

May 23, 2025

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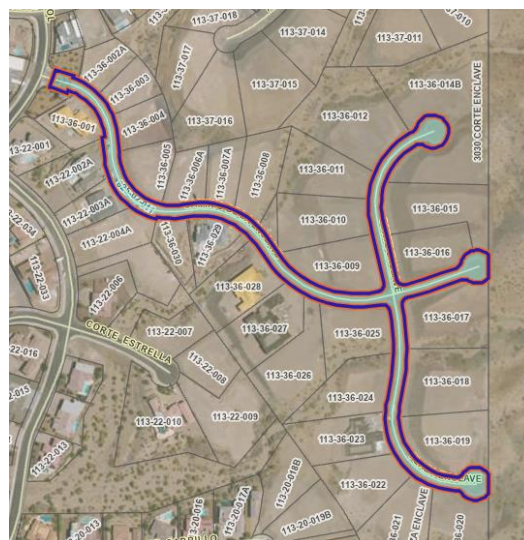
Subject: **Geotechnical Evaluation of Paver Roads**
Enclave at Lake Havasu (34.508809⁰, -114.251130⁰)
Lake Havasu City, Arizona 86406
CSET 81-142

Dear Mr. Holmgren,

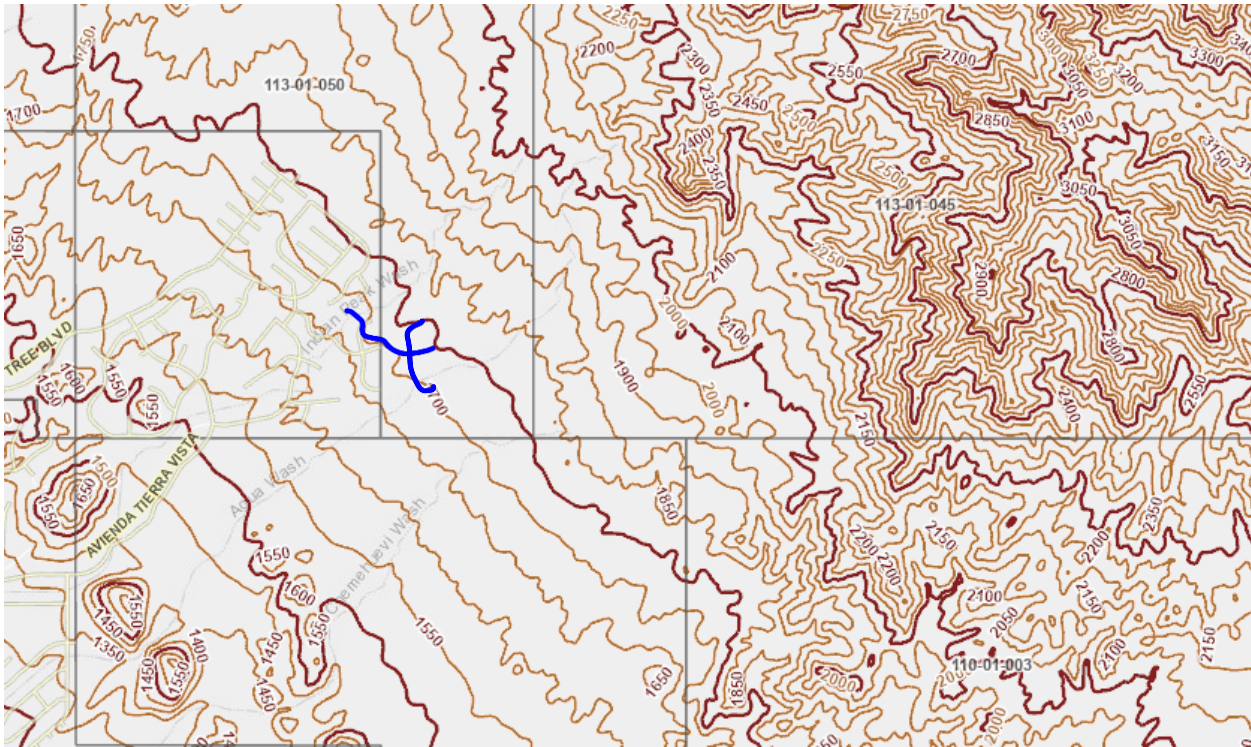
Copper State – TEAM, Inc. (CSET) herein presents our limited geotechnical evaluation of the paver roads constructed inside the Enclave at Lake Havasu subdivision (the “subdivision”). Based on our review of historical aerial photos, it appears the pavers were constructed in the first half of 2022. CSET was hired to conduct limited geotechnical investigation of the underlying soils and opine on the causation of the paver road distress.

BACKGROUND

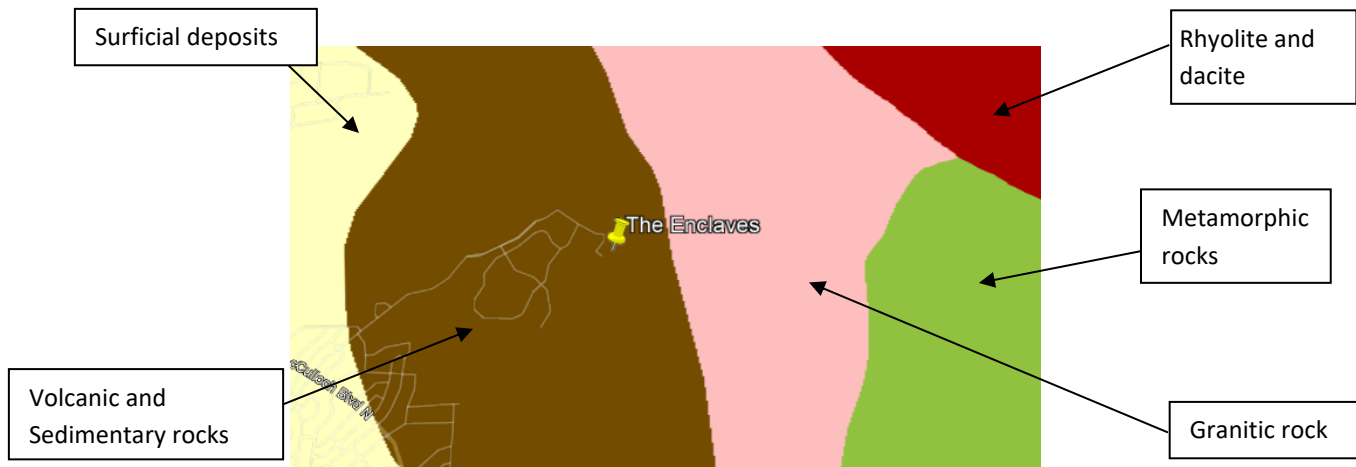
There are thirty lots in the subdivision with the paver roads providing access to the lots. The paver roads are 30 feet wide which includes the 2-foot-wide concrete ribbon on both sides of the road. The total length of the roads is approximately 3250 feet. The elevations of the roads decrease from east to west. The lowest elevation point is located approximately 250 feet east of the entry gate.



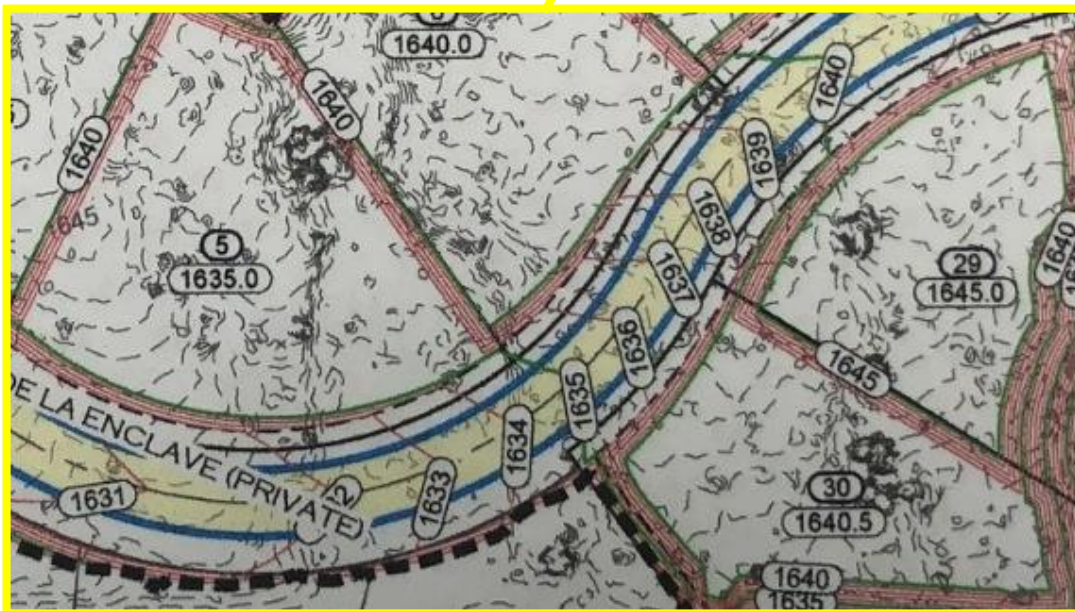
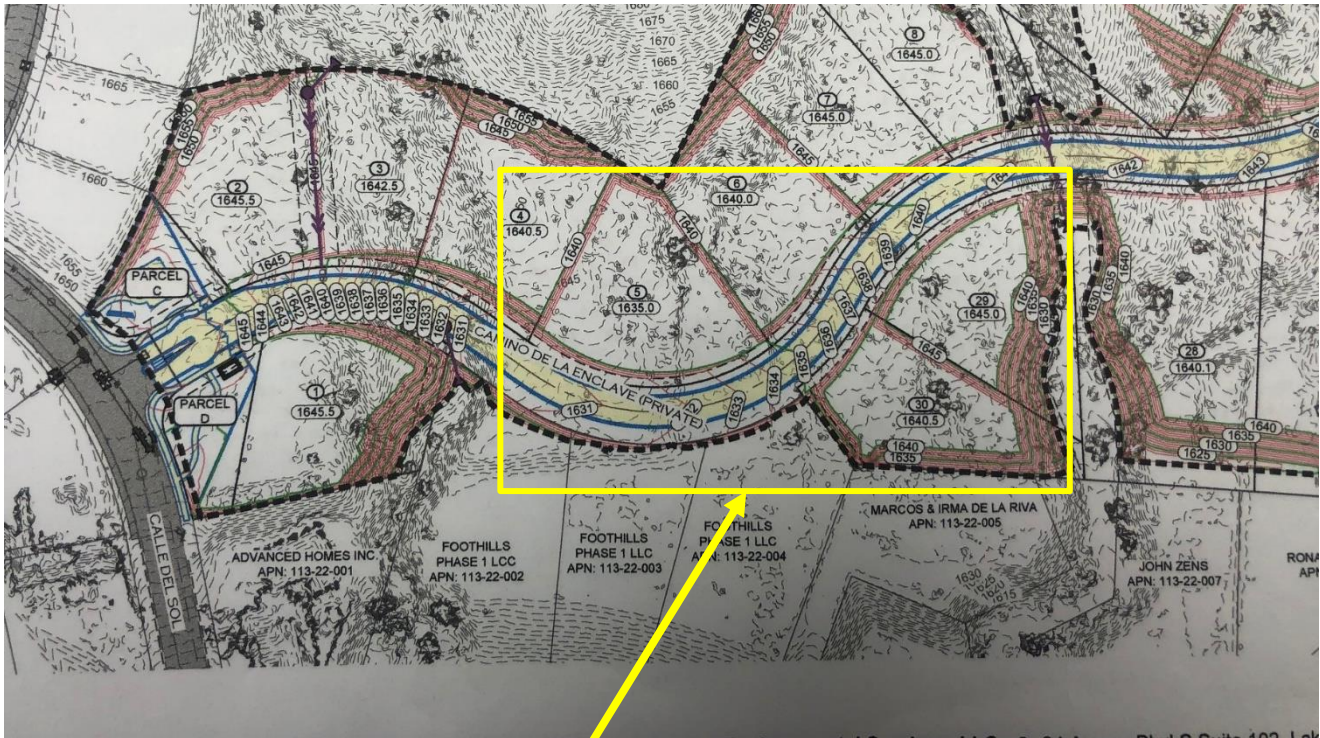
A 50-foot contour interval topographic map is shown below. The subject roads are highlighted with blue. The original ground topography slopes down to the southwest to Colorado River located approximately 6.5 miles southwest of the subdivision. The spacing between the contour lines indicates the degree of the slope, that is the closer the lines the steeper the slope. The subdivision natural grade prior to the development is estimated at 3 foot drop every 45 feet (6.7%).



Arizona is divided into three major physiographic provinces; 1) Colorado Plateau Province, which covers northern Arizona, 2) Basin and Range Province that covers southern Arizona, and 3) Central Highlands Province is the transitional zone between the Colorado Plateau and the Basin and Range Provinces. The lots are situated in the portion of the Basin and Range Province. The regional geological map shows that the lots are underlain with volcanic and sedimentary rocks.



Copper State Engineering, Inc (CSE) was acquired by another company about a year ago and became Copper State – Team, Inc (CSET). The authors of this report previously evaluated the slope between the Enclave subdivision and the Ladera South subdivision situated north and northwest of Enclave. As part of that work, CSE took photos of the grading and drainage plan for Enclave at Havasu Foothills, prepared by Advanced Engineering and Environmental Services, LLC. The grading and drainage plan shows that the Camino de la Enclave Road was designed with an inverted crown (the center of the road is lower than the edges).



SITE VISIT

CSET representatives visited the site on April 7, 2025 and conducted field density tests, documented the condition of the roads and collected soil samples. The pavers were removed at four locations for field density testing. The locations shown below were selected by the contractor.



After the pavers were removed by the paver contractor, CSET removed the sand bedding and measured the thickness of the bedding. The field density test of the aggregate base (AB) layer was conducted on level surface. The AB was then removed to conduct field dry density tests of the subgrade soil underneath the AB. The field density tests were conducted using CPN nuclear density gauge. In all except one hole, the nuclear gauge probe was driven to a depth of 12 inches in both the AB and the subgrade. The field dry density was measured at a depth of 12 and 6 inches to see if there is a significant difference in densities.



TP-1



TP-1 - The subgrade is similar to the AB except the subgrade has rocks as large as three inches



TP-2



TP-3 The subgrade is different from all the other test locations. It is darker in color, has plasticity and more fines.



TP-3 A closer view of the subgrade soil



TP-4

The results of the field density tests are summarized in the table below.


Location ID	Depth from Top of Paver (in.)	Probe Depth (in.)	Field Dry Density (pcf)	Field Moisture (%)	Proctor Maximum Dry Density (pcf)	Optimum Moisture (%)	The Ratio of Field Dry Density to Maximum Dry Density (%)
TP-1	4	12	129.3	7.8	133.2	7	97.1
TP-1	4	6	130.8	8.4	133.2	7	98.2
TP-1	11	12	126.5	5.9	135.4	7	93.4
TP-1	11	6	118.0	6.3	135.4	7	87.1
TP-2	5	12	132.6	6.3	133.2	7	99.5
TP-2	5	6	130.1	6.2	133.2	7	97.7
TP-2	11	12	119.2	6.0	135.4	7	88.0
TP-2	11	6	123.4	8.1	135.4	7	91.1
TP-3	5	12	127.0	7.0	133.2	7	95.3
TP-3	5	6	126.7	6.6	133.2	7	95.1
TP-3	13	12	113.8	12.6	122	12.3	93.3
TP-3	13	6	114.4	12.2	122	12.3	93.8
TP-4	6	6	127.1	8.4	133.2	7	95.4
TP-4	6	9	124.1	8.0	133.2	7	93.2
TP-4	12	12	129.4	7.1	135.4	7	95.6

Limited visual observation of the paver roads was made, especially near the test locations. In addition, the entire roadway was videotaped using our Insta360 3D camera. Below are some of our observations.

- Chipped pavers
- Vertical movement of pavers around utilities
- Broken pavers around utilities
- Gap between pavers

Example photos are provided below.



	
<p>Settled and broken pavers around utilities</p>	<p>Vertical offset between manhole cover and pavers</p>
	
<p>Chipped pavers along the concrete ribbon</p>	<p>Gap between pavers</p>
	
<p>Gaps between pavers</p>	<p>Chipped pavers</p>

LABORATORY TEST

The soil samples collected from the test locations were tested in CSET soils laboratory. The laboratory tests include gradation (ASTM D6913), Atterberg Limits (ASTM D4318) and standard proctor (ASTM D698). The results of the tests are summarized below.

Location I.D.	Sample Depth (in.)	Standard Proctor Maximum Dry Density (pcf)	Standard Proctor Optimum Moisture (%)	Gravel		Coarse Sand	Med. Sand	Fine Sand		Clay & Silt	Atterberg Limits			ASTM Classification
				< 3" %	< 1" %	< # 4 %	< # 10 %	< # 40 %	< # 100 %	< # 200 %	LL	PL	PI	
TP-1	3 - 4	Not Tested		100.0	100.0	98.0	83.0	29.0	6.0	4.3	Not tested			
TP-1	4 - 11	133.2	7	100	99	67	52	30	15	13.9	NP	NP	NP	SM
TP-1	11 -18	135.4	7	100	83	53	40	22	11	10.5	NP	NP	NP	GM
TP-3	13 -18	122	12.3	100	97	72	56	36	20	18.5	33	25	8	SM

DISCUSSIONS

A. **Compaction** - The field investigation was conducted to evaluate the field densities of the AB and subgrade. The field dry densities are compared to the standard proctor maximum dry densities. Typically, vehicular roads in urban setting are constructed with flexible (asphaltic concrete) pavement or rigid (concrete) pavement. Depending on the expected type of traffic, the pavement section for these types of roads consists of compacted subgrade, compacted AB and a driving surface constructed with asphalt or concrete. For instance:

- Arizona Department of Transportation (ADOT) Standard Specifications for Road and Bridge Construction requires that the AB layer be compacted to 100% of the maximum dry density.
- The Maricopa Association of Governor (MAG) standard specification recommends scarification and compaction of the subgrade to a depth of six inches. MAG recommends a minimum 95% compaction of the subgrade soil and minimum of 100% and 95% compaction of the AB under asphalt and concrete pavement, respectively.
- Interlocking Concrete Pavement Institute (ICPI) recommends 98% compaction for both the subgrade and aggregate base.

The thickness of the AB layer varies from 5 to 8 inches. The results of the field density tests indicate that the compaction of the AB layer ranges from 95.3 to 99.5 percent. The percent compaction of the subgrade soils ranges from 88 to 95.6. Based on the results of the field density tests, the percent compaction of the AB layer is slightly lower than the specification that is commonly used for vehicular roads.

The dry densities of the subgrade soils were lower than 95% of the maximum dry density in three of the four test locations. The dry densities were 1.2 to 7.9 pcf lower. If there are project specific compaction requirements, CSET should be provided for review. In summary, CSET did not observe widespread settlement of the pavers due to lower densities of the AB and subgrade soils.

- B. **Chipped Pavers** - There are several chips at the corners of the pavers. There are a lot more chipped pavers on the western half of the Camino de la Enclave than the rest of the roadways. We suspect that a rock rests on the corners of the pavers where minor depression exist, and vehicle loads on top the rock causes the paver to chip. Chipped pavers are common along the concrete ribbon at driveway ramps to empty lots.



Chipped pavers are circled



Chipped next to the concrete ribbon



Note the slightly depressed paver. The Arizona Registrar of Contractors (AROC) states that there should be no more than 1/8" elevation difference between pavers.



A rock at the corner of the pavers

C. **Interlocking Pavers** - The ICPI 's technical specification report titled "Structural Design of Interlocking Concrete Pavement for Roads and Parking Lots" revised in June 2006 discusses the importance of interlocking. The report states the following.

- *Interlock is the inability of a paver to move independently from its neighbors. It is critical to the structural performance of interlocking concrete pavement. When considering design and construction, three types of interlock must be achieved: vertical, rotational, and horizontal interlock.*

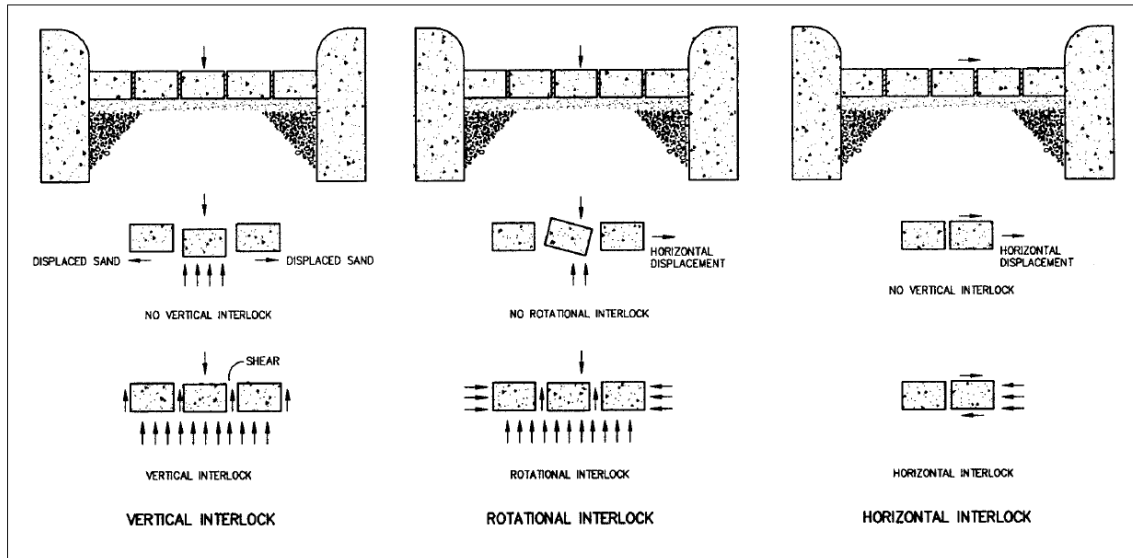
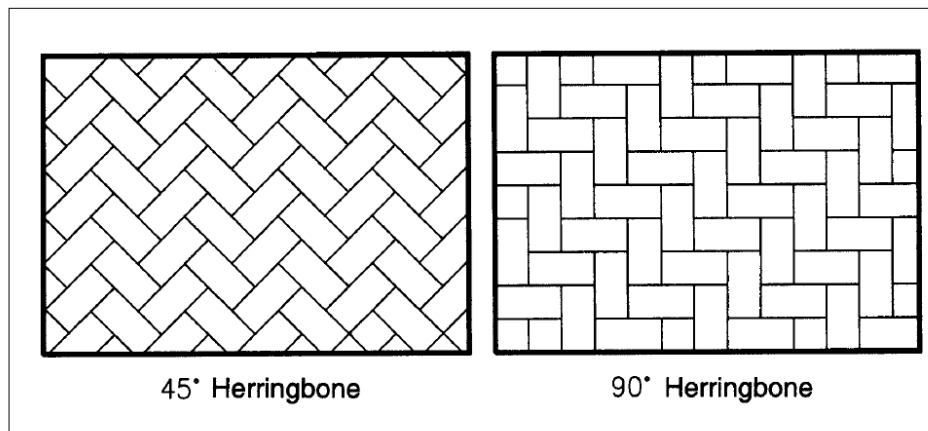


Figure 2. Types of interlock: vertical, rotational, horizontal

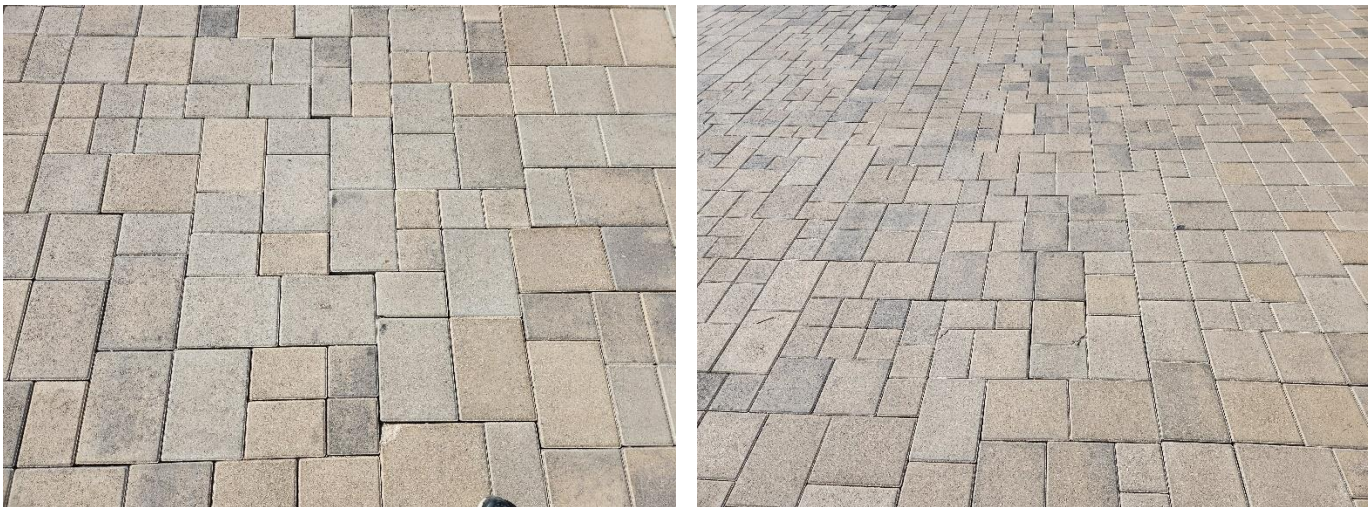
- *Herringbone patterns are recommended in areas subject to vehicular traffic.*



CSET noted in several areas that the installation of the pavers lacks the necessary interlocking pattern. The following photos show long linear joints between the pavers that lack the locking pattern. The right photo is a snapshot of a 360 video.



In addition to the long, linear joints, the joint width (gaps between the adjacent pavers) appears to be wider. AROC recommends the joint width should be between 1/16 and 3/16 inch.



- D. **Bedding Sand Thickness** - The bedding thickness ranges from 1.5 to 2.5 inches. The thickness of the sand bedding should ideally be one inch thick. Arizona Registrar of Contractors (ROC) states the leveling sand should be no more than 1.5 inches thick. AROC states that the contractor is responsible for making the necessary repairs.

The ICPI 's technical specification states the following with regards to the sand bedding thickness.

- *Bedding sand thickness should be consistent throughout the pavement and not exceed 1.5 in. (40 mm) after compaction. A thicker sand layer will not provide stability. Very thin sand layers (less than 3/4 in. [20 mm] after compaction) may not produce the locking up action obtained by sand migration upward into the joints during the initial compaction in construction.*

SUMMARY

1. The dry densities of the AB and subgrade soils are slightly lower than specifications, but CSET did not observe widespread settlement of the pavers that can be attributed to aggregate base or subgrade compaction. There are no visible settlements of the pavers consistent over the vehicle driving lanes (tire) where traffic load is transferred to the subgrade and AB.
2. The roadways may have been graded with inverted crowns and appear to be lower in the center.
3. Vertical offset of the pavers was noted around manholes and water valve covers.
4. Chipped pavers were noted throughout the subdivision roadways but are significant in the western half of the Camino De La Enclave. On going construction activities exacerbate the situation.
5. Long, linear paver joints due to lack of interlocking pavers were noted throughout. The lack of interlocking may lead to lateral and vertical movement of the pavers.
6. The joint widths are found to be wider in some areas. They were either installed incorrectly or the pavers had shifted.
7. The thickness of the bedding sand is slightly more than ideal. Minor settlement of the sand can lead to depressed paver corners where rocks could get stuck and cause chipping of the pavers.

CLOSING

CSET's opinions and recommendations are based on visual observations and review of available documents. We reserve the right to expand or amend our opinions, as additional information becomes available. The opinions are based on a reasonable degree of engineering certainty. Reliance on this letter is subject to the terms and conditions. Please contact CSET with any questions.

Respectfully submitted,
Copper State Engineering, Inc.



Moges Gebregiorgis, P.E.
Senior Geotechnical Engineer

Attachment: Copper State -Team Terms and Conditions



COPPER STATE-TEAM dba COPPER STATE ENGINEERING
TERMS AND CONDITIONS

PAYMENT TERMS _ Payment is due upon receipt of our invoice. If payment is not received within thirty days from the invoice date, Client agrees to pay a finance charge on the principal amount of the past due account of one and one-half percent per month. If one and one-half percent per month exceeds the maximum allowed by law, the charge shall automatically be reduced to the maximum legally allowable. Client agrees to pay all costs associated with collection of overdue invoices, including reasonable attorney's fees.

TERMINATION OF SERVICES _ In the event Client requests termination of the services prior to completion, a termination charge in an amount not to exceed thirty per cent of all charges incurred through the date services are stopped plus any shutdown costs may, at the discretion of Copper- State-TEAM be made. If during the execution of the services, Copper-State-TEAM is required to stop operations as a result of changes in the scope of services such as requests by the Client or requirements of third parties, additional charges will be applicable.

INSURANCE _ Copper-State-TEAM maintains Workers' Compensation and Employer's Liability Insurance in conformance with applicable state law. In addition, we maintain Comprehensive General Liability Insurance and Automobile Liability Insurance with limits of \$1,000,000/\$1,000,000, Professional Liability Insurance in the amount of \$2,000,000 (per claim & aggregate), and Pollution Liability Insurance in the amount of \$1,000,000. A certificate of insurance can be supplied evidence of such coverage which contains a clause providing that ten days written notice be given prior to cancellation. Cost of the above coverage is included in our quoted fees. If additional coverage or increased limits of liability are required, Copper-State-TEAM will endeavor to obtain the requested insurance and charge separately for costs associated with additional coverage or increased limits.

STANDARD OF CARE _ The only warranty or guarantee made by Copper-State-TEAM in connection with the services performed hereunder, is that we will use that degree of care and skill ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. No other warranty, expressed or implied, is made or intended by our proposal for consulting services or by our furnishing oral or written reports. Unless specified by the client in writing, the client agrees to a "Simple Acceptance" as a decision rule, i.e. the tolerance and/or results will not be evaluated by any measurement uncertainty when deciding in/out of tolerance, complies (yes/no) or meets/does not meet project specifications noted on any test report.

LIMITATION OF LIABILITY _ Client agrees that Copper State-TEAM's liability of any damage on account of any error, omission or other professional negligence will be limited to a sum not to exceed \$50,000 or Copper-State-TEAM fee, whichever is greater. If client prefers to have higher limits on professional liability Copper-State-TEAM agrees to increase the limits up to a maximum of \$1,000,000 upon Client's written request at the time of accepting our proposal provided that Client agrees to pay an additional consideration of two percent of our total fee, or \$200, whichever is greater. The additional charge for higher liability limits is because of the greater risk assumed and is not strictly a charge for additional professional liability insurance.

SAMPLING OR TESTING LOCATION _ The fees included in this proposal do not include costs associated with surveying of the site or the accurate horizontal and vertical locations of tests. Field tests or boring locations described in Copper State-TEAM's report or shown on sketches are based on specific information furnished by others or estimates made in the field by our technicians. Such dimensions, depths or elevations should be considered as approximations unless otherwise stated in the report.

RIGHT OF ENTRY _ Unless otherwise agreed, Client will furnish right of entry on the property for us to make the planned borings, surveys, tests, and/or explorations. We will take reasonable precautions to minimize damage to the property caused by our operations, but we have not included in our fee the cost of restoration of damage which may result. If Client desires us to restore the property to its former condition, we will accomplish this and add the cost to our fee.

DAMAGE TO EXISTING MANMADE OBJECTS _ It shall be the responsibility of the Client or his duly authorized representative to disclose the presence and accurate location of all hidden or obscure man-made objects relative to field tests or boring locations. Copper State-TEAM's field personnel are trained to recognize clearly identifiable stakes or markings in the field and without special written instructions to initiate field testing drilling and/or sampling within a reasonable distance of each designated location. If Copper-State-TEAM is cautioned, advised or given data in writing that reveal the presence or potential presence of underground or overground obstructions, such as utilities, Copper-State-TEAM will give special instructions to its field personnel. As evidenced by Client's acceptance of this proposal, Client agrees to indemnify and save harmless from all claims, suits, losses, personal injuries, death and property liability resulting from unusual subsurface conditions or damages to subsurface structures, owned by Client or third parties, occurring in the performance of the proposed services, whose presence and exact locations were not revealed to Copper-State-TEAM in writing, and to reimburse Copper-State-TEAM for expenses in connection with any such claims or suits, including reasonable attorney's fees.

SAMPLE DISPOSAL AGREEMENT _ Unless otherwise requested, test specimens or samples will be disposed of immediately upon completion of tests and drilling samples or other specimens will be disposed of 60 days after submission of our report. Upon written request, Copper-State-TEAM will retain test specimens or drilling samples for a mutually acceptable storage charge and period of time.



OWNERSHIP OF DOCUMENTS _ All documents, including, but not limited to, drawings, specifications, reports, boring logs, field notes, laboratory test data, calculations and estimates, prepared by Copper-State-TEAM are instruments of service pursuant to this Agreement, shall be the sole property of Copper State-TEAM. Client agrees that all documents of any nature furnished to Client or Client's agents or designees, if not paid for, will be returned upon demand and will not be used by Client for any purpose whatsoever. Client further agrees that under no circumstances shall any documents produced by, pursuant to this Agreement, be used at any location or for any project not expressly provided for in this Agreement without the written permission of Copper State-TEAM. At the request and expense of Client, Copper State-TEAM will provide Client with copies of documents created in the performance of the work for a period not exceeding five years following submission of the report contemplated by this Agreement.



SAFETY _ Should Copper-State-TEAM provide periodic observations or monitoring services at the job site during construction, Client agrees that in accordance with generally accepted construction practices, the contractor will be solely and completely responsible for working conditions on the job site, including safety of all persons and property during the performance of the work and compliance with OSHA regulations, and that these requirements will apply continuously and not be limited to normal working hours. Any monitoring of the contractor's procedures conducted by Copper-State-TEAM is not intended to include review of the adequacy of contractor's safety measures in, on, adjacent to, or near the construction site.

SITE VISITS _ Client agrees that Copper-State-TEAM will not be expected to make exhaustive or continuous on-site inspections but that periodic observations appropriate to the construction stage shall be performed. It is further agreed that Copper-State-TEAM will not assume responsibility for the contractor's means, methods, techniques, sequences or procedures of construction, and it is understood that field services provided by Copper-State-TEAM will not relieve the contractor of his responsibilities for performing the work in accordance with the plans and specifications. The words "supervision," "inspection," or "control" are used to mean periodic observation of the work and the conducting of tests by Copper-State-TEAM to verify substantial compliance with the plans, specifications and design concepts. Continuous inspections by our employees does not mean that Copper-State-TEAM is observing placement of all materials. Full-time inspections mean that an employee of Copper-State-TEAM has been assigned for eight-hour days during regular business hours.

GOVERNING LAW _ This agreement shall be governed in all respects by the laws of the State of Arizona.