City of La Quinta

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ENGINEERING BULLETIN #09-03

TO: All Interested Parties

FROM: Timothy R. Jonasson, Public Works Director/City Engineer

EFFECTIVE DATE: June 18, 2010

SUBJECT: Technical Memorandum with Respect to Collapsible Soils for Geotechnical Reports

This engineering bulletin establishes supplemental guidance with respect to collapsible soils for geotechnical reports that are used to prepare grading plans for City Engineer approval in the areas of the City highlighted in Attachment 1. This supplemental guidance is applicable to (but not necessarily limited to) soil investigations in areas of potentially high settlement as shown in Attachment 1. The City Engineer, on a case by case basis, will determine whether this supplemental guidance will apply to a project that is not within the areas shown in Attachment 1.

The common types of settlement observed include the following:

- Regional land subsidence in the lower Coachella Valley has been documented by the Coachella Valley Water District (CVWD) and the U.S. Geological Survey (USGS). The USGS report on Coachella Valley subsidence can be found at http:/ca.water.usgs.gov/.

- Localized loose (weak zone) soil profiles in La Quinta have been documented in geotechnical engineering reports. This has been verified by recording blow counts per foot using various sampler types corrected to N_{60} values. Resulting blow counts of less than 10 are fairly common and can range in depth from about 5 to 30 feet below the ground surface. Although the blow counts in some cases are less than 10, the consultant should provide sufficient testing and analysis to evaluate the short/long term effect of potential settlement. The depth of influence for pad footings is about 2B and for continuous footings is about 4B, where "B" is the width of the footing. Loose soil profile conditions are commonly mitigated by overexcavation and recompaction of the zone beneath the building pad. Whether the design team recommends a grading solution or a structural solution (or a combination of these) the end goal is to quantify the potential for settlement. An example of a loose soil profile boring log is shown in Figure 1. There is a low blow count layer at about 15 feet of depth likely due to ancient lake deposits.

Figure 1 – Loose Soil Profile

PROJECT:	SilverRock Clubhouse		DRILLER:	2R Drilling (CME 75)	SHEET:	1 of 2	
CTE JOB NO:	40-2244		DRILL METHOD:	8" Hollow stem auger	DRILLING DATE:	2/5/2008	
LOGGED BY:	R. Ellerbusch		SAMPLE METHOD:	140 lb/30" autohammer	ELEVATION:	~	

BORING: B-1

Depth (Feet)	Sample: Bulk	Sample: Driven Type	Blows/Foot	Dry Density (pcf)	Moisture (%)	U.S.C.S. Symbol	Graphic Log	DESCRIPTION	Laboratory Tests
0						SM-ML		**Undocumented Fill**	
			44	104.2	10.0			Dense, Moist, Gray-Brown Silty SAND. fine, slightly clayey	MD
5			37	93.6	13.8	ML		Hard, Moist, Light Gray-Brown Sandy SILT.	MD
						SM-ML		**Lake Deposits (Ql)**	
10			26	90.5	12.7			Medium Dense, Moist, Olive-Brown Silty SAND. very fine, slightly porous	MD
15			6		6.6	SM		Loose, Moist, Gray Silty SAND. faint iron-oxide staining	M
20			14		2.2	SP-SM		Medium Dense, Damp, Light Gray Poorly-graded SAND with Silt.	M
25						ML			

B-1

Table 1 is a different example that illustrates that for a given soil profile, varying the spread footing width can significantly affect the estimated settlement. This again reinforces the concept that the geotechnical professional and the foundation design professional must work closely together to address these issues.

Table 1
(Loose Soil Assumed to Commence at 7.5 ft Below Grade)

Example		1	2	3	4	5	6	7	8
Foundation Load	psf	2000	2000	2000	2000	2000	2000	2000	2000
Spread Footing Width	Ft	2	3	4	5	6	7	8	9
Estimated Settlement	inches	0.16	0.26	0.44	0.67	0.92	1.19	1.42	1.60

Hydrocollapsible soils have been documented in La Quinta. The hydrocollapse test values have ranged from about 0.5% to 7.0% at a load of 2.0 kips/sq ft. The applied stress that induces hydrocollapse is a combination of those from the footings and those from the overburden soil.

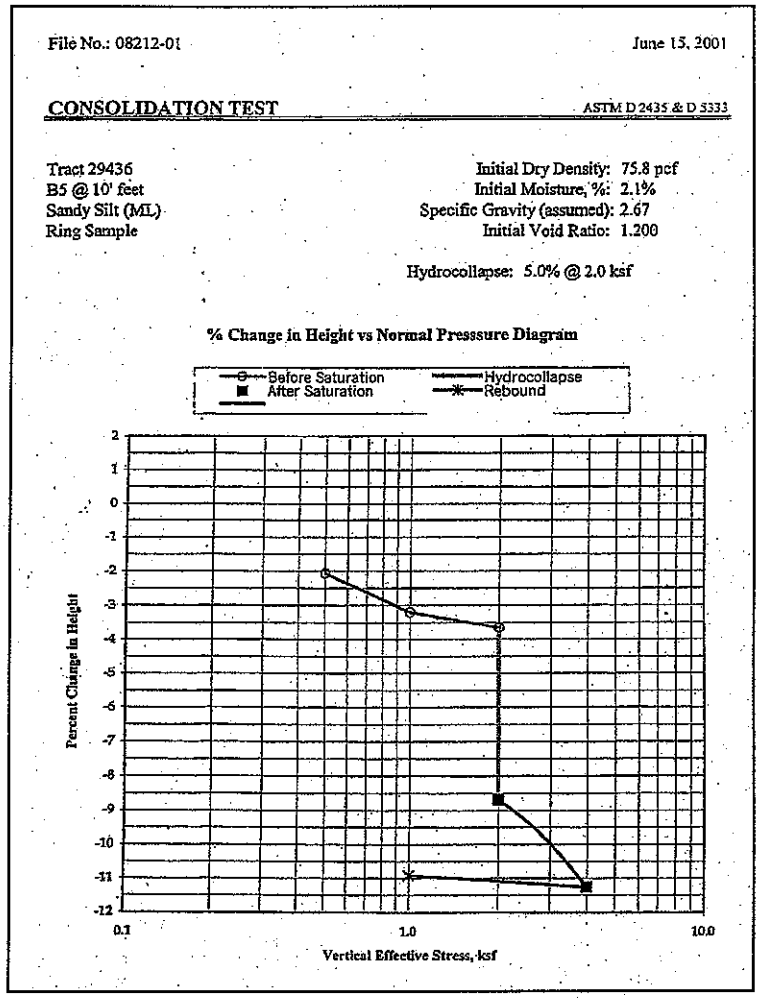
The City of La Quinta requests that all hydrocollapse testing be conducted in accordance with ASTM D5333 with soil saturation occurring at 4.0 kips/sq ft loading. This will reduce the cost of the test, reduce time requirements and better define the soil profile. When specific loading magnitudes are known, the test results may be adjusted to properly model actual loads and the corresponding collapse percentage. If the tests are run at a lower loading, any designation related to potential collapse shall use an extrapolated line to the 4 ksf loading and the test during inundation shall be carried to the 4 ksf loading. The extrapolated line shall have the same slope as the line coming to 2 ksf or the other applied loading.

Hydrocollapse can be mitigated by several methods that may include: moisture conditioning and compacting soils to depths necessary to mitigate these zones, dynamic compaction (if there are favorable soil conditions), or use of an enhanced foundation system.

Table 2 – 0.8% Hydrocollapse Settlement Example Calculation on Historical Foundation Failure Site

Boring Number		1	2	3	4	5	6	7	8
Max Existing Density	pcf	84	84	84	84	84	84	84	84
Max Existing Moisture Content	%	4	4	4	4	4	4	4	4
Length of Boring with Collapse	ft	5	10	15	20	25	30	35	40
2 kip/sq ft Collapse Potential per ASTM D5333	%	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Estimated Settlement	inches	0.48	0.96	1.44	1.92	2.40	2.88	3.36	3.84

Figure 2 - 5% Hydrocollapse Test Results



- Seismically-induced settlement - Because of the proximity of the San Andreas Fault, La Quinta is expected to someday be subjected to significant seismically-induced ground motions, which may result in settlement, particularly in the loose soils. This settlement may impact buildings and infrastructure.

- Static settlement of buildings due to foundation loads – Static settlement also needs to be considered. This type of settlement may impact buildings and infrastructure.

Options for Addressing Collapsible Soils

Attachment 2 shows some options for addressing the above issues. Additional options to address collapsible soils include removing the collapsible soil, avoiding or minimizing wetting on the site, transferring the load through the collapsible soils to stable soils below, injecting chemical stabilizers or grout, prewetting the soil, compacting the soil with rollers or vehicles, compacting the soil with displacement piles, and compacting the soil by heavy tamping. Vibroflotation, deep blasting combined with prewetting, and controlled wetting could also be considered. The structure, itself, could also be designed to be tolerant of differential settlement.

Suggested Supplemental Geotechnical Specifications for Soils Investigations Showing Potentially High Settlement for Grading Plans

The interrelationship between land subsidence, weak zone and hydrocollapsible soil conditions is complex and subject to professional interpretation. A key objective of the City grading plans is to address these conditions by using grading methods, enhanced building foundations or a combination of both.

Building designs are typically not fully completed when grading plans are submitted for review. Accordingly, the Civil Engineer of Record in conjunction with the Geotechnical Engineer of Record should mitigate land subsidence, weak zone and hydrocollapsible soil conditions by grading design (i.e. overexcavation, water saturation and recompaction) OR provide the City with a confirming Structural Engineer of Record report documenting the foundation design solution methods.

Supplemental grading plan geotechnical specifications for investigations showing potentially high settlement are as follows:

a. Geotechnical Engineer determination of total Collapse Potential of identified dry to moist soils.
b. Foundation Design based on saturated conditions.
c. Geotechnical Engineer estimation of total settlement and differential settlement for buildings based on a Schmertmann Analysis or equal and hydrocollapse potential as applicable.
d. Geotechnical Engineer shall provide the anticipated total and differential settlement, while the structural engineer shall determine acceptable tolerance for buildings.
e. Borings at least 50 ft deep. If building envelopes have been established, provide a minimum of 2 borings within each building area. If the building exceeds 10,000 square feet, provide a minimum of 1 boring for each additional 10,000 sf (with any increment rounded up to the next highest whole number). For example a 12,000 square foot building would require 2 borings (up to 10,000 square feet plus 2,000 sf/10,000 sf equals 0.2 which is rounded up to 1 for a total of 3 borings). For tracts, one boring per 10 building pads is the required minimum. For pipelines, pavement and other facilities the minimum number of boring is as determined by the Geotechnical Engineer.
f. Geotechnical Engineer determination of grading recommendations for:
    - Solution feasibility of identified collapse potential strata below buildings, PCC/AC roads, concrete paver roads, flatwork and related infrastructure.
    - Overexcavation check including worse case Schmertmann Analysis or other acceptable method of analysis.
g. Structural Engineer determination of Maximum Allowed Total and Differential Settlement.
h. Structural Engineer approval letter accepting Geotechnical Report Foundation Recommendations.
i. Structural Engineer determination of Maximum Footing Size.
j. The report shall have a discussion on in-situ dry densities related to city estimated and accepted dry density value.
k. A laboratory degree of saturation shall be provided for all collapse test samples.

l. If collapse potential solution measure used to saturate in-situ soils, then the estimated degree of saturation from the in-situ soil shall be provided within the report. Furthermore, a plan when the degree of saturation can not be met shall be provided.

Standard Penetration Testing, Split Barrel Sampler (ASTM D1586-08a) or Cone Penetration Testing (CPT, D3441)

In addition to sampling for Collapse Potential testing, the investigation shall provide borings to the following specifications:

a. 50 ft minimum depth or greater based on soil or foundation data.
b. If SPT and Split Barrel Samplers are used during the investigation, the blow count data shall be converted to equivalent N_{60} values.
c. Continuous sampling (SPT or Split Barrel Sampler) or identification (CPT) of soil layers shall be performed. When sampling for collapse potential or consolidation, the sample diameter should be large enough to reduce sidewall disturbance.
d. Sufficient number of borings to define the soil strata or worse case condition if indefinable after a minimum of 3 borings.

Schmertmann Analysis Criteria

Based on the worse case boring log and footings (Continuous and Spread) for the structure in question, a Preliminary Schmertmann Settlement Analysis, or equivalent method shall be provided. Coefficients required to determine this analysis are:

a. Footing widths and loads
b. Footing depth of embedment
c. Unit weight of soil
d. Time (please use 100 years)
e. Document in the boring logs, the sampler type used and the blow counts corrected to equivalent N_{60} values. (All coefficients used to determine N60 shall be shown in the report). The sampler should be driven at least 18 inches with blow counts recorded in 6-inch increments.

The Schmertmann (or other acceptable method) settlement shall not exceed the allowed Structural Engineer's stated total and differential settlement nor exceed an angular distortion ratio of 1:360 (1 inch in 30 feet). Solution measures shall be provided to reduce settlements at or below the stated allowable settlements. The Structural Engineer shall certify that the foundation is designed to handle the total and differential settlements.

Hydrocollapse Testing (ASTM D5333)

All moist or dry sands to silt layers shall be checked and given an assumed collapse potential percentage. Dry, light, and airy clays shall also be investigated for collapse potential.

Based on the geotechnical report, an assumed worse case log scenario shall be provided within the report. The log shall provide a minimum depth of 50 ft or deeper than the estimated bottom of footing. It could be deeper based on geotechnical information and/or foundation design. Note, the geotechnical report should review identified collapse potential

strata to depths deemed non collapsible and the report should be titled "Preliminary Geotechnical Investigation" until the details of the project are known, i.e. building construction types, minimum and maximum loading, etc.

If the categorization is "slight" for hydrocollapse potential for all soil layers, no further analysis is required. If some of the soil layers yield "moderate" or "severe" potential, actual building loading should be used to calculate the total settlement and differential settlement. The total settlement due to hydrocollapse shall be shown in the report. A statement must be received from the foundation designer of record saying that the foundation was designed to handle the differential settlement. If the total differential settlement exceeds an angular distortion ratio of 1:360 or is greater than the foundation designer (structural engineer) deems appropriate for the foundation design, then solution measures shall be provided.

Finally, the collapse potential shall be included in the quantity under estimated subsidence due to collapse potential.

Change in Geotechnical Engineer of Record

The original and new Geotechnical Engineer of Record shall immediately inform the City Engineer of the potential change of Geotechnical Engineer of Record. The new Geotechnical Engineer of Record shall show in writing that he or she approves all past and present reports for the project.

Past Report Submittals

A current submitted geotechnical report shall include copies of all known past reports relating to the subject property. Known past reports shall be made available to the new geotechnical engineer for review and shall be referenced in the current geotechnical report.

If current recommendations are found to differ from past recommendations, the Geotechnical Engineer of Record shall provide the City with sufficient data and explanation within the report or updated letter to justify the modified requirements. The City Engineer shall approve all such recommendations.

Oct 26, 2003 - June 12, 2005

ATTACHMENT 1

N
W
E
S

10

Indio Hills

Coachella Branch of the All-American Canal

DUNE

COCH

Indio

111

R70R

Coachella

54JA/JA54

TMAP

S753

C143

C132

Palm Desert (Area 1)

COTD

MAGF

Indian Wells (Area 2)

OSDO

MANI

La Quinta (Area 3)

CAHU

DEEP

74

San Jacinto Mountains

Santa Rosa Mountains

Subsidence Contour-Interval 10 mm

Consolidated Rock or
Partly Consolidated Deposits

COTD CGPS station and identifier

OSDO GPS station and identifier

Summary of Certain Settlement Types

Attachment 2

Settlement Type:	Regional Land Subsidence	Weak Soils	Hydrocollapse/Swelling
Identification:	CVWD/USGS Monitoring	Blow Counts ≤ 10 (at a minimum)	a. ASTM D5333 and ASTM D546 (Swelling) b. Silt layers or any potential collapse soils @ 4 KSF (showing Moderate Collapse)
Limits of Investigation:	Water Surface to Ground Surface	a. 2B or 4B where B = width of footing b. Differential Settlements > 1:360 or 1" in 30ft	a. 0 to 50 feet b. Depth with no increase in saturation.
Mitigation Measure:	Groundwater Recharge	a. Overexcavation of Low Blow Count Layers in Influence Zones b. Surcharge c. Wetting (if proven by Soil Engineer to mitigate)	a. Overexcavation of moderate or greater potential layers. b."Foundation Design Principles and Practices" Second Edition by Donald P. Coduto, pp 715 to 718, describes 12 preventive and remedial measures to mitigate collapsible soils including: “removal of the collapsible soil, avoidance or minimization of wetting, transfer of load through the collapsible soils to the stable soils below, injection of chemical stabilizers or grout, prewetting, compaction with rollers or vehicles, compaction with displacement piles, compaction by heavy tamping, vibroflotation, deep blasting combined with prewetting, controlled wetting or design the structure to be tolerant of differential settlement.”