

INTERIM RELEASE: CLSM (to the City Standard Specifications Manual)

206 Backfill of Utility Trenches using Controlled Low Strength Materials (CLSM)

UTILITY CUT, BACKFILL AND PATCHING

1 DESCRIPTION OF WORK

This work shall consist of the excavation and rapid backfill of trenches for the installation or repair of utility and underground features. The work also includes utilizing temporary pavement patching materials, and final permanent pavement surfaces. The work requires the use of removable, controlled low-strength materials (CLSM) for the backfill material, as an alternative to traditional compacted soil, for trenches and cuts too small for traditional soil compaction and safe human entry for testing. Various temporary pavement materials may also be utilized, prior to permanent pavement repairs. The use of traditional compacted backfill (for installation and repair of utilities) remains an acceptable method of backfill. The use of CLSM provides the advantage of being a self-compacting material.

1A Description of removable, flowable, controlled low strength materials CLSM

The term CLSM used in this Section shall mean the same as Removable CLSM or flowable backfill. This material is covered in detail due to the many time saving and engineering benefits of this type of backfill material. CLSM does not need compacting, or moisture density compaction testing. Only a few physical tests of the CLSM properties are needed to assure durability and future removability with light excavating equipment. A low strength is desired so that surrounding utilities or structures will be accessible without causing damage if the CLSM must be removed in the future. Air entrainment is required to prevent damage and heave displacement of trench patches due to freeze-thaw damage.

In addition, CLSM may be used for other applications apart from trench or street cut backfill. These include filling voids due to pipe abandonment or undercutting of excavation in caving or normal soils. CLSM offers quick restoration of the trench and improving other subgrade conditions for roadway or structure support in a rapid time frame without the need for traditional soil backfill testing requirements or when a quick strength is needed to support upper layers. These benefits may outweigh the extra costs vs. using traditional methods that require compaction and testing.

Other applications include: backfilling behind retaining walls and abutments, filling void areas including pipe abandonment, annular spaces, undercut areas and other approved void filling

applications. Other suitable applications include structural support for utilities and replacement of unstable subgrade during pavement repairs.

Utility types that can utilize CLSM include: conduits or pipes for electrical, wired or fiber optic communications, traffic signal or other utilities such as gas and water lines, sanitary and storm sewer lines, and other types of utilities under existing pavements or ground surfaces to be built upon or improved later.

1B Objectives for Required Use of CLSM

The objectives of requiring the use of the CLSM specified below, instead of reusing excavated soils, is to provide a self-leveling, frost heave-resistant, non-settling, controlled low-strength material (defined by American Concrete Institute in ACI 229 as a CLSM), that does not normally require compactive effort and compaction testing. Traditional use of compacted soil or aggregate materials for backfill shall require **CITY** approval and testing for acceptance.

1C Requirements for CLSM – Flow-Fill or Flashfill

This ITEM further specifies two distinct CLSM material products: The Flashfill products will allow trench backfill, temporary or permanent pavement restoration and traffic access to occur more quickly than Flow-Fill. The term 'CLSM' in this Section shall mean either or both.

A **high slump** is required to aid in the self-leveling and void filling objective. The visual consistency may appear to range in appearance from thin batter or mud, to thick water. It must be foremost removable with light machinery in the future, and also quickly stable to support paving operations and traffic.

Minimum air contents are required in the top 4 feet of CLSM fill to limit permanent frost heave. This air content requirement should be used for the entire depth, to aid in the ability to remove or excavate CLSM in the future. The air content requirement may be forbidden by some utility applications, such as for thrust blocks or for pipe bedding normally used for lateral support of pressurized pipes.

A **Removability Modulus (RE)** is specified at a maximum 1.5, and is based on compressive strength and unit weight of the CLSM Backfill. Refer to section 2C

2 CLSM MATERIALS

2A Flow-Fill

Flow-Fill shall consist of a controlled low-strength, self-leveling concrete material composed of various combinations of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment. Generally, the **CONTRACTOR** may place Flow-Fill in approximate 3 feet thick layers, allow bleed water to rise and divert away from placement before another layer may be added. Refer to Section 3 for more information.

The Flow-Fill shall be limited to a maximum Removability Modulus (RE, as described in section 2C) of 1.5 to ensure ability to excavate in the future. Slumps of less than 7 inches will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond specified removability limits.

The **CONTRACTOR** shall submit a mix design for approval by the **CITY**, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

TABLE 2A

Flow-Fill Property	Flow-Fill Specification
Air Content, ASTM C231	15% -- 25%
Compressive Strength, ASTM D4832	50psi – 150psi at 28 days
Slump, ASTM C143	7" – 10"
Removability Modulus, RE	1.5 Maximum

*All other requirements for Flow-Fill shall meet CDOT Section 206 for CLSM.

2B Flashfill

Flashfill shall consist of a controlled low-strength, self-leveling cementitious material composed of various combinations of fly ash, water, chemical admixtures and/or cellular foam for air-entrainment. No aggregate or sand is usually needed. It shall have a minimum specified air content to provide suitable resistance to frost-heave. Flashfill may generally be placed without lift thickness limits.

Higher strengths may be permitted over Flow-Fill; however, the Flashfill shall still be limited to a maximum Removability Modulus (RE) of 1.5. Slumps of less than 8 inches or spreads of less than 8 inches will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond removability limits.

The **CONTRACTOR** shall submit a mix design for approval by the **CITY**, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

TABLE 2B

Flashfill Property	Flashfill Specification
Air Content, ASTM C231, or by Section 2D volumetric calculations (recommended)	15% Minimum
Compressive Strength, ASTM D4832	100psi – 300psi at 28 days
Slump, ASTM C143 (one lift, no rodding)	8” – 11”
Spread, ASTM D6103 (recommended)	8” – 12”, or greater
Removability Modulus, RE	1.5 Maximum

*All other requirements for Flashfill shall meet CDOT Section 206 for CLSM.

2C Removability Modulus

The Removability Modulus* ,RE , is a value calculated by

$$RE = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

where: W = in-situ unit weight (pcf) and C = 28-day compressive strength

*RE was developed & is used by Hamilton County, Ohio; per the NCHRP #597 CLSM Report. A lower RE means CLSM is easier to excavate or remove.

Some examples of RE based on strength and unit weights are shown below:

TABLE 2C
Removability Modulus (RE)

Compressive strength, psi [C]	Unit Weight, pcf [W]										
	50	60	70	80	90	100	110	120	130	140	150
25	0.18	0.24	0.30	0.37	0.44	0.52	0.60	0.68	0.77	0.86	0.96
50	0.26	0.34	0.43	0.53	0.63	0.74	0.85	0.97	1.09	1.22	1.35
75	0.32	0.42	0.53	0.64	0.77	0.90	1.04	1.18	1.33	1.49	1.65
100	0.37	0.48	0.61	0.74	0.89	1.04	1.20	1.37	1.54	1.72	1.91
125	0.41	0.54	0.68	0.83	0.99	1.16	1.34	1.53	1.72	1.93	2.14
150	0.45	0.59	0.75	0.91	1.09	1.27	1.47	1.67	1.89	2.11	2.34
175	0.49	0.64	0.81	0.98	1.17	1.38	1.59	1.81	2.04	2.28	2.53
200	0.52	0.68	0.86	1.05	1.26	1.47	1.70	1.93	2.18	2.44	2.70
RE less than or equal to 1.50 indicates Removable							1.70	Shading indicates Not Readily Removable			

2D Air Content Volumetric Calculation

Air content can be calculated as follows (using wet unit weights before and after foaming or entraining air):

$$\text{Air Content} = \frac{(\text{Unit Weight not Air-Entrained} - \text{Unit Weight Air-Entrained}) \times 100\%}{\text{Unit Weight not Air-Entrained}}$$

2E Flow Consistency of CLSM

Flow shall be measured by ASTM D6103, which utilizes a moistened 3” diameter, 6” high open-ended cylinder, filled with the flashfill. When the cylinder is lifted, the resulting “pancake” is measured at its longest and shortest dimensions and averaged.

MATERIAL CONSTITUENTS

2F Cement

Cement shall meet the standard chemical requirements of Type II or Type IP, ASTM C150 or ASTM C595, respectively.

2G Fly Ash

Fly ash shall meet the requirements of ASTM C618 Type C or Type F. Fly ash not meeting the requirements of ASTM C618 may be used if prior testing indicates acceptable, consistent results for strength and air content.

2H Water

Potable water or reasonably clean and free of chemicals injurious to the final product are to be used.

2I Chemical Admixtures

Air-entraining admixtures shall conform to ASTM C260 requirements; other chemical admixtures shall conform to ASTM C494 requirements.

2J Foaming Agents

Foaming agents shall conform to ASTM C869 and C796, or as approved by the **CITY**.

2K Suitability of CLSM Constituents

The supplier shall have the required Beneficial Use Determination (BUD) from the CDPHE for the product they are supplying. Material Safety Data Sheets (MSDS) must be available for any cement, flyash or admixture component of the mixture upon request. Flowable Backfill shall be compatible with bedding materials, electrochemically and otherwise if used as a metal pipe backfill application. Thermal compatibility with plastic pipes should be considered for direct contact of the CLSM with the pipe; heat generation of the mix must not exceed the softening point of the pipe material.

2L CLSM Use Restrictions

CLSM products containing coal combustion residuals (CCR) (i.e. fly ash, bottom ash, boiler slag, and flue gas desulfurization materials generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers) may not be placed below groundwater, or into permanent standing water, without the CONTRACTOR obtaining a

written waiver from the Colorado Department of Public Health & Environment's (CDPHE's) Hazardous Materials and Waste Management Division (HMWMD), and providing such waiver to the CITY for review / concurrence prior to placement.

The above noted use restriction with respect to groundwater and permanent standing water is not applicable if the CLSM product is being used in association with an emergency. An emergency is an occurrence involving a clear and imminent danger to human health or the environment, or similar occurrence demanding immediate attention, such as the restoration of a damaged utility, roadway, or storm water conveyance. If the emergency has subsided and sufficient time is available for planning (e.g., three weeks or more) the project is not considered an emergency with sole respect to CLSM placement.

Additionally, if a project involves the placement of CLSM on the land in non-roadway applications and the CLSM will contain 12,400 tons of CCR or more, the CONTRACTOR shall obtain written project specific approval from the CDPHE's HMWMD and provide such approval to the CITY for review / concurrence prior to placement. To obtain such approval, the CONTRACTOR shall adequately demonstrate that environmental releases to groundwater, surface water, soil and air are comparable to or lower than those from analogous products made without CCR, or that environmental releases to groundwater, surface water, soil and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

2M Aggregates

The final blend of aggregates for CLSM, including rock, gravel or sand, shall conform to the following gradations:

TABLE 2L

Sieve Size	% Passing
1 inch (25 mm)	100
No. 200	0 to 10

When coarse aggregate is used, 100 percent shall pass the 1 inch sieve, and it shall comprise not more than 40 percent of the total aggregate content. Other aggregate products such as aggregate base, crushed rock, pea gravel, or reject sand which has no more than 20 percent passing the No. 200 sieve and is free of organic material and other deleterious substances, may

be accepted by the **CITY** if a flowable, workable mix can be produced without segregation of the aggregate.

3 TRENCH BACKFILL WITH CLSM

Except as otherwise provided or approved by the **CITY**, after the pipe or conduit is laid, trenches shall be backfilled with CLSM in the pipe zone as defined in the following table:

TABLE 3

Pipe or Conduit	Pipe Zone ^{1,2}
2-inch or less diameter	6 inches above the top of the pipe up to subgrade
Greater than 2-inch diameter, except vitrified clay pipe	12 inches above the top of the pipe up to subgrade
Vitrified clay pipe	24 inches above the top of the pipe up to subgrade

¹ The Utility Owner shall dictate any variance to these CLSM separation distances.

² Where depths of flashfill exceed 3 feet over water or wastewater mains please contact Colorado Springs Utilities for bedding depths.

CLSM should be well mixed and discharged directly from the truck into the space to be filled, or by other methods approved by the **CITY**. The mix may be placed part depth or full depth as conditions at the site and CLSM type dictate. When used as backfill in the pipe zone, care should be taken to prevent flotation or misalignment of the pipe by means of straps, soil anchors or other approved means of restraint. Material may be placed in stages with initially lesser flowability, to prevent movement or flotation of pipe. Refer to Section 2K for thermal compatibility when using CLSM directly against plastic pipe materials. CLSM shall not be placed when the trench bottom or walls are frozen or contain frozen materials.

Compaction of CLSM shall not be performed.

The maximum layer thickness for CLSM shall be determined by the Contractor. Additional layers shall not be placed until the backfill has lost sufficient moisture to be walked on without indenting more than 2 inches. Allow bleed water to rise and divert away from placement area before another layer may be added. Do not place CLSM on top of bleed water or on any water above the bearing layer. Any damage resulting from placing Flow-Fill in layers that are too thick

or from not allowing sufficient strength gain time between placement of layers shall be repaired at the **CONTRACTOR's** expense.

The maximum layer thickness for Flashfill is not restricted except to prevent flowing or running into undesired areas.

Contractor shall observe all other Construction Requirements as provided in CDOT Section 206 for placement of CLSM.

4 STREET SURFACING and PATCHING

Placement of pavement materials for vehicle traffic shall not be allowed until the removable CLSM backfill has cured 24 hours (Flow-Fill only) or achieved sufficient resistance to allow paving. CLSM (either type) should be subjected to standard proofroll criteria, or penetration resistance tests. CLSM should achieve a penetration resistance of at least 3.6 tsf (tons per square foot) (equivalent to 50 psi) using a hand-held soil penetrometer, typically pushed to ¼" depth, in accordance with the penetrometer manufacturer's instructions. Alternately, penetration resistance shall be considered achieved when a person weighing 100 pounds by use of their body weight as an axial load, cannot penetrate the CLSM backfill with the square cut end of a ½" diameter (#4) steel reinforcing bar.

4A Temporary Pavement Selection

Whenever permanent pavement patches are not constructed immediately following trench backfilling operations, temporary pavement patch construction consisting of:

- A minimum of 3 inches of hot mix asphalt (or approved warm mix if allowed) or cold plant mix asphalt on Flashfill or cured Flow-Fill CLSM , or
- A thickness of Flash-Patch equal to existing pavement thickness on CLSM, or
- Steel plates per **CITY** requirements on CLSM,

must be utilized to provide the required number of paved travel lanes. Sufficient excavation of backfill shall be done to allow the temporary surfacing to be level with surrounding pavement. Use of steel plates may be left in place for a short duration as approved by the **CITY**.

Temporary pavement patches may be left in place for a maximum of 30 working days following completion of backfilling operations unless otherwise approved by the **CITY**.

When Flow-Fill is used as backfill material on collector or arterials streets needed to be opened within 24 hours, it must fill the excavation, using 3 feet maximum lifts as required in Section 3, up to the existing pavement surface grade, less enough thickness to provide for steel plates. The **CONTRACTOR** must then plate the excavation with heavy duty steel plates adequate to carry heavy traffic and wait at least 24 hours for the Flow-Fill to cure prior to applying the Permanent Patch or another Temporary Patch. Steel plates should be set below the street surface to avoid lateral displacement; the patch size may be increased to accommodate side support and a smooth height transition. The **CITY** does not allow steel plates on arterials during snow plow operation season. Alternately, Flash-Patch may be placed as a temporary patch and driving surface over CLSM, and shall match the existing pavement thickness.

Neither Flow-Fill nor Flashfill shall be allowed for a driving surface, except for very low traffic conditions and only when allowed by the **CITY**.

4B Temporary Pavement Patching Materials

Various materials for temporary patching options can be selected, and include:

- **Hot Mix** (HMA) or **Warm Mix Asphalt** (WMA) conforming to the Pikes Peak Region Asphalt Paving Specifications. These may be used for either concrete or asphalt streets.
- **Cold-mix** asphalt materials (with cut-back asphalt cements only allowed from October 1 to March 1). This may only be used for asphalt streets.
- **VOC compliant Cold-mix** asphalt materials, (conforming to CDPHE Regulation No. 7, 5CCR 1001-9, Section XI, required from March 1 through September 30). This may only be used for asphalt streets.
- **Flash-Patch** materials (consisting of cementitious fly ash, water and cellular foam) shall include approximately 10 to 15% air content. This may be used for either concrete or asphalt streets. Flash-Patch can be produced with the same volumetric-mixing truck as delivers and produces the Flashfill CLSM material. Flash-Patch materials will exceed

CLSM strengths, but are limited in thickness to the existing pavement thickness to allow removal.

- o Flash-Patch usage on arterial roadways will require that **Small Aggregate topping** be used. Gradations shall meet ASTM C33 for size #9, and be crushed stone or natural gravels, with gradations requirements listed below:

TABLE 4B

Sieve	3/8"	#4	#8	#16	#50
% Passing	100	85 – 100	10 - 40	0 - 10	0 - 5

4C Temporary Pavement Patch Placement

*Temporary asphalt should ideally be placed according to the Pikes Peak Region Asphalt Paving Specifications requirements. Any temporary asphalt pavement patch shall be placed and compacted and shall be maintained by the **CONTRACTOR** so that the patched surface and the surrounding area remain a single even (smooth) unbroken plane, suitable to handle the traffic, for the duration of Temporary Patch.*

Flash-Patch usage on arterial roadways will require that the **Small Aggregate** shall be broadcast on and embedded into the surface, for increased skid-resistance. Aggregate application will occur on patches within 100 feet of approaching stop signs or signal lights on other city streets. This aggregate shall be applied at approximately 5 lb per SY of patch surface, before the Flash-Patch hardens. The **CONTRACTOR** shall be responsible to apply and embed the surface aggregate in a timely manner before set occurs.

The following **surface tolerance** for any temporary patches shall be observed. When a 10 foot straight edge is laid across the temporary patch parallel to the centerline of the street and in the direction transverse to the centerline, there shall be no more than a 3/4 inch rut, hump, or depression evident. Deteriorated temporary patches exhibiting ruts, humps, or depressions shall be repaired or replaced immediately. If the existing street exceeded the above tolerances prior to patching, then the temporary patch shall be equal to or better than the condition of the surrounding pavements.

Temporary patches with hot or cold mix asphalt may be **opened to traffic** after proper compaction and clean-up of the adjacent areas has occurred. Temporary patches of Flash-Patch may be opened to traffic usually within 1-1/2 hours after placement on arterial roadways, and usually within one hour on other streets.

4D Permanent Pavement Materials

Asphalt for replacement of Asphalt Pavement streets, shall be **HMA** (Hot Mix Asphalt), or **WMA** (Warm Mix Asphalt) if allowed by **CITY**, and shall meet the material requirements in the Pikes Peak Region Asphalt Paving Specifications for Grading S or SX with PG 64-22 binder, unless specified otherwise. Completion of the permanent patch in areas where an open graded surface course (SMA) exists shall include placement of a surface course to match the existing surface texture.

4E Permanent Pavement Construction

Prior to placing the permanent patch, the existing cuts made for trenches shall be properly prepared for final pavement patching.

Existing Asphalt Pavement shall be saw cut to a neat straight line and to a minimum 12 inches outside of the trench area. The **CITY** may require just the top lift be outside the trench edges. The resulting "T patch" edges shall not fall within existing wheel paths. Patches parallel to the direction of traffic and encompassing the wheel path shall extend to lane lines.

The **asphalt thickness** shall be the thicker of the existing depth, or the minimum depth of at least 4 inches.

A tack coat shall be applied to all edges to the existing freshly cut and/or approved well cleaned edges of asphalt pavement prior to placing new pavement.

Compaction of each lift shall be to a density of 94% ($\pm 2\%$) of the maximum theoretical density of the approved Job Mix Formula, and conforming to the Pikes Peak Region Asphalt Paving Specifications.

The top of CLSM placed for temporary paving or for steel plates in section 4A shall be excavated to the top of subgrade/bottom of the final asphalt or concrete pavement level. The depth of excavation shall allow for the permanent pavement section to be equal to, or greater than, the existing section, or as otherwise required by the **CITY**.

Any improvements in the right-of-way or on private property disturbed or damaged during construction shall be replaced prior to placement of the permanent pavement patch. Damaged sections of concrete sidewalk shall be removed and replaced to the nearest expansion joint or score line. Damaged concrete curb and gutter shall be removed and replaced to the nearest contraction joint. Replacement of less than a standard length of curb and gutter will not be permitted. Integral curb, gutters, and/or sidewalk shall be replaced in their entirety.

The following **surface tolerance** for permanent pavement patch for asphalt, including any surface treatment before striping, shall be observed. The surface shall be thoroughly compacted, smooth, and free from ruts, humps, depressions, or irregularities. When a 10 foot straight-edge is laid across the permanent patch parallel to the centerline of the street and in a direction transverse to the centerline, the surface shall not vary more than 1/4 inch from the lower edge of the straight edge. Patches exhibiting deviations greater than 1/4 inch shall be replaced prior to acceptance of the patch. If the existing street exceeds the above tolerances, then the patch shall be equal or better than the condition of the surrounding pavement.

Patches shall also have a cross slope or cross section consistent with the design of the existing roadway.