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GEOTECHNICAL INVESTIGATION

1346 NM-150, VILLAGE OF TAOS SKI VALLEY, NM

EEG Project No.: A17-705

Prepared for:

VILLAGE OF TAOS SKI VALLEY

Prepared by

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September 6, 2017

SUMMARY

The information presented in this section is a partial summary intended for reference use only. This information is intended for use only in conjunction with the complete geotechnical investigation report. Significant information contained in the complete geotechnical report may not be present here.

ON-SITE SOILS

The test holes encountered a thin layer of surface soils composed of clayey sand (SC) and clayey gravel (GC) approximately one to two feet thick. The surface soils were underlain by silty gravels (GM) and slightly clayey gravels (GP-GC) containing frequent cobbles and some small boulders. The soils were medium moist to very moist to the touch. Excavator refusal on boulders was encountered at depths between seven and nine feet. Groundwater was not encountered in the test holes to the maximum depth of exploration, approximately nine feet.

GEOTECHNICAL ANALYSIS

The test pits encountered gravelly soils that have a low potential for post-construction settlement or shrink-swell behavior. The site soils are suitable for direct support of conventional shallow foundations. We do recommend the installation of prudent moisture control measures around the buildings to protect the soils supporting foundations from increasing in moisture content. These recommendations are intended to reduce the potential for post-construction differential movement and distress of the buildings to acceptable levels.

SITE GRADING AND DRAINAGE

The implementation of conservative grading, drainage and landscaping designs are imperative in order to reduce the potential for foundation damage. Site grading must comply with the most current IBC Section 1804.3. General guidelines for site grading, drainage, and landscaping are included herein. However these recommendations do not consist of a thorough site-specific evaluation and design; a grading and drainage plan must be designed by a qualified civil engineer. This office must review site grading and drainage plans to evaluate conformance with our recommendations as well as those of the civil engineer of record.

REMEDIAL EARTHWORK

No remedial earthwork appears to be necessary to prepare the building addition areas for construction of new foundations and floors. The new building addition areas may be graded with cut/fill earthwork as necessary. This office must perform inspections and compaction testing during foundation excavation and placement of any engineered fill. Material quality specifications for engineered fill, as well as detailed recommendations for placement, compaction, and testing of engineered fill, are contained in the "General Earthwork Procedures" of this report.

Excavated soils appear suitable for reuse as engineered fill provided that aggressive screening is performed in order to remove oversize material (cobbles and boulders). We recommend a grizzly screen or skeleton bucket with a 2-inch slot size be used to separate cobbles from useful fill material. Alternately imported fill soils may be used. Material specifications for engineered fill are included in the "General Earthwork Procedures" section of this report.

FOUNDATIONS

If the recommendations herein are followed particularly those concerning earthwork, grading, drainage and landscaping, the new building additions may be supported on conventional spread and strip foundations. Foundations and stem walls should be designed and constructed per the Taos Ski Valley Building Department minimum guidelines.

All foundations should be embedded a minimum of forty-eight inches below grade. All foundations should be a minimum of twenty-four inches wide in least dimension. Foundations may be designed for an allowable bearing capacity of 3,000 psf.

CONCRETE SLABS-ON-GRADE

If utilized, concrete floor slabs may be either isolated from foundations or monolithic-style. Concrete floors should be underlain by an impermeable moisture vapor barrier. The slab reinforcement should be designed to resist shrinkage and curling. Concrete slabs-on-grade should be designed by a qualified structural engineer. All exterior concrete (exposed to weather) should conform to an approved air entrained mix design having between 4.5% and 7.5% air. This also applies to interior slabs, if it is anticipated that they will be placed or left unprotected during winter months.

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INTRODUCTION

This report presents the results of our geotechnical investigation and makes recommendations for design and construction of the proposed redevelopment of the Taos Mountain Lodge. The property is located at 1346 New Mexico Highway 150 in the Village of Taos Ski Valley, New Mexico.

The investigation was performed to determine the site subsurface conditions, and based on the conditions encountered, develop geotechnical recommendations for:

- Site Grading, Drainage, and Landscaping
- Earthwork Construction
- Foundation Design
- Slabs-on-Grade
- Retaining Walls

The conclusions and recommendations presented are based on information provided by the client regarding the proposed construction, subsurface conditions disclosed by the test holes, laboratory testing, and the local standards of our profession at the time this report was prepared.

PROJECT DESCRIPTION

We anticipate the property will be re-developed with new driveways, parking lots, and site retaining walls. The upper two buildings will remain the Taos Mountain Lodge while the lower building closer to NM-150 will be re-developed with new additions and serve as the Village of Taos Ski Valley administrative offices.

The office building will be a maximum of two stories in height. The ground floor will consist of either a concrete slab-on-grade or a joisted floor over a crawlspace.

For the purposes of this report, column and strip loads (dead + live) were estimated as not exceeding 10 kips and 3 kips per linear foot, respectively. If actual loads are significantly different that those assumed, this office should be contacted to verify the recommendations presented herein remain applicable.

If structure loads or configuration differ from those indicated in this report, this office should be notified.

SOIL CONDITIONS

To explore the site subsurface conditions three test holes were excavated on the site. The test holes were excavated with a John Deere 310 SE backhoe using a twenty-four inch wide bucket.

The approximate test hole locations are presented on the attached Site Plan, Figure 2. Detailed logs of the test holes are presented on Figures 3 and 4. Soil index test results are summarized on Table 2.

The test holes encountered a thin layer of surface soils composed of clayey sand (SC) and clayey gravel (GC) approximately one to two feet thick. The surface soils were underlain by silty gravels (GM) and slightly clayey gravels (GP-GC) containing frequent cobbles and some small boulders. The soils were medium moist to very moist to the touch. Excavator refusal on boulders was encountered at depths between seven and nine feet.

Groundwater was not encountered in the test holes to the maximum depth of exploration, approximately nine feet.

The subsurface conditions presented above allow observation of a very small portion of the soils below the site. Significant variation in subsurface conditions may occur across the site that was not disclosed by the test holes.

GEOTECHNICAL ANALYSIS

The test pits encountered gravelly soils that have a low potential for post-construction settlement or shrink-swell behavior. The site soils are suitable for direct support of conventional shallow foundations.

We do recommend the installation of prudent moisture control measures around the buildings to protect the soils supporting foundations from increasing in moisture content. These recommendations are intended to reduce the potential for post-construction differential movement and distress of the buildings to acceptable levels.

DRAINAGE, GRADING, AND LANDSCAPING

The implementation of conservative grading, drainage and landscaping designs are imperative in order to reduce the potential for foundation damage. Site grading must comply with the most current IBC Section 1804.3. A grading and drainage plan must be designed by a qualified civil engineer.

To reduce the risk of moisture induced soil movement, the site must be graded to promote positive drainage away from structures on all sides. We suggest a minimum five percent gradient within at least the first ten feet away from structures in unpaved areas and a minimum one percent gradient of paved surfaces. Where utilized to facilitate drainage for example side yards and other "trapped drainage" areas, surface swales must be paved or lined with a 45-mil EPDM liner and graded to drain at a minimum of two percent. Planters and sidewalks must not "dam" water adjacent to structures.

Roof gutters and downspouts must be utilized on the buildings. Down spouts must discharge down slope from and well away from buildings, a minimum of ten feet away where discharging onto ground not covered with pavement or EPDM-lined swales.

Landscaping adjacent to structures must be designed and constructed to minimize the potential for wetting of soils supporting the proposed facilities. We suggest utilizing a xeriscape design. Watering must be carefully controlled to prevent over watering. All lawns, plantings, drip irrigation, and sprinkler lines must be located a minimum of five feet away from foundations.

If onsite leach fields or stormwater ponding areas are required, they must be located downhill from and as far away from structures as possible, a minimum of twenty feet.

Permanent, non-retained slopes must be graded to a maximum slope of 3:1 horizontal to vertical for gross slope stability. All earth slopes will require protection from erosion.

This office must review site grading and drainage plans to evaluate conformance with the recommendations presented herein and those of the civil engineer of record.

REMEDIAL EARTHWORK

No remedial earthwork appears to be necessary to prepare the building addition areas for construction of new foundations and floors. The new building addition areas may be graded with cut/fill earthwork as necessary. This office must perform inspections and compaction testing during foundation excavation and placement of any engineered fill. Material quality specifications for engineered fill, as well as detailed recommendations for placement, compaction, and testing of engineered fill, are contained in the "General Earthwork Procedures" of this report.

Excavated soils appear suitable for reuse as engineered fill provided that aggressive screening is performed in order to remove oversize material (cobbles and boulders). We recommend a grizzly screen or skeleton bucket with a 2-inch slot size be used to separate cobbles from useful fill material. Alternately imported fill soils may be used. Material specifications for engineered fill are included in the "General Earthwork Procedures" section of this report.

FOUNDATION RECOMMENDATIONS

If the recommendations herein are followed particularly those concerning earthwork, grading, drainage and landscaping, the new building additions may be supported on conventional spread and strip foundations. Foundations and stem walls should be designed and constructed per the Taos Ski Valley Building Department minimum guidelines.

All foundations should be embedded a minimum of forty-eight inches below grade. All foundations should be a minimum of twenty-four inches wide in least dimension. Foundations may be designed for an allowable bearing capacity of 3,000 psf.

Lateral foundation loads will be resisted by a combination of passive soil pressure against the sides of foundations and friction along the base. A passive soil resistance of 300 pounds per cubic foot may be utilized for design. Frictional resistance may be determined by multiplying foundation dead load by a coefficient of friction of 0.40.

The allowable bearing capacity values presented herein may be increased by one-third for short term loading conditions due to wind and earthquakes. Foundations widths may need to be larger than the minimum widths stated herein based on actual structure design loads. Foundations should be designed by a qualified structural engineer.

Foundations designed and constructed as described herein are not anticipated to experience total or differential movements of more than one inch. This estimate is implicit in the method used to calculate the allowable bearing capacities and also relies on the assumption the site soils will not be allowed to increase in moisture content and that all recommendations presented in this report will be fully implemented, particularly those regarding earthwork, drainage, grading, and landscaping. Additional movement on the order of 1/8 inch per foot of wetted soil and distress to the building may occur if the soils are allowed to increase in moisture content.

CONCRETE SLABS

Ground floors may consist of either joist floors over a crawlspace or concrete slabs-on-grade. If utilized, concrete floor slabs may be either isolated from foundations or monolithic-style. Concrete floors should be underlain by an impermeable moisture vapor barrier. The slab reinforcement should be designed to resist shrinkage and curling.

Concrete floors should be designed, constructed and jointed as discussed in the ACI Committee Report 302.1R-04 "Guide for Concrete Floor and Slab Construction" and/or 302.2R-06 "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials." Concrete slabs-on-grade should be designed by a qualified structural engineer.

Vapor barriers should have a minimum 15-mil thickness and should consist of extruded polyolefin plastic (no recycled content or woven materials permitted) that conforms in every way to an ASTM E 1745 Class A material. Vapor barriers should be installed in accordance with ASTM E 1643, including perimeter seal. Care should be taken during construction to minimize damage to the vapor barrier.

Concrete slabs-on-grade and exterior flatwork should be isolated from all utility lines.

Some movement should be expected to occur between the building and adjacent exterior concrete flatwork. Joints and cracks in concrete flatwork should be sealed as discussed in the Maintenance section of this report.

All exterior concrete (exposed to weather) should conform to an approved air entrained mix design having between 4.5% and 7.5% air. This also applies to interior slabs, if it is anticipated that they will be placed or left unprotected during winter months.

This office should be allowed the opportunity to review project plans and material submittals prior to the start of construction.

RETAINING WALLS

Retaining walls are anticipated to consist of both "Redi-Rock" style proprietary engineered wall systems, and conventional cast-in-place concrete walls. Retaining walls constructed in association with this project are not anticipated to exceed sixteen feet in height. The values presented below do not include surcharge loads or hydrostatic pressures. If actual conditions differ, this office must be contacted.

If tiered retaining walls are utilized, the foundations must be embedded deep enough so that uphill retaining walls do not create lateral and surcharge loads on downhill retaining walls. To achieve this, uphill foundations must be embedded so that they are no closer to the downhill foundation than 30 degrees as measured from the toe of the uphill foundations to the back of the lower wall. This is displayed on the figure below:

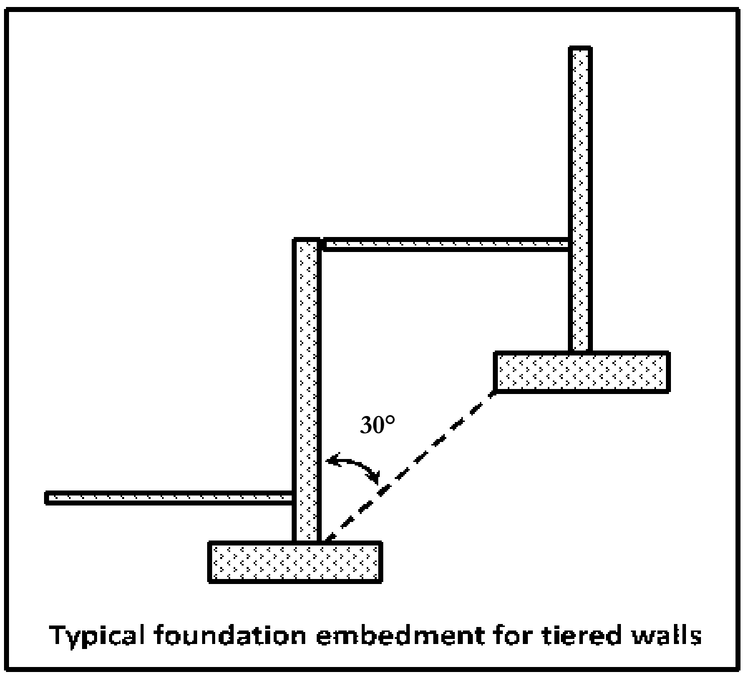

Figure 1: Foundation Embedment for Tiered Walls

Redi-rock and other proprietary retaining wall systems and their foundations must be embedded and constructed per the manufacturer's recommendations.

Conventional retaining wall foundations must be designed and constructed as discussed in the preceding "Foundation Recommendations" section of this report.

Differential movement will occur between yard walls and buildings; control joints must be used to isolate the independent structures.

Retaining walls must be designed to resist an Active Earth Pressure calculated as an equivalent fluid pressure from a fluid having a unit weight of 35 pounds per cubic foot. If the wall is restrained against rotating the wall must be designed for an At-Rest Earth Pressure calculated as an equivalent fluid pressure from a fluid having a unit weight of 55 pounds per cubic foot.

Wall movement will be resisted by Passive Earth Pressure at the toe calculated as an equivalent fluid pressure from a fluid having a unit weight of 300 pounds per cubic foot. Friction along the base can be calculated as the normal force multiplied by a friction factor of 0.40.

The backside of retaining walls must be waterproofed to prevent moisture infiltration. A french drain or gravel-packed weep holes must be installed behind the wall to help prevent hydrostatic forces from developing.

Retaining walls must be backfilled with an approved granular material. Retaining wall backfill must be treated as engineered fill with compaction testing every vertical foot. Care must be taken during compaction of retaining wall backfill to avoid stressing and deflecting the walls.

EARTHWORK

STRIPPING AND GRUBBING

Prior to performing earthwork, all borrow and fill areas should be stripped of vegetation and deleterious materials. All strippings should be hauled offsite or utilized in landscaped areas. Any existing fill or debris should be removed from below the proposed structures.

NATURAL GROUND PREP

We anticipate the site soils may be excavated with conventional earthwork equipment. Following all cut earthwork, the exposed natural soils should then be compacted to a minimum of 95% of maximum dry density as determined by ASTM D-1557.

ENGINEERED FILL SPECIFICATIONS

Excavated soils appear suitable for reuse as engineered fill provided that aggressive screening is performed in order to remove oversize material (cobbles and boulders). We recommend a grizzly screen or skeleton bucket with a 2-inch slot size be used to separate cobbles from useful fill material. Alternately imported fill soils may be used. Sieve analysis and Atterberg Limits tests will be required prior to acceptance of proposed fill materials. Engineered fill soil should have a Plasticity Index of ten or less and should not contain any frozen, organic, or decomposable material. Cobbles, boulders and rock fragments should not be placed within engineered fills. Engineered fill should meet the following gradation which allows for the use of either screened onsite soils, aggregate base course, or other granular soil materials:

U.S. SIEVE SIZE	%-PASSING
6-INCH	100
3-INCH	80-100
NO. 4	40-80
NO. 200	5-40

Table 1: Fill Specifications

Engineered fill should be stockpiled on site, moisture conditioned, and blended to a homogeneous mixture prior to use.

FILL PLACEMENT AND COMPACTION

Engineered fill should be placed in horizontal lifts a maximum of eight-inches in loose thickness, moisture conditioned to optimum moisture content (+/- 3%), and mechanically compacted. Lift thickness may need to be reduced based on the size of the compaction equipment utilized. All engineered fill should be compacted to a minimum of 95% of maximum dry density as determined by ASTM D-1557.

UTILITIES

Care should be taken when installing utilities that the prepared building pad is not overly disturbed. Trenches should be no wider than is necessary for proper installation of utilities. Utility line trenches should not be located parallel and below/immediately adjacent to foundations.

If water or sewer line leaks occur, differential movement of the structure may result. Prior to backfilling utility line trenches, all water and sewer lines should be pressure checked for leaks. Any leaks found should be repaired.

Per the APWA Manual of Standard Specifications 2007 Edition, Section 33-05-20-3.3, the maximum particle size allowable within the pipe zone is ¾-inches for plastic pipes. If the onsite soils cannot be milled or screened to these specifications then we recommend that buried utilities be surrounded by approximately one cubic foot of nominal 3/8-inch "pea gravel" in the pipe zone.

The excavation spoils may be reused as trench backfill provided that the minimum pipe bedding and cover requirements are fulfilled as described above. Cobbles, boulders and rock fragments should not be placed within pipe bedding or pipe backfills.

To reduce the possibility of breaking utility lines, compaction of pipe backfill should be performed with light, hand-operated equipment. In order to achieve compaction, it will be necessary to place backfill in thinner lifts than would normally be necessary. The fill soils in trenches should be compacted to a minimum of 95% of maximum dry density as determined by ASTM D-1557, except where applying this compactive effort may damage pipes or insulation, in which case the backfill should be compacted to a minimum 90%.

LEAN CONCRETE FILL

As an alternate to engineered/compacted earth fill, a flowable lean concrete fill/CLSM may be utilized to level foundation excavation bottoms and backfill trenches, etc. Flowable concrete lean fill/CLSM must have a compressive strength between 30 psi and 200 psi and conform to Vulcan Materials mix design R11138 (or approved equivalent). An example concrete lean fill mix design and literature from the National Ready Mixed Concrete Association are included in Appendix A.

Flowable concrete lean fill/CLSM must be placed in lifts not exceeding three vertical feet. A minimum set time of 72 hours must be maintained between the placement of overlying lifts. During this initial curing period, approximately ¼-inch to 1-inch of settlement per vertical foot should be anticipated unless the concrete lean fill/CLSM is air-entrained to medium/high levels. During curing, concrete lean fill/CLSM must be protected from freezing conditions, rain, vehicles, and pedestrian traffic. This office must perform sampling and compressive strength testing on concrete lean fill/CLSM.

FOUNDATION EXCAVATIONS

Caving and raveling of excavation sidewalls should be expected. Prior to pouring concrete, foundation excavations should be cleaned of any slough, loose soil, or debris. Footing excavations should be scarified and moisture conditioned to optimum moisture content (+/- 3%). Foundation excavations should be compacted to a minimum of 95% of maximum dry density as determined by ASTM D-1557.

OBSERVATION AND TESTING

Compaction testing must be performed by this office during earthwork construction to verify the compaction requirements outlined in this report have been met. The base of footing excavations and finished pad grade should be tested prior to placing reinforcement and pouring concrete. Compaction testing cannot be performed if reinforcement has been installed and will need to be removed to perform testing.

Modified Proctor testing (ASTM D-1557) will be necessary to determine the maximum dry density and optimum moisture content of the natural soils at the base of excavations. The surface of natural soils should be tested for compaction prior to placing engineered fill.

Engineered fill material should be approved by this office prior to use. Following acceptance of the fill material, Modified Proctor testing (ASTM D-1557) will be necessary to determine the maximum dry density and optimum moisture content. Compaction testing should be performed on engineered fill at a minimum of every other lift until finished grade is reached.

Testing of utility line trenches for compaction should be performed at a minimum of every foot of compacted backfill thickness.

EARTHWORK CERTIFICATION

An earthwork certification letter may be requested **prior to** placing structural concrete.

Earthwork certification will only be provided if all recommendations presented herein are followed. It is up to the client to read and understand the recommendations prior to starting construction. Earthworks Engineering Group will answer all questions the client may have concerning these recommendations.

Earthwork certification will be valid for five days following the last inspection by this office. Foundations should be poured during this time-period. The site must be re-inspected if foundations are not poured during this time-period or if site conditions change for any reason following the previous inspection.

SHORING

All trenches greater than five feet in depth must be sloped, shored or braced, or otherwise supported according to OSHA Construction and Safety Standards. Site soils should be considered OSHA Class "C" soils. Temporary construction excavations must be sloped no steeper than 1½:1 (horizontal: vertical).

Limited raveling of slopes will occur particularly as the exposed soils dry out. Material excavated from the trench or spoil must be placed away from the edge of the excavation. The spoil must be retained in an effective manner such that no loose material can fall into the excavation. Heavy equipment and material stockpiles must be located a minimum of five feet from the top of slope.

The above information is intended to provide only general guidelines. This office is not responsible for excavation safety. Temporary construction excavations must be evaluated by the contractor's competent person. Design of safe excavations must conform to the regulations set forth in 29 CFR 1926 Subpart P by the contractor or their designated engineer of record.

MAINTENANCE

Performance of structures depends not only on proper design and construction, but also on an ongoing foundation maintenance program. A properly designed foundation may still experience distress from incorrectly controlled water sources, improper drainage, and landscaping. The owner should perform a yearly inspection to observe for necessary maintenance and repair.

Positive drainage should be provided away from the structure over the life of the building. A minimum slope of five percent within the ten feet of the structure should be maintained. Flowerbeds and landscaping that requires irrigation should not be installed adjacent to structures. Walkways and borders that dam water adjacent to foundations should be eliminated.

Depressions and excavations should be backfilled with compacted, non-swelling, relatively-impervious soils such as clayey sands.

Gutters and downspouts should be installed to control roof drainage. Downspouts should discharge a minimum of ten feet away from structures. Area drains may be installed around structures to improve drainage. Discharge pipes should slope a minimum of 1/8th inch vertical per foot of horizontal pipe. Drainage sewers and discharge channels should be kept free of debris.

Water bills should be monitored for unexplained increases in usage. Higher than normal water usage may indicate a leaking utility line. If a leaking line is suspected, utility lines should be pressure checked for leaks.

Expansion joints within exterior concrete flatwork should be filled with a flexible joint sealer to minimize water infiltration.

Some minor cracking of new concrete foundations, concrete flatwork, and interior dry wall is normal. This is a result of concrete shrinkage as it cures, “settling in” of the new structure, drying of timbers used in construction, etc. Normally the majority of this movement should cease within the first year following construction. However, depending on the structure and site conditions, movement may continue at a slow rate for several years. If cracks tend to open and close, increase significantly within a short period of time, or resume after a period of relative inactivity, it is recommended that this office be contacted to review the situation.

CLOSURE

The recommendations presented in this report are based upon the subsurface conditions disclosed by the test holes. Soil and groundwater conditions may vary between test holes and with time. This office may change the recommendations presented herein based on the conditions encountered during construction.

Prior to performing earthwork, a meeting between the client, this office, and the earthwork contractor should be arranged to discuss the earthwork and foundation recommendations and testing requirements of this project. The purpose of this meeting is to assure that recommendations and requirements are implemented and to minimize delays and expenses during construction.

In order to verify the recommendations presented herein are followed this office must perform field inspections and earthwork Proctor and compaction testing. If this office is not utilized to perform these services, the client agrees to assume all risk for post-construction movement and distress.

This report reflects our interpretation of the site subsurface conditions. We strongly recommend that prior to bidding all contractors perform their own subsurface investigation to form their own opinion of the site soil, rock and groundwater conditions. Should contractors elect to use this report for construction, bidding or estimating purposes, they do so at their own risk.

As this report makes recommendations concerning prudent landscaping and site maintenance, the property owner should be given access to this report and the recommendations herein.

The staff of Earthworks Engineering Group, LLC is available for supplemental consultation as necessary at (505) 899-4886.

1346 NM-150, Village of Taos Ski Valley, NM

Site Plan

*Not To Scale

◆ Test Pit Locations

LOG OF TEST PIT NO.: 1

Project:	1346 NM-150, Village of Taos Ski Valley, NM
Date Excavated:	8.3.2017
Excavation Method:	John Deere 310 SE Backhoe with 24" bucket
Surface Elevation:	Not Available
Depth to Groundwater:	Not Encountered
Bottom of Hole:	Test Hole 1: 7ft Test Hole 2: 9 ft

Depth (feet)	N-Value (blows/ft)	Sample Type	Unified Class.	Description	Dry Density (pcf)	Moisture Content (%)
		B	GC	GRAVEL & COBBLES, with clayey fines, dark brown		
2		B	GP-GC	GRAVEL & COBBLES, sandy, slightly clayey, moist, dark yellow-brown - some small boulders		4.8
5						
				Bottom of Test Hole at 7 Feet		
10						

LOG OF TEST PIT NO.: 2

Depth (feet)	N-Value (blows/ft)	Sample Type	Unified Class.	Description	Dry Density (pcf)	Moisture Content (%)
		B	GC	GRAVEL, clayey, sandy, moist, dark brown		11.3
2			GM	GRAVEL & COBBLES, silty, sandy, moist, dark-yellow-brown		
5		B		- some small boulders - very moist		10.2
				Bottom of Test Hole at 9 Feet		
10						

LOG OF TEST PIT NO.: 3

Project:	1346 NM-150, Village of Taos Ski Valley, NM
Date Excavated:	8.3.2017
Excavation Method:	John Deere 310 SE Backhoe with 24" bucket
Surface Elevation:	Not Available
Depth to Groundwater:	Not Encountered
Bottom of Hole:	7 ft

Depth (feet)	N-Value (blows/ft)	Sample Type	Unified Class.	Description	Dry Density (pcf)	Moisture Content (%)
		B	SC	SAND, clayey, gravelly, moist, dark brown		10.6
			GM	GRAVEL, silty, sandy, medium moit, yellow-brown		
2		B		with cobbles		4.8
5						
				Bottom of Test Hole at 7 Feet		
10						

Test Hole	Depth (feet)	Moisture Content (%)	Liquid Limit	Plasticity Index	Percent Passing - U.S. Sieve Numbers										USCS CLASS
					1-1/2"	3/4"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	N0. 100	No. 200	
1	1-5	4.8			100	48	35	27	22	19	16	14	10	6.9	GP-GC
2	0-2	11.3			100	90	66	57	51	47	44	40	32	24.8	GC
	5-6	10.2			100	88	70	58	50	45	40	34	24	16.6	GM
3	0-1	10.6	24	8	100	95	74	64	55	49	45	39	30	22.3	SC
	3-5	4.8			100	82	66	52	45	40	36	32	23	16.5	GM

APPENDIX A

EXAMPLE LEAN FILL MIX DESIGN & NRMCA BROCHURE

Vulcan Materials Company
WEST REGION

Mix N° : R 11138
State leanfill

Plant: 146 - Hollywood
Job Site :
Usage :
Contract No :

Submitted To :

MIX DESIGN COMPONENT (1 CUBIC YARD)

COMPONENTS	SUPPLIER	TYPE / NAME	QTY oz / yd³	VOLUME ft³	Cost
Cement	GCC - 1	CEMENT TYPE I/II - RIAA1	50 lb	0.25 ft3	
	Phoenix Cement - 9	FLYASH TYPE F - RIB40	200 lb	1.59 ft3	
Sand	Placitas Pit - 2	Concrete Sand - AG2109	1768 lb	10.94 ft3	
Stone	Placitas Pit - 2	CONCRETE STONE - AG7203	863 lb	5.40 ft3	
Water		Water - RIW00	35.95 gal	4.81 ft3	
Air		AIR	15.0 %	4.05 ft3	
Total			3181	27.04	

ADMIXTURES (fl. oz / yd³)

COMPONENTS	SUPPLIER	TYPE / NAME	(fl. oz / yd³)	VOLUME ft³	Cost
Air Entrainment	W. R. Grace - 7	DARAVAIR AT60 BULK - RIE20	15.00 foz	0.02 ft3	
Total				27.06	

				Slump: Air Content : Actual - Required W/C ratio: 1.2 -

Remark :

Prepared by: ____________________

Date : 3/6/2013

PLEASE COMPLETE AND RETURN

Unit Weight: 117.62

Mix submitted by

Accepted [ ] Refused [ ]

Approved by: ____________________

Date: ____________

F - 3 - 2 Revision 0

CIP 17 - Flowable Fill Materials

WHAT is Flowable Fill?

Flowable fill is a self-compacting low strength material with a flowable consistency that is used as an economical fill or backfill material as an alternative to compacted granular fill. Flowable fill is not concrete nor it is used to replace concrete. Terminology used by ACI Committee 229 is *Controlled Low Strength Material (CLSM)*. Other terms used for this material are unshrinkable fill, controlled density fill, flowable mortar or lean-mix backfill.

In terms of its flowability, the slump, as measured for concrete, is generally greater than 8 inches (200 mm). It is self-leveling material and can be placed with minimal effort and does not require vibration or tamping. It hardens into a strong material with minimal subsidence.

While the broader definition includes materials with compressive strength less than 1200 psi (8.3 MPa), most applications use mixtures with strength less than 300 psi (2.1 MPa). The late-age strength of removable CLSM materials should be in the range of 30 to 200 psi (0.2 to 1.4 MPa) as measured by compressive strength of cylinders. It is important that the expectation of future excavation of flowable fill material be stated when specifying or ordering the material.

WHY is Flowable Fill Used?

Flowable fill is an economical alternative to compacted granular fill considering the savings in labor costs, equipment and time. Since it does not need manual compaction, trench width or the size of excavation is significantly reduced. Placing flowable fill does not require people to enter an excavation, a significant safety concern. CLSM is also an excellent solution for filling inaccessible areas, such as underground tanks, where compacted fill cannot be placed.

Uses of Flowable Fill include:

1. Backfill - sewer trenches, utility trenches, bridge abutments, conduit encasement, pile excavations, retaining walls, and road cuts.
2. Structural Fill - foundation sub-base, subfooting, floor slab base, pavement bases, and conduit bedding.
3. Other Uses - abandoned mines, underground storage tanks, wells, abandoned tunnel shafts and sewers, basements and underground structures, voids under pavement, erosion control, and thermal insulation with high air content flowable fill.

How is Flowable Fill Ordered?

Ask for it by intended use and indicate whether excavatability in the future is required. Ready mixed concrete producers generally have developed mixture proportions for flowable fill products that make best use of economical aggregates, fly ash and other materials. Frequently site-excavated materials and materials that do not meet standards for use in concrete can be incorporated in flowable fill mixtures.

Strength - For later excavatability the ultimate strength of the flowable fill must be kept below 200 psi (1.4 MPa) to allow excavation by mechanical equipment, like backhoes. For manual excavation the ultimate strength should be less than 50 psi (0.3 MPa). Mixtures containing large amounts of coarse aggregate are more difficult to excavate. Mixtures with entrained air in excess of 20% by volume are used to keep the strength low.

Higher strength structural fills can be designed for a specific required strength. Compressive strength of 50 to 100 psi (0.3 to 0.7 MPa) provides an allowable bearing pacity similar to well-compacted soil.

Setting and Early Strength may be important where equipment, traffic, or construction loads must be carried or subsequent construction needs to be scheduled. Judge the setting characteristics by scraping off loose accumulations of water and fines on top and see how much force is necessary to cause an indentation in the material. ASTM C 403 or ASTM D 6024 may be used to estimate the load carrying ability of the flowable fill. Penetration values by C 403 between 500 and 1500 psi are adequate for loading flowable fill.

Density in place is usually in the 115 to 145 lb./cu. ft. range for non-air entrained or conventionally air-entrained mixtures. These densities are typically higher than most compacted fills. If lightweight fills are needed to reduce the weight or to provide greater thermal insulation, high entrained air (greater than 20%) mixtures, preformed foam or lightweight aggregates may be used.

Flowability of flowable fill is important, so the mixture will flow into place and consolidate due to its fluidity without vibration or puddling action. The flowability can be varied to suit the placement requirements of most applications. Hydrostatic pressure and floatation of pipes should be considered by appropriate anchorage or by placing in lifts.

Subsidence of some flowable fill mixtures with high water content is on the order of 1/4 inch per foot (20 mm percameter) of depth as the solid materials settle. Mixtures with high air content use less water and have little or no subsidence.

Permeability of flowable mixtures can be varied significantly to suit the application. Most mixtures have permeability similar to or lower than compacted soil.

Durability - Flowable fill materials are not designed to resist freezing and thawing, abrasive or most erosive actions, or aggressive chemicals. If these properties are required, use a high quality concrete. Fill materials are usually buried in the ground or otherwise confined. If flowable fill deteriorates in place it will continue to act as a granular fill.

How is Flowable Fill Delivered and Placed?

Flowable fill is delivered by ready mixed concrete truck mixers and placed easily by chute in a flowable condition directly into the cavity to be filled. To avoid segregation, the drum should be kept agitating. Flowable fill can be conveyed by pump, chutes or buckets to its final location. For efficient pumping, some granular material is needed in the mixture. Due to its fluid consistency it can flow long distances from the point of placement.

Flowable fill does not need to be cured like concrete but should be protected from freezing until it has hardened.

References

1. *Controlled Low Strength Materials*, ACI 229R, American Concrete Institute, Farmington Hills, MI.
2. *Recommended Guide Specification for CLSM (Flowable Fill)*, NRMCA Publication 2PFFGS, National Ready Mixed Concrete Association, Silver Spring, MD.
3. ASTM *Book of Standards, Volumes 04.09 and 04.02*, American Society for Testing and Materials, West Conshohocken, PA.
4. *Controlled Low Strength Materials*, ACI SP-150, ed. W.S. Adaska, American Concrete Institute, Farmington Hills, MI.
5. *The Design and Application of Controlled Low-Strength Materials (Flowable Fill)*, ASTM STP 1331, ed. A.K. Howard and J.L. Hitch, American Society for Testing and Materials, West Conshohocken, PA.
6. *Controlled Low-Strength Materials*, W.S. Adaska, Concrete International, April 1997, pp. 41-43, American Concrete Institute, Farmington Hills, MI.

Testing Flowable Fill Mixtures

Quality assurance testing is not necessary for pre-tested standard mixtures of flowable fill. Visual checks of mixture consistency and performance have proven adequate. Test methods and acceptance criteria for concrete are generally not applicable. Testing may be appropriate with new mixtures or if non-standard materials are used.

- Obtain samples for testing flowable fill mixtures in accordance with ASTM D 5971.
- Flow consistency is measured in accordance with ASTM D 6103. A uniform spread diameter of at least 8 in. without segregation is necessary for good flowability. Another method of measuring flowability is with a flow cone, ASTM C 939. The mixture tested should not contain coarse aggregate retained on the No. 4 (4.75-mm) sieve. An efflux time of 10 to 26 sec is generally recommended.
- Unit weight, yield and air content of flowable fill are measured by ASTM D 6023.
- Preparing and testing cylinders for compressive strength is described in ASTM D 4832. Use 3 x 6 in. (75 x 150 mm) plastic cylinder molds, fill to overflowing and then tap sides lightly. Other sizes and types of molds may be used as long as the length to diameter ratio is 2 to 1. Cure cylinders in the molds (covered) until time of testing (or at least 14 days). Strip carefully using a knife to cut plastic mold off. Capping with sulfur compounds can damage these low strength specimens. Neoprene caps have been used but high strength gypsum plasters seem to work best.
- Penetration resistance tests such as ASTM C 403 may be useful in judging the setting and strength development. Penetration resistance numbers of 500 to 1500 indicate adequate hardening. A penetration value of 4000, which is roughly 100 psi (0.7 MPa) compressive cylinder strength, is greater than the bearing capacity of most compacted soil. Another method of testing for adequate hardening after placement is the ball drop test, ASTM D 6024. A diameter of indentation of less than 3 in. (75 mm) is considered adequate for most load applications. A relationship between the strength gain of the flowable fill and the penetration resistance can be developed for specific mixtures.

CAUTIONS

1. Flowable fill while fluid is a heavy material and during placement will exert a high fluid pressure against any forms, embankment, or walls used to contain the fill.
2. Placement of flowable fill around and under tanks, pipes, or large containers, such as swimming pools, can cause the container to float or shift.
3. In-place fluid flowable fill should be covered or cordoned off for safety reasons.

1989 AND 2000