558 / 4.08
Resistance value of compacted soil (R-Value)	D2844 / 4.08
California bearing ratio (CBR)	D1883 / 4.08
Permeability of granular soil (constant head)	D2434 / 4.08
Consolidation	D2435 / 4.08
Expansion index (EI)	D4829 / 4.08
Direct shear	D3080 / 4.08
Unconfined compression	D2126 / 4.08
Sand equivalent test (SE)	D2419 / 4.03
Aggregate durability index	D3744 / 4.03
Fractured Particles of Aggregate	D5821 / 4.03
Bulk density and voids in aggregate	C29 / 4.02
Specific gravity & absorption of fine aggregates	C128 / 4.02
Specific gravity & absorption of coarse aggregates	C127 / 4.02
Sieve analysis of fine & coarse aggregates	C136 / 4.02
Abrasion of small aggregate (L.A. abrasion)	C131 / 4.02
Abrasion of large aggregate (L.A. abrasion)	C535 / 4.02
Soundness of aggregates by Sodium/Magnesium Sulfate	C88 / 4.02
Percentage of friable particles	C142 / 4.02
Reducing samples to test size (splitting samples)	C702 / 4.02
Total moisture content of aggregates	C566 / 4.02
Test for lightweight particles in aggregates	C123 / 4.02
Alkali - Silica reactivity of aggregate	C289 / 4.02
PH and Resistivity	ARIZ 236
Sulfate in soil	ARIZ 733

Field

Visual manual classification, USCS	D2488 / 4.08
Moisture/density determination by nuclear gauge	D6938 / 4.08
In-place density by sand cone (6.5")	D1556 / 4.08
Density by the drive cylinder method	D2937 / 4.08

Final Acceptance and Payment

- Payment shall only be made for materials used that conform to the project specifications.
- Final acceptance and payment shall not be made by the County until a bound report has been submitted to the County by the contractors' QC engineering firm, in accordance with the "Reports" section herein.

Method of Measurement Aggregate Base and other materials necessary to be quantified during placement shall be delivered with delivery tickets. Tickets must be provided to the County for all products delivered to the project. Tickets shall include:

- Plant or manufacture name and location
- Description of material delivered
- Project name, and location of delivery
- Date of delivery
- Time of arrival at site
- Weight of material (by ADOT approved scale)
- Truck number or license
- Driver name
- Signature by the Contractor's representative acknowledging receipt of the product

A copy of the delivery ticket shall be given to the County or their designated representative at the time of delivery. Material that is delivered without proper ticket information will not be accepted by the County.

Health and Safety During the construction process, all applicable "OSHA Standards for the Construction Industry" shall be followed, including (but not limited to) 29 CFR Part 1926, Subpart P – Excavations. All construction equipment, materials, open trenches and excavations shall be safely fenced off from public access during the entirety of the project. The County may stop construction on a project until safety concerns have been corrected.

Knowing and following OSHA Safety Standards is the contractor's responsibility. If at any time a representative of the County determines that a safety or health concern is present, he/she may stop construction on a project until safety concerns have been corrected to the satisfaction of the County—the County shall pay no additional monies for such corrections.

During construction the contractor shall supply the work area (job site) with a minimum of one porta-toilet, and more as necessary or directed by the County for larger projects. The County may stop a project until safety violations have been corrected, and may choose to rescind the grading permit for continued safety violations.

Traffic Control A traffic control plan shall be submitted to the County a **minimum of 7 days prior to the commencement of any roadwork** (or construction, where the contractor may be entering or crossing the roadway with equipment during construction). The traffic control plan must be approved by the County prior to commencement of construction.

The traffic control plan shall conform to Part 6 – Temporary Traffic Control, in the MUTCD. Traffic control shall be maintained in accordance with the Manual on Uniform Traffic Control Devices (MUTCD), which is published by ATSSA/ITE/AASHTO, and approved by USDOT and the Federal Highway Administration (current edition). It is the contractor’s responsibility to implement the traffic control plan. The County may stop construction on a project until traffic safety concerns have been corrected.

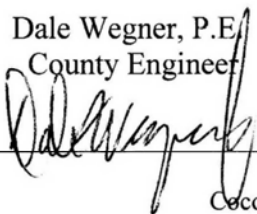
Within all County residential areas and roadways, a minimum of two flaggers with approved construction warning signage shall be used during all construction. Flaggers shall use standard hand held “Stop” and “Slow” paddles (not hand held flags). Flaggers shall be equipped with radio communication when not in full view of each other. Pilot vehicles used during paving and other roadway projects shall be clearly marked, be equipped with warning lights, and be in radio communication with flaggers at each end of the traffic control area.

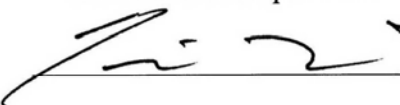
Flaggers shall be certified by the ATSSA or a County accepted equivalent program. It is the contractor’s responsibility to have properly trained flaggers—and they must perform their duties according to all County traffic safety standards. Flaggers that do not perform their work according to County and ATSSA standards will be removed from the project.

Dust Control Dust and airborne particulate must be limited in all areas that a contractor is performing construction, or where equipment is driven to access the work area. Dust generated by a construction project shall not impact the health or safety of personnel on or nearby the project site. Dust shall not impede the visibility of traffic or pedestrians around the project site. All trucks transporting material while working on Coconino County projects shall have their loads covered during transit and until they unload at their destination.

Dust control shall be maintained throughout the duration of the project, including weekends, and other off-work hours as necessary. It is the contractor’s responsibility to maintain dust control. The County may stop a project until dust and debris have been properly controlled.

Existing paved roadways, driveways, and any other paved/concrete areas must be washed or swept free of dirt and debris daily, or more often as necessary. The County may stop a project until dust and debris have been properly controlled, or until truck loads are properly covered. For repeated offenses regarding dust or any other safety violations the County may choose to rescind the grading permit.

Dale Wegner, P.E.
County Engineer


Tim Davis
Construction Supervisor


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Standards may be downloaded at: <http://www.coconino.az.gov/> (Public Works; Engineering)