STRUCTURAL CONDITION ASSESSMENT

MUNICIPAL PIER – HERMOSA BEACH, CALIFORNIA

JANUARY 19, 2026



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1. EXECUTIVE SUMMARY

1.1. Assessment Summary

Overall, the piles and pile caps are in Fair condition. The deck panels are in Poor to Serious condition. The load capacity of the pier is currently governed by the condition of the deck panels. The current pier load rating allows for pedestrian access and vehicles under 5 tons. The pier was originally designed for 10-ton trucks. Repairs to the deck panels in Serious condition must be conducted within the next 1-2 years to avoid a reduction in the current pier load rating of 5 tons, restriction of vehicles, and partial pier closures.

1.2. Repair Recommendation Summary

The following summarizes our repair and maintenance recommendations. Repairs may be combined, at the Owner's discretion, to realize economies of scale for design work, project management and construction cost.

A. NEAR TERM – HIGH PRIORITY (Repairs within 1-2 years)

i. **Concrete Deck Panels:** Replace 4 deck panels; Repair 14 deck panels with fiberglass laminate; Crack injection and spall repairs to approximately 35% of deck panel soffits (13 bays). Note: Due to the high cost of scaffolding, we have assumed that all panel soffits in a bay will be repaired at the same time. **Repairs to these deck panels in Serious condition must be completed within the next 1-2 years to avoid a load rating reduction and partial pier closures.**

ii. Estimated Construction Cost of High Priority Repairs in 2025 Dollars = $3.25 million (see **Appendix E, Pages E-2 and E-3**).

B. NEAR TERM – MEDIUM PRIORITY (Repairs in 3-5 years)

i. **Concrete Pile Caps:** Localized crack injection and spall repairs to approximately 80% of pile caps.

ii. **Concrete Deck Panels:** Localized crack injection and spall repairs to approximately 45% of deck panel soffits and 90% of deck panel tops.

iii. Estimated Construction Cost of Medium Priority Repairs in 2025 Dollars = $3.22 million (see **Appendix E, Pages E-4 and E-5**).

C. MID TERM (Repairs in 6 - 10 years)

i. **Concrete Piles:** Spall repairs and fiberglass jacket repairs to approximately 6 piles. (Note: due to 41% of the existing 60-year-old piles not previously being repaired, we anticipate there will be additional piles requiring repairs in 6 to 10 years.

ii. **Concrete Pile Caps:** Anticipated future spall repairs to pile caps identified in future inspection efforts.

D. LONG TERM (Repairs beyond 10 years)

The field inspection did not identify any current defects that will specifically require repairs 10 years or more in the future. However, we anticipate the need for additional rounds of pile repairs, pile cap repairs, and deck panel repairs as deterioration continues to accelerate. This facility is 60+ years old and nearing the end of its service life. Concrete structures in the marine environment typically require concrete corrosion repairs on an average 5-year cycle after they reach 50-years of age. The volume and cost of these repairs accelerate until the end of the facility's useful life.

The recommended repair for piles is to remove all loose and damaged concrete, install a fiberglass form around the pile, clean the reinforcing, apply a corrosion inhibitor or bonding agent, and then fill the jacket with pumpable grout. The repair recommendation for pile caps and deck panels with spall damage is to chip out the deteriorated concrete, clean the reinforcing, apply a corrosion inhibitor, and then apply a polymer modified epoxy mortar. Reinforcing steel that is missing or exhibiting section loss should be supplemented with additional reinforcing of the same size and spacing. Wide cracks not caused by corrosion may be injected with epoxy. Panels that have Significant areas of weak concrete may require strengthening, which can likely be achieved using a wet-layup fiberglass or carbon-fiber laminate. Deck panels deemed in Severe condition from overstress require demolition and replacement-in-kind.

1.3. Future Inspection Recommendations

The Pier is currently in Poor to Serious condition. Assuming that the high priority repairs are completed as recommended, we recommend inspecting the Municipal Pier at 5-year intervals as recommended by the California Building Code for Marine Structures; the next routine inspection should occur in Fall 2029. As the structure ages, and if subsequent inspections determine that the pier has rapidly advancing deterioration, a more frequent interval may be appropriate. The inspection timing should also be coordinated with the timing of funding for repairs. Design Level inspection should be coordinated with the start of construction to provide the City with the best value and to reduce the number of Change Orders during construction for changed conditions.

1.4. Condition Assessment Limitations

Evaluation of architectural, civil, mechanical, electrical, and plumbing elements are outside the scope of this assessment. Structural analysis calculations including lateral capacity

analysis, design of repairs, and preparation of construction documents are outside the current scope of this assessment, but these services are available, if requested.

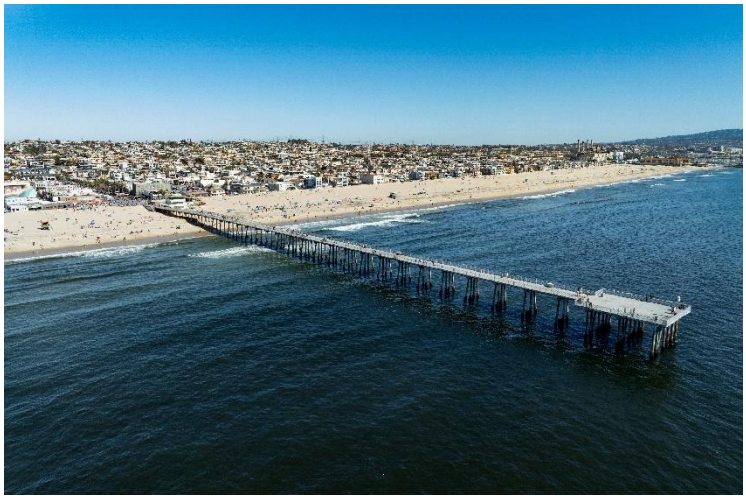
1.5. Cost/Benefit Analysis

The City of Hermosa Beach engaged us to develop a 45-year construction repair program for the Hermosa Beach Pier, including budgets and timelines, based on existing conditions, deterioration, and past repairs, with work grouped into 5-year projects to reduce costs and public impacts. We also prepared a cost–benefit analysis comparing long-term repair costs with full pier replacement, identifying the most cost-effective timing for new construction given its significantly lower maintenance needs in the first 15 to 20 years.

2. INTRODUCTION

2.1. Facility Description

The Hermosa Beach Municipal Pier is a concrete fishing and pedestrian pier, constructed in 1965, located at the end of Pier Avenue in the City of Hermosa Beach, CA (see **Appendix A**). The pier is 1,140 feet long by 20 feet wide with a wider 50 feet by 68 feet long turn-around at the end. The pier is constructed of 16-inch and 18-inch precast prestressed concrete octagonal piles, supporting 3'-0" high by 2'-8" wide cast-in-place concrete pile caps (see **Appendix C, Photo 1**). Precast concrete deck panels, measuring 1'-5" thick by 5'-0" wide, span between the pile caps (see **Appendix B, Figures 1 and 2**). There is a metal guard railing running around the entire perimeter of the pier with a wood top rail.



There are three piles per bent in Bents 1 through 18 and four piles per bent in Bents 19 through 33 (see **Figures 3 and 4**). The outer piles, closest to the pier edge, batter away from the pier (see **Photo 2**). In Bents 34 through 36, two additional piles are added to each side of the pier for a total of seven piles per bent (see **Figures 5 and 6**). There are a total of 36 Bents and 135 piles. The typical spacing between bents is 32'-0" with a smaller spacing of 25'-0" between Bents 0 and 1 and Bents 34 to 36. The pier deck begins at street level, approximately 10 feet above mean seal level, and rises over the first 10 bents to an elevation approximately 20 feet above mean sea level, which is then consistent to the end of the pier. Bent 0 is a concrete abutment wall. Transverse expansion joints are located across the deck panels at Bents 5, 10 and 19 (see **Figure 7**).

Vehicle access to the pier is currently restricted to lifeguard, police, and maintenance vehicles under 5 tons. Structural drawings and previous inspection reports were provided by the City of Hermosa Beach for review.

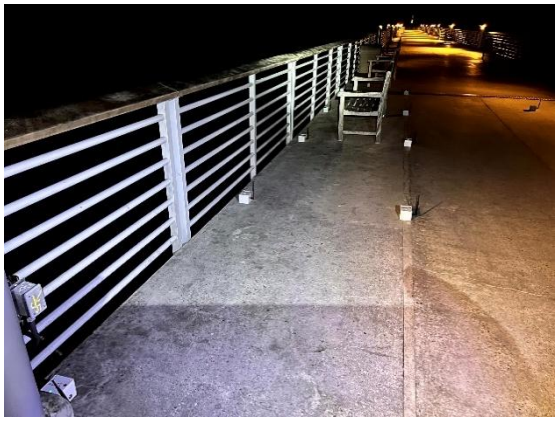
2.2. Structural Conditions Assessment

The scope of work provides for the inspection and analysis of the existing pier conditions, above and below water, of the piles, pile caps, and deck panels, of the Municipal Pier in Hermosa Beach, CA. The scope also includes repair recommendations and repair cost

estimates. The inspection of the deck top, deck soffit, pile caps, and piles was conducted over the following periods: October 15-17, 2024 (use of Rough Terrain Boom Lift), October 29 to November 8, 2024 (use of Trailerable Scaffold Rig), October 15 to December 17, 2024 (Top Deck Inspection) and December 17-18, 2024 (Dive Inspection).

The Engineer Divers conducted a close visual inspection of 100% of the pier piling, pile cap beams, and pier deck. Marine growth was removed at 3 elevations from at least 10% of the piling to closely inspect the piles for damage, where surf conditions allowed. The underside of deck inspection was performed using two pieces of equipment to closely assess the deck soffit. Elements over the beach were inspected using a rough terrain boom lift and elements over the water were inspected by access from a trailerable scaffold rig. The surfaces of the concrete deck panels and pile caps were sounded with a hammer or solid steel headed putter to identify areas of delaminated, weak, damaged, or spalled concrete. A crack width gauge was used to record crack widths greater than hairline width. Due to the high cost of equipment rental to closely examine the deck soffit, a Design Level survey was performed for all observed damage and deterioration that is recommended for repair.

The engineering team was responsible for the assessment of the concrete piles, concrete pile caps, and concrete deck panels (both soffit and topside), guardrails, stairs, CMU walls, storage areas under the pier, and trash receptacles. We also assessed the impact on the structural deck panels of bench attachments (current, removed, and abandoned fasteners) and surfer plaques. The team was also tasked with evaluating the conclusions by Sensequake of ambient vibration deck testing of the four deck panels between Bents 10 and 11 tested on November 17, 2024, and comparing the Sensequake conclusions with our visual and tactile observations. Sensequake subsequently tested an additional 9 bays in March of 2025, and ESN Engineering has reviewed, evaluated and incorporated Sensequake's conclusions into our recommendations.



This report includes a summary of observations, their structural significance, repair recommendations, and cost estimates for repairs recommended within the next 5 years. The report discusses the overall structural system and typical conditions of the structural elements of the pier, as well as recommendations to maintain the structure.

2.3. Cost / Benefit Analysis

The City of Hermosa Beach asked us to perform construction repair programming to establish budgets and timelines to maintain and repair the Hermosa Beach Pier for the next 45 years (through the end of the pier's serviceable lifespan). We reviewed existing conditions, deterioration levels, and past repair projects to extrapolate into yearly estimates of work to maintain the pier. Anticipated repairs were grouped into projects on a 5-year basis to capitalize high mobilization costs, reduce temporary public use restrictions, and limit public impact. Budgets have been provided for each project year with supporting documentation.

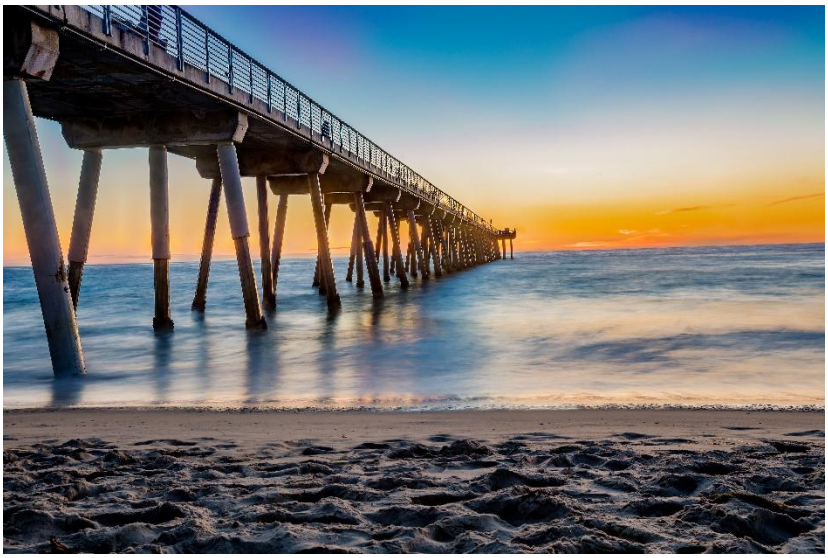
We then prepared a cost / benefit analysis to define the most cost-efficient timing for the City to plan for the long-term replacement of the pier with new construction. We compared the significant capital outlay cost of a new facility with the projected escalating cost of repairs as the pier nears the end of its design service life. The benefit of the new facility includes its very low to no maintenance costs typically for the first 15 to 20 years.

3. CONDITIONS & REPAIR RECOMMENDATIONS

Observed conditions, their structural significance, and repair recommendations are provided below for each element of the pier.

3.1. Concrete Piles

Observed Conditions: A total of 54 octagonal 16" and 81 octagonal 18" precast concrete piles support the Hermosa Beach Municipal Pier. The Engineer Divers conducted a Level I inspection (see **Appendix F** for Inspection Procedures) on all the piles both above and below water. Engineer Divers conducted a Level II inspection on 10% of the piles. Between Bents 9 and 36, approximately 51 piles have been repaired with a grout-filled fiberglass jacket; 34 piles were repaired in 2023 (see **Photo 3**) and approximately 27 piles have been repaired with a fiberglass jacket prior to 2017 (see **Photo 4**). The 2023 jacket repairs appear to be performing well. The first 8 bents of piles have been previously repaired by wrapping a fiberglass jacket tightly around the pile and no subsequent damage was noted (see **Photo 6**). Pile 16:A has been repaired with a steel jacket (see **Photo 7**) that appears to be performing well. Many of the older jacket repairs have split open with visible cracks in the concrete behind the jacket (see **Photo 8**) or show signs of degradation due to wave impact and/or UV exposure (see **Photo 9**). At approximately 7 locations, stainless steel straps have been wrapped around the existing fiberglass jacket to hold the jacket in place. A fiberglass form filled with concrete has been installed around the bottom 6 feet of Piles 36:F and 36:G extending into the mudline. Approximately 41% of the concrete piles have not been previously repaired. Overall, the piling is in Fair condition.



Approximately 23 piles have at least one area of corrosion induced Vertical Cracking or Spalling. Between Bents 9 and 36, there are approximately 4 piles with Moderate Open Corrosion Spalls (see **Photos 10 and 11**) and approximately 19 piles with Minor Closed Corrosion Spalls, typically at the top of the pile (see **Photo 12**).

Overall, approximately 58% of the piles show no visible damage, 25% of piles have Minor vertical cracking, and 18% of the piles have Minor to Moderate corrosion defects. The piles in the tidal zone experience a continuous wetting and drying cycle due to changes in tides and splashes from waves. This aggressive environment accelerates corrosion.

The Level II examination performed on a 10% sample of piles is intended to represent general pile conditions. The piles were cleaned at 3 water depths, where surf conditions allowed, and checked for softness and the presence of abnormalities (see **Photos 5 and 14**). Most of the concrete piles examined were found firm, which suggests that the piles are not under chemical attack beyond typical corrosion related defects.

Structural Significance: The concrete piling provides both vertical and lateral support for the pier. The previously performed pile jacket repairs appear to mostly be performing well. The older pile jackets that have split open with cracked grout behind the jackets are indicative of advancing corrosion deterioration of the original pile reinforcing. As the original pile reinforcing continues to corrode, it expands, bursting open the fiberglass jacket and cracking the grout between the original pile and jacket. This frequently occurs near the jacket tops. This represents a Moderate loss of capacity and requires repair as a Medium Priority. The jackets should be held in place with straps until repairs are made as the straps do slow the rate of environmental attack and hold the debris in place, so it does not become a hazard to beachgoers. No reductions in pile capacity are recommended currently.

Repair Recommendations: No repairs to the piling are recommended within the next 5 years. In 5 to 10 years, repairs will likely be required for the following:

1. Fiberglass Jacket Tears: Piles 9:A and 11:E
2. Closed Corrosion Spalls: Pile 15:A,
3. Open Corrosion Spalls: Piles 23:B, 34:F, 35:Y and 35:A
4. Future pile repairs which are identified in future inspection efforts.

3.2. Concrete Pile Cap Beams

Observed Conditions: The Municipal Pier is made up of 36 bents of cast-in-place concrete pile caps. The pile caps are 3’-0” high by 2’-8” wide. They are 18’-4” long for the first 33 bents and spaced at 32’-0” on center. Bents 34 to 36 are spaced at 25’-0” on center. The pile cap at Bent 34 is 48’-4” long and the pile caps are 52’-2” long at Bents 35 and 36. Prior concrete repairs can be seen on many of the pile caps. Overall, the pile caps are in Fair condition.

Overall, approximately 17% of the pile caps do not have any new visible damage and 83% of the pile caps have Minor to Moderate corrosion defects. There are approximately 27 pile caps that have Closed Corrosion Spalls (see **Photo 15**) and an additional 3 pile caps that have

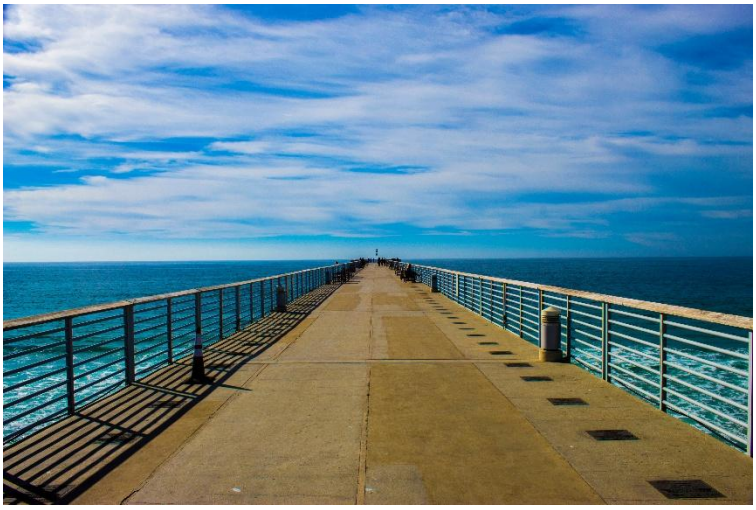
Open Corrosion Spalls (see **Photo 16**). The spalling that was observed usually occurs along the bottom of the pile cap and at the pile cap ends.

Structural Significance: The pile caps are a critical vertical and lateral load carrying element. They transfer all the deck vertical loads to the piles and tie the piles together to share lateral (wave or seismic) loads in the transverse direction. The pile caps are continuous across all piles at each bent in a series of very short spans. Due to the short span length, the bottom reinforcing is less critical than the top reinforcing. For this reason, minor deterioration of soffit reinforcing does not create a significant reduction in load capacity. The estimated reduction in pile cap load capacity is 5% or less for all bents.

Repair Recommendations: Spall repairs are recommended within the next 3 to 5 years for all the pile cap bents except for 6 pile caps (Bents 1, 2, 12, 25, 30, and 32). A second round of pile cap spall repairs is anticipated to be required in 5 to 10 years. See **Appendix D, Pages D-47 and D-48** for a list of the locations of pile cap defects for which repairs are recommended. Although the pile caps currently have a reduced capacity of 5% or less, we recommend their repair, prior to significant loss of the rebar section, to avoid a much higher future repair cost if rebar replacement is needed. Left alone, the corrosion deterioration accelerates.

3.3. Concrete Deck Panels

Observed Conditions: The deck of the Municipal Pier is constructed with 156 hollow precast concrete panels. The panels are 1'-5" thick by 5'-0" wide with four 10.5" diameter hollow Sonovoid Tubes in the middle of each panel. Between Bents 1 and 34, the panels are 32' long with 4 panels placed side by side. Between Bents 34 and 36, the panels have an overall length of 34' (25' span between pile caps plus a 9' cantilever overhang) and 6 additional panels have been added to produce the wider pier end. Each deck panel is connected to its adjacent panels with a concrete grout shear key. Additionally, a steel tie rod connects the panels typically at midspan (see **Figure 7**). The Engineers visually inspected the top, underside and edges of the concrete deck panels. The Engineers also sounded the surfaces of the deck panels with a hammer or solid steel headed putter to identify areas of delaminated, weak, damaged, or



spalled concrete. Shallow delamination (separation of material into layers) in the concrete deck panels can be found by tapping a hammer on the surface of the concrete producing a distinct sound. This sound will allow the user to distinguish the difference between delaminated and solid concrete. Delaminated surfaces make a dull or hollow sound and solid concrete surfaces make a clear ringing sound. Many of the panels were observed to have existing patches, especially between panel joints. There is typically rust bleeding present at the edges of the patches on the soffit. Overall, the deck panels are in Poor to Serious condition.

Corrosion Spalls: Approximately 75% of the deck panel soffits have at least one area of Closed Corrosion Spalling, typically along the panel edges (see **Photos 17, 18 and 29**). Approximately 7 panel soffits also exhibit Open Corrosion Spalling (see **Photo 27-28**). Approximately 70% of the deck panel tops have areas with shallow spalls and delamination, representing approximately 12% of the total top deck area (see **Photo 30**).

Deck Fractures: Approximately 20 deck panels have Serious deterioration, typically due to overstress damage because of overload from a wheel or outrigger point load. There are approximately 13 panels that exhibit fractures from overloading, typically evident by continuous splits in the concrete along the panel edges and by vertical offsets either internally along the fracture or between adjacent panels (see **Photos 21-26**). A few of the panels with fractures have a large missing section of concrete at the fracture, typically with exposed reinforcing with Moderate section loss (see **Photos 19-20**). Approximately 7 panels have a significant area of weak and delaminated concrete.

Deck Cracking: Approximately 67% of the deck panel soffits have transverse full width cracks greater than 0.016" wide; approximately 45% of those deck panel soffits also exhibit longitudinal cracking greater than 0.016" wide. Approximately 67% of the deck panel tops have transverse full width cracks greater than 0.016" wide (see **Photos 31-32**); approximately 12 of those panels also have longitudinal cracks greater than 0.016" wide. The transverse cracks are indicative of flexural stress and shrinkage.

Shear Keys: Spalling was observed on the topside between deck panels at the shear key at approximately 14 locations. Vertical offsets between deck panels were observed at the soffit at approximately 6 additional locations. This indicates that the shear key has failed at these locations and therefore the deck panels at these locations are not adequately sharing loads.

Uneven Deck Elevation: The deck appears to dip in elevation at Bent 13. There was a slight elevation drop at Bent 13 shown in photos taken in 2012. In 2017, the drop appeared to be larger. We recommend that this elevation drop be reviewed during the next routine pier inspection in case pile settlement is ongoing. Specifically, we recommend obtaining

elevation measurements of the deck at Bent 13 within the next year that can then be compared to measurements taken in the future. Assuming that the recommended high priority repairs are completed, we recommend inspecting the Municipal Pier at 5-year intervals as discussed below. The next routine inspection should occur in Fall 2029.

Structural Significance: The deck panels provide the first and most important means to distribute pedestrian and vehicle loads to the pile caps and piles below. If the deck panels are not maintained, a safety hazard will develop.

The transverse hairline cracks on the bottom of the panels near their centerline are Minor because the bottoms of the panels are in tension and the steel reinforcing is carrying the flexural loads. However, longitudinal cracking and corrosion spalling on the bottom face of the panels is significant. This spalling is indicative of corrosion of the flexural reinforcing and can result in diminished capacity. Based on the level of rust bleeding, the current closed nature of the spalling, and location on the extreme edges of the panels, the deck panels with minor cracking have an estimated 5% to 10% loss in capacity.

The pier was originally designed to support a 10-ton truck. Due to the observed deck shear key failures, the current 5-ton load rating for the pier has assumed that a wheel load placed near a panel edge is supported entirely by the loaded panel, without assistance from adjacent panels. This assumption may be conservative in bays with in-tact shear keys.

The 7 panels with Significant areas of weak and delaminated concrete and the 13 panels with overloading fractures and displacements are a Serious concern. These panels have an estimated loss of capacity of 50% which is the basis for the current 5-Ton Load Limit (half of the original design 10-Ton Load Limit). As such, it is crucial that these panels are repaired or replaced in the next 1 to 2 years to avoid further load restrictions.

Repair Recommendations: Within the next 1 to 2 years, we recommend replacing 4 deck panels that have experienced Severe overstress damage. Within the next 2 years we recommend repairing approximately 14 deck panels with an FRP laminate where Significant delamination has occurred. Within the next 3 to 5 years, we recommend crack injection and spall repairs to portions of approximately 45% of deck panel soffits and 90% of deck panel tops where large flexural cracks, closed corrosion spalling, and open corrosion spalling have occurred. Due to the high cost of scaffolding, we recommend that all panel soffits in a bay be repaired at the same time. See **Appendix D, Pages D-125 to D-131** for a complete list of the locations of recommended deck panel repairs.

3.4. Railing

Observed Conditions: Wooden railing on the steel guardrail condition was generally acceptable. However, several screws connecting the wood to the steel guardrail with the base plates were found missing as can be seen in the following photos. In September 2025, the City's Public Works Department inspected and replaced all missing railing screws.

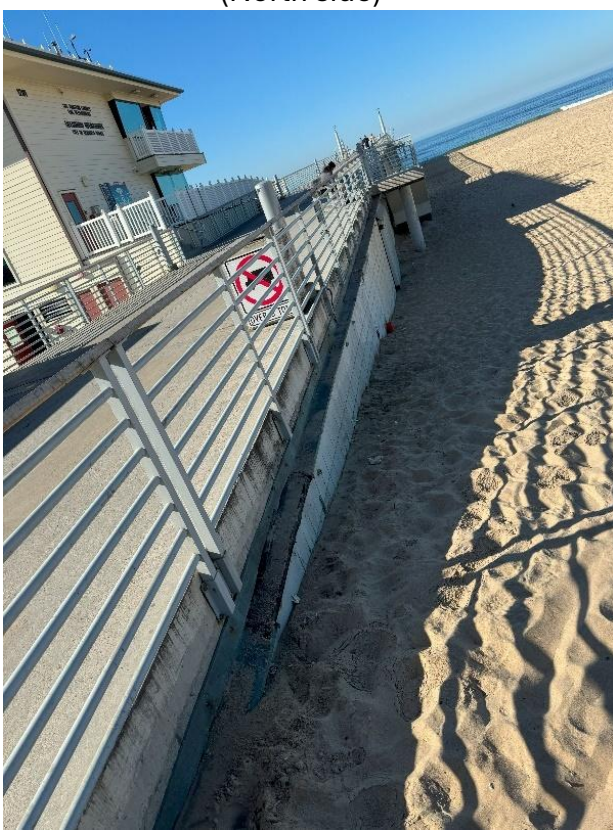


3.7n Missing screws between Bents 1-2 (North side)



3.7o Missing screws between Bents 8-12 (North side)





3.7p & q Guardrail post to structure bolts acceptable

Structural Significance: All the wooden guardrails have been replaced recently as they are an important pier safety feature. The railings should be properly secured to the steel railing system.

Repair Recommendations: None currently.

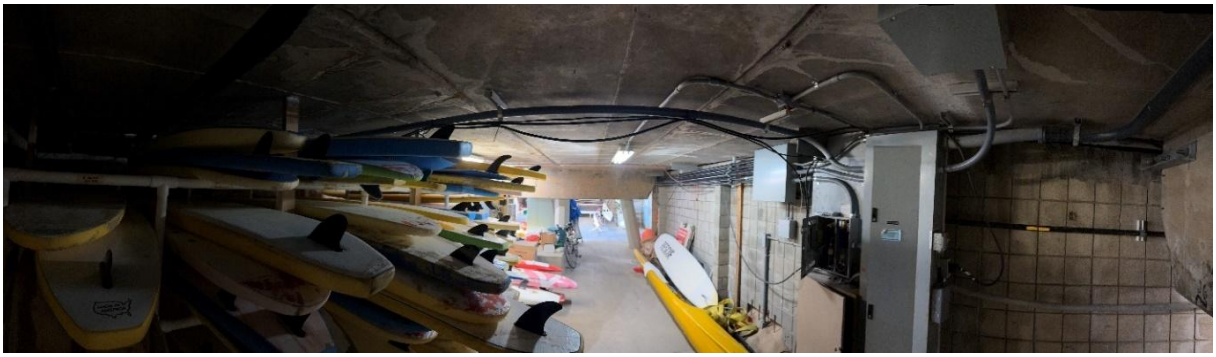
3.5. Lifeguard Storage Area

Observed Conditions: The CMU wall is a part of the Lifeguard Storage building that is located below the deck at the beginning of the Pier in the first three bays, starting with a low height retaining wall. See **Photos 3.5a to 3.5e** below.

The CMU wall was found to be anchored laterally at the top from the bent, where available or the slab soffit—see **Photos 3.5f to 3.5h** below. Clearly the wall is a non-load bearing structure, as the pier slab is independently supported by the bents and the end retaining wall.



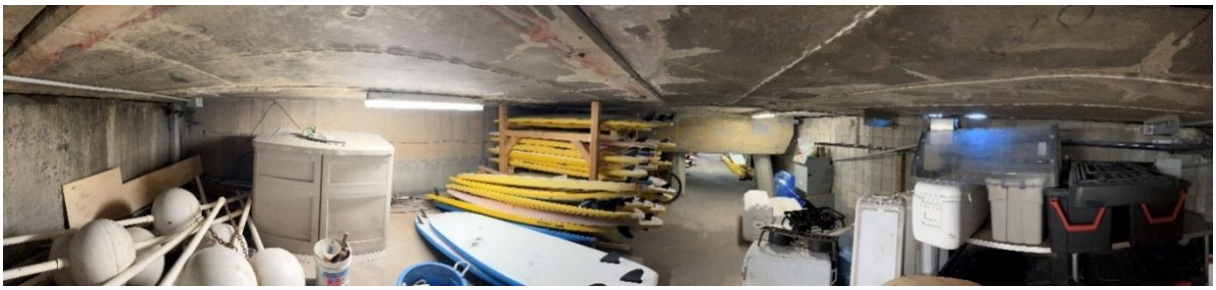
3.5a Panoramic view between bents 2 & 3



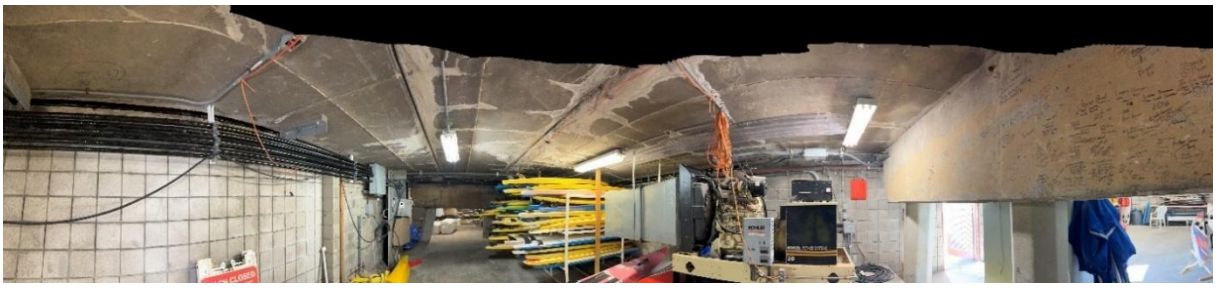
3.5b Panoramic view between bents 1 & 2



3.5c Panoramic view between bents 1 & retaining wall—looking at retaining wall



3.5d Panoramic view between bents 1 & retaining wall--looking parallel to retaining wall.



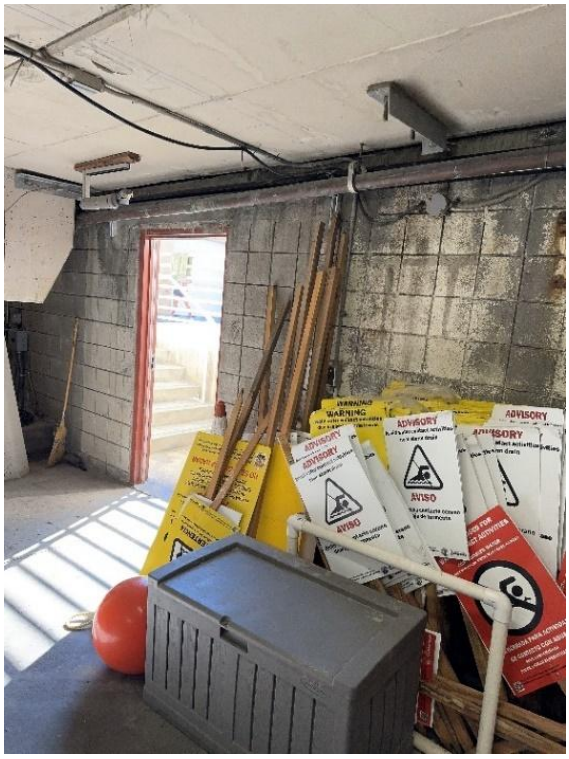
3.5e Panoramic view between bents 1 & 2



3.5f East view looking at Bent 2 and beyond



3.5g Lateral support of CMU wall from bent

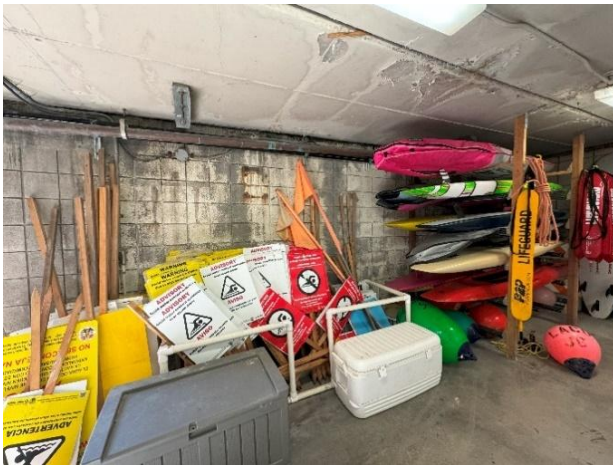


3.5h Lateral support of CMU wall from slab soffit

There were marks of running water with effervescence possibly from superstructure concrete. Minor signs if effervescence see **Photos 3.5i to 3.5k**. There was no sign of dampness nor rust, barring one or two places due to a metallic object being hung from it, though now removed. Generally, the condition of the CMU wall was healthy.



3.5i Minor signs if effervescence at bottom left of photo



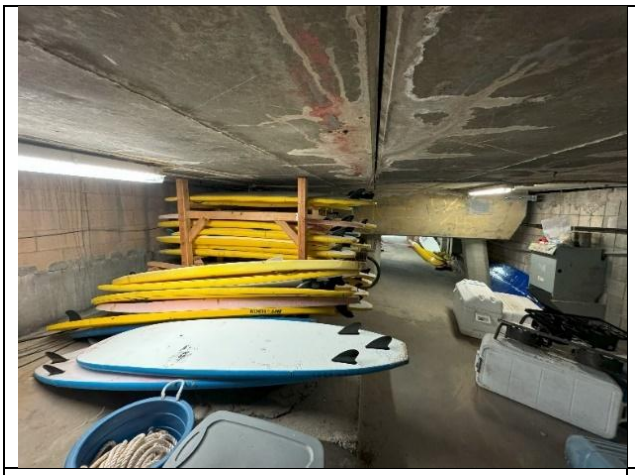
3.5j Close up of CMU wall between Bent 2 & 3—minor rust marks due to old metallic object hung on the wall, now removed



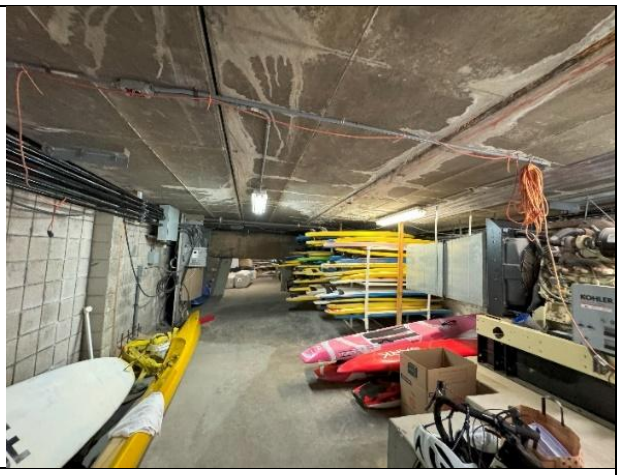
3.5k Marks of running water with effervescence possibly from superstructure concrete

Slab soffit within lifeguard storage room Bents 1 to 3 & retaining wall

All three bays the slab soffit showed signs of water damage. Between Bents 2 & 3 the soffit had been painted over relatively recently, and cracks were hidden, but water damage to paint was evident See **Photos 3.5k & 3.5l**. In other bays, where there is no painting done, the flexural cracks are evident like the slab soffits outside lifeguard enclosure, past Bent 3. There are also telltale marks of cracks being studied by a previous team highlighting crack locations. There are widespread water running marks along with effervescence.



3.5k Red marks on ceiling indicative of cracks being studied by a previous team



3.5l Widespread effervescence indicative of potential corrosion activity in slab

Structural Significance: There are no signs of structural significance to the pier even with observance of widespread effervescence.

Repair Recommendations: No structural repairs are recommended currently.

3.6. Utility Lines

Observed Conditions: It was observed that the clamps securing the electrical conduit to the deck were missing or detached at the following locations:

- Bent 25.3 on North side face (Photo 3.6a)
- Bent 25.7 on North side face (Photo 3.6b)
- Bent 29.3 on North side soffit (Photo 3.6c)
- Bent 29.3 on South side soffit (Photo 3.6d)

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>3.6a Bent 25.3 on North side face</td><td>3.6b Bent 25.7 on North side face</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3.6c Bent 29.3 on North side soffit</td><td>3.6d Bent 29.3 on South side soffit</td></tr>
</table>

The water line on the South side of the soffit has a steady drip leak at the following splice locations:

- Bent 27.5 (Photo 3.6e)
- Bent 31.5 (Photo 3.6f)

	
3.6e Bent 27.5 steady drip leak	3.6f Bent 31.5 steady drip leak

Structural Significance: The missing conduit clamps and leaking water lines have a minimal effect on the pier structure.

Repair Recommendations: We recommend replacing the missing electrical conduit clamps at Bents 25 and 29 and repairing the leaking water lines as part of the upcoming pier repair project while the slab soffits are being repaired utilizing underdeck scaffolding.

3.7. Embedded Plaques

Observed Conditions: The plaques were found to be installed only between bents 13 and 18, both on North and South faces, see **Photos 3.7a & 3.7b** below. There were some "missing" plaque locations, that are potential water ingress points **Photo 3.7c**. Also, plaques that have been installed show signs that the waterproof treatment around them has been compromised at several locations or missing all together forming a source of water into the structure below (**Photos 3.7d & 3.7e**)



3.7a South side plaques



3.7b North side plaques



3.7c Potential plaque location—possible water ingress points





3.7d & 3.7e Typical plaque showing gaps in waterproofing seal around its perimeter or missing entirely

Structural Significance: Plaques are non-structural architectural appendages. Their installation typically requires damaging portions of the concrete cover through chase cutting, as they must remain flush with the walking surface to avoid becoming tripping hazards.

We do not recommend cutting into the deck concrete, especially since there is no topping slab present. Such modifications may compromise the protective cover over the reinforcing steel in the panels and other exposed elements. Water ingress through these areas can lead to corrosion.

Cracked edges, as shown in **Photo 3.7d**, may persist even after proper sealing. All polymers used for sealing have a limited lifespan when exposed to sunlight and UV radiation. Once the sealant deteriorates and cracks, water ingress becomes inevitable.

From a durability and long-term maintenance perspective, embedding plaques into the pier's concrete deck is no longer advisable.

Repair Recommendations: In consultation with the City, it has been decided to prohibit further installation of plaques on the deck and to remove the existing ones. The removal of plaques leaves recesses or craters in the deck surface, which should be properly sealed using polymer-modified cement mortar to prevent water ingress and deterioration.

Moving forward, both existing and future plaques will be installed on the handrails instead of the deck.

3.8. Light Fixtures

Observed Conditions: One low height light pole was found to be tilted over and needs repair.



3.7f Tilted Light Standard at Bent (South face)



3.7g Possible old location of light standard—water ingress




3.7h & i Light standard at gate on the pier having anchor bolts at wrong holes

Structural Significance: Light fixtures are non-structural architectural features. When installed these require concrete cover portions to be damaged by drilling of holes. As stated before, there is no “topping” concrete slab above the structural slab, so installation of the light fixtures damages the structural concrete members. For the given situation, the best that can be done is repair any potential water ingress points to reduce corrosion.

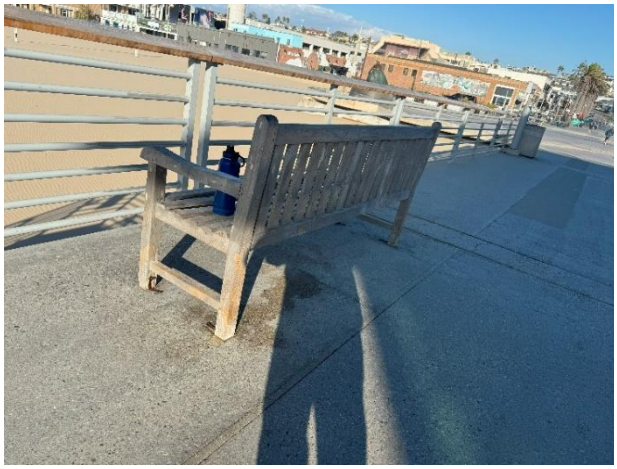
Repair Recommendations: For safety reasons, it’s important to ensure all the light standards are securely fastened to the pier deck. The City should routinely check under normal maintenance that lights are being held firm and upright and replace missing anchor bolts. We also recommend monitoring cracks and repairing them with appropriate sealants.

No significant cracks were observed at this time, and no further action is required at this point.

3.9. Benches

Observed Conditions: Virtually all benches on both the north and south edges of the pier have empty holes in existing cleats, both to the ground as well as the legs. When either the fasteners or cleats or both are rusted, the following table shows they need attention:

Benches between Bent #	Replace number of bench anchorages (also number of legs affected); "-" indicates no bench; OK indicates sound condition; greater than one line in a bent pair indicates additional benches	
	South	North
1-2	-	Replace 4
9-10	-	Replace 1
10-11	OK	Replace 3
11-12	Replace 2	Replace 1
12-13	Replace 1	Replace 2
	Replace 4	OK
13-14	Replace 3	OK
18-19	Replace 2	Replace 4
19-20	Replace 4	Replace 4
	Replace 4	-
20-21	Replace 4	Replace 2
22-23	-	Replace 4
23-24	-	Replace 4



3.7j Example: North face bench between Bents 1&2 needs replacement



3.7k Missing bolts



3.7l Rusted anchorages



3.7m Rusted anchors and bolt holes in deck beyond

Structural Significance: As stated already, any penetration into the pier's deck is the start of future concrete and steel deterioration.

Repair Recommendations: Within the next 2 years, replace all the bench anchorages as denoted in the table. Remove the affected benches and reinstall them using an approved methodology that does not involve drilling holes into the deck or creating potential leak points.

3.10. Staircase

Observed Conditions: The external staircase has classic marks of rainwater running on the soffit of the slab due to capillary action, see **Photos 3.7r to 3.7t**. The soffit had previously been painted over, but upon request, the paint was removed, revealing a structural crack-- **Photo 3.7u**. The crack appears to be flexural in nature, possibly resulting from corrosion that has reduced the effective area of reinforcing steel available for bending. This crack should be repaired using the same methodology applied to the deck panels, including fiber-reinforced polymer (FRP) strengthening.



3.7r Rust marks at top of column



3.7s



3.7t



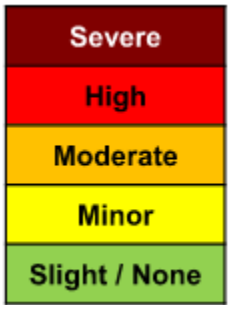
3.7u

Structural Significance: For staircase, there is visible corrosion and immediate maintenance should occur. See repair recommendations below.

Repair Recommendations: A drip course can be provided at soffits where water tends to flow beneath to prevent further damage. This applies to staircase structure and other slab and even pile cap soffits. This is a one-time fix and should be a part of the Pier Repair Plans.

4. SENSEQUAKE TESTING COMPARISON

Sensequake and JMC[2] conducted ambient vibration testing of the four deck panels between Bents 10 and 11 in November 2024. Sensequake summarized their conclusions in a PowerPoint presentation provided on January 13, 2025. Sensequake provided color-coded graphics of the structure showing their deterioration conclusions based on the scale shown to the right. Sensequake subsequently tested all the panels in an additional 9 bays in March of 2025; the bays tested were 12-13, 13-14, 15-16, 18-19, 21-22, 27-28, 30-11, 32-33, and 35-36. Sensequake summarized their conclusions in a PowerPoint presentation provided in PDF format on May 2, 2025. Sensequake provided "heat maps" for both the vertical and transverse mode shapes, which summarized their conclusions on the level of deterioration in each tested zone of the tested deck panels. On May 12, 2025, Sensequake also provided separated vertical and transverse "heat maps" for Bent 10 to 11.



Sensequake Deterioration Rating Scale

4.1. Concrete Piles

Sensequake Analysis Results: Sensequake concluded that the Piles at Bent 11 have Minor Deterioration and the Piles at Bent 10 have Moderate Deterioration. For the additional 9 bays tested between Bents 12 and 36, substructure conclusions were provided only at Bents 21 and 32. Sensequake concluded that there is High Deterioration of the pile cap and/or piles at Bents 21 and 32.

Visual and Tactile Observations at the Sensequake testing locations: ESN Engineering observed Minor Closed Corrosion Spalling at the tops of Piles 10:A, 10:C, and 11:C. In 2023, Pile 10:E was repaired with a grout-filled fiberglass jacket from the mudline to the underside of the pile cap. Pile 11:A was previously repaired with a tight fiberglass wrap at the top and a grout filled fiberglass jacket approximately 2 feet above the mudline. Pile 11:E was previously repaired with a grout-filled fiberglass jacket from the mudline to the underside of the pile cap. In 2023, eight stainless steel straps were installed around the jacket at Pile 11:E to

secure it in place due to a vertical split; ESN Engineering observed five diagonal cracks in the grout across the jacket split.

ESN Engineering did not observe any notable defects at Piles 21:A, 21:B, and 32:E. ESN Engineering observed an existing fiberglass pile jacket at Pile 32:B and fiberglass pile jackets constructed in 2023 on Piles 21:E, 32:A and 32:D. ESN Engineering noted a Moderate vertical crack in the outboard face of Pile 21:D.

Results Comparison and Conclusions: ESN Engineering does not recommend any repairs during the next 5 years to the piles in Bents 10, 11, 21, and 32, nor is there justification to reduce the current pier load rating based on the conditions of these piles. In 5 to 10 years, repairs will likely be required for the deteriorated jacket at Pile 11:E. ESN Engineering does not consider the deterioration in the piles in Bents 10, 11, 21 or 32 to be Significant. It is possible that Sensequake is seeing abnormal behavior in these piles and differing behavior between adjacent bents because of various types of jacket repairs modifying the relative stiffness of the jacketed piles compared to the original prestressed concrete piles.

The Sensequake analysis does not individually model the unbraced pile heights, which change with water depth, the depth to the stiff formational soil layer at each bent and the variation of top of deck elevation. Longer piles are less stiff than shorter piles and could appear to have excessive flexibility, interpreted as a deteriorated element, as opposed to a change in relative stiffness. ESN Engineering considers the deterioration in the piles at Bent 10 to be Minor; whereas Sensequake has categorized that same deterioration as Moderate – this difference should be considered negligible based on the different rating scales used. ESN Engineering has used the ASCE Manual 130 rating scales (see **Appendix F**) and Sensequake has used a frequency-based rating scale for the vertical modes and a curvature distortion scale for the transverse modes.

ESN Engineering considers the deterioration in the piles at Bents 21 and 32 to be Minor; whereas Sensequake has categorized that same deterioration as High, which carries a general recommendation for repairs in the mid-term timeframe. (Note that the Sensequake scale recommends short-term repairs for areas with Severe deterioration). It is possible that the Sensequake testing has identified flexibility in the soil-pile interaction at these piles; however, ESN Engineering did not observe settlement damage in the substructure. It should be noted that Bent 13 appears to have settled but Sensequake did not note excessive flexibility in the Bent 13 substructure. It is possible that the soil interaction is more flexible at Bents 21 and 32 but has not resulted in any movement. ESN Engineering recommends that these bents be carefully checked for signs of settlement during the next routine pier inspection.

Since the Sensequake testing was focused on the deck panels, the data provided for piling was limited; the correlation between the Sensequake pile conclusions and the visual observations was Poor. As such, ESN Engineering found no justification for adjusting our pile repair recommendations at this time.

4.2. Concrete Pile Cap Beams

Sensequake Analysis Results: Sensequake concluded that the Pile Cap at Bent 11 has Moderate Deterioration. For the additional 9 bays tested between Bents 12 and 36, substructure conclusions were provided only at Bents 21 and 32. Sensequake concluded that there is High Deterioration of the pile cap and/or piles at Bents 21 and 32.

Visual and Tactile Observations at the Sensequake testing locations: ESN Engineering observed Minor corrosion spalling on the faces of the pile caps at Bents 10, 11, and 21. ESN Engineering did not observe any notable defects in the pile cap at Bent 32.

Results Comparison and Conclusions: ESN Engineering recommends making concrete spall repairs during the next 3-5 years to the pile caps at Bents 10, 11 and 21. Although the pile caps currently have a reduced capacity of 5% or less, we have recommended spall repairs be conducted prior to significant loss of the rebar section to avoid a much higher cost repair. ESN Engineering considers the deterioration in the pile cap at Bent 11 to be Minor, whereas Sensequake has categorized that same deterioration as Moderate. ESN Engineering considers the deterioration in the pile caps at Bent 21 and 32 to be Minor, whereas Sensequake has categorized that same deterioration as High. It is possible that deteriorated deck panel ends or inadequate lateral connections of deck panels to the pile caps are triggering some of Sensequake's conclusions that some of the pile caps have High Deterioration. Refer to the Concrete Pile Results Comparison and Conclusions section above for additional discussion on the differences between the Sensequake substructure and visual / tactile substructure conclusions.

Since the Sensequake testing was focused on the deck panels, the data provided for pile cap beams was limited; the correlation between the Sensequake pile cap conclusions and the visual observations was Poor. As such, ESN Engineering found no justification for adjusting our pile cap repair recommendations at this time.

4.3. Concrete Deck Panels

Sensequake Analysis Results: Sensequake divided each of the deck panels into four sections, creating a total of 16 sections for their analysis of typical 4-panel bents. Between Bents 10 and 11, Sensequake concluded that 9 of the 16 sections have Minor Deterioration and the remaining 7 sections have Moderate Deterioration. Sensequake also concluded that

the shear key between Panels C and D (the two southmost panels) has High Deterioration. Sensequake recommended that the areas showing High Deterioration should be evaluated but did not recommend any specific repairs.

For the additional bays tested between Bents 12 and 36, Sensequake concluded that the panels in the vertical mode exhibit:

- Slight to Minor Deterioration in Bay 12-13.
- Slight to Moderate Deterioration in Bays 13-14, 15-16, 18-19, 21-22, 30-31 & 35-36.
- Slight to High Deterioration in Bays 27-28 & 32-33.

Sensequake concluded that the panels in the transverse mode exhibit:

- Slight to Moderate Deterioration in Bays 13-14 & 18-19.
- Slight to High Deterioration in Bays 27-28 & 35-36.
- Minor to High Deterioration in Bays 12-13, 15-16 & 21-22.
- Minor to Severe Deterioration in Bays 30-31 & 32-33.

Visual and Tactile Observations at the Sensequake testing locations: Between Bents 10 and 11, ESN Engineering observed longitudinal and transverse cracking on the east ends of the soffits of Panels A, B, and C, indicative of overload damage. There is a noticeable vertical offset along the overload cracks in Panels A and C. The soffits of Panels B and C also had Moderate Closed Corrosion Spalling at the intersection with the pile cap at Bent 10 along the longitudinal panel edges. Panel D has three Minor transverse cracks in the east end of the soffit that extend to the south face of the panel. ESN Engineering observed between two to four Minor to Moderate transverse cracks on the top surface of all four panels at their west end.

Typically, the deck panels are longitudinally tied together across the pile cap top pour strip with dowels from both deck panels and the pile cap; this detailing allows the deck panels to act as continuous beams across the pile cap at Bent 11. As such, the top transverse cracking at the west end is indictive of flexural stress in this negative bending region. ESN Engineering also observed that a large light pole has been removed from Panel A, as evidenced by a large diameter of abandoned anchor bolts on the deck surface, above the location of soffit overload cracking.

Note: Bent 10 is one of three locations along the length of the pier, which has a transverse deck expansion joint with detailing to allow rotation between subsequent deck panels (the end of the panel intersecting the expansion joint acts as a simple beam as opposed to the typical continuous beam behavior). Per the 1965 as-built drawings, these panels do not

appear to have additional bottom longitudinal reinforcing, which if present, may have provided additional capacity where the beam behavior changes.

For the bays tested between Bents 12 and 36, ESN Engineering observed the following range of deterioration:

Panel Soffits

- Minor to Moderate transverse and longitudinal cracking.
- Minor to Moderate Closed Corrosion Spalling.
- Moderate to Severe Open Corrosion Spalling.
- Significant areas of weak and delaminated concrete.
- Major to Severe overstress fractures with vertical offsets between panels/fractures.

Panel Tops

- Minor to Moderate transverse and longitudinal cracking.
- Shallow spalling and Minor delamination.
- Minor to Moderate shear key spalling.

Results Comparison and Conclusions: ESN Engineering recommends repairing the Closed Corrosion Spalls in the panel soffits near Bent 10 and repairing the larger cracks with epoxy injection. ESN Engineering also recommends strengthening the overloaded deck panels between Bents 10 and 11 with a fiberglass laminate.

For the bays tested between Bents 12 and 36, ESN Engineering recommends the following types of deck panel repairs:

- Crack injection and spall repairs.
- Strengthening of deck panels with fiberglass laminate.
- Replacement of 4 deck panels with Severe overstress fractures.

ESN Engineering found that in the vertical mode, there was a Good correlation between the Sensequake conclusions and our visual conclusions in 30% of the tested bays and that the correlation was Poor in the remaining 70% of bays. For the transverse mode, we found that the correlation was Fair in 50% of the bays and Poor in the remaining 50% of bays. The bays with Good correlation assisted ESN Engineering with making more precise conclusions regarding the severity of the deterioration that was observed, both in the panels with Good correlation as well as in other panels with similar defects.

ESN Engineering has considered possible reasons for the Poor correlation in some bays and offers the following professional opinions which require physical destructive testing to prove, which is beyond the scope of this activity. It is possible that some of the Poor

correlation is due to previous internal repairs that are concealed by new deck topping, the shear keys providing connectivity and good load sharing between adjacent panels in some bays, or possibly some deterioration resulting in less of a capacity reduction than initially thought.

Sensequake concluded that the deck panels between Bents 10 and 11 have deterioration ranging from Minor to Moderate. The correlation was Poor between the areas that ESN Engineering observed as having signs of overload damage or flexural stress and the areas that Sensequake identified as having Moderate deterioration. It is possible that the shear keys and past grout injection repairs have bonded some of the internal delamination and are helping to share load between panels. Sensequake also noted that the shear key between Panels C and D has High Deterioration. ESN Engineering did not observe signs of shear key failure at this location, such as differential settlement between adjacent panels, longitudinal cracking along the joint or spalling along the joint, except for a Minor Closed Corrosion Spall at the east end.

In Panels 12-13:B, 12-13:C, 15-16:B, and 18-19:A the Good correlation between the Sensequake conclusions and our visual observations showed that the overstress fractures in the panel soffits with wide shear and flexural cracks and vertical deflections have less interior deterioration that appears from the surface, allowing ESN Engineering to recommend spall repairs and epoxy crack injection repairs with FRP laminate strengthening for these panels in lieu of complete panel replacement. Although, the correlation between the Sensequake conclusions and visual observations was Poor in Bays 13-14, 21-22, and 27-28, Sensequake's conclusions regarding the overall level of deterioration in the bay in conjunction with matching visual deterioration levels with corresponding data, allowed ESN Engineering to recommend repairs instead of panel replacement.

The correlation in Panels 30-31:C, 32-33:A, 32-33:C, and 35-36:B was Poor; however, the High Deterioration that Sensequake captured adjacent to Severe visual deterioration, helped ESN Engineering confirm that panel replacement is required in those 4 panels.

4.4. GENERAL CONCLUSION STATEMENT ON SENSEQUAKE TESTING

It is ESN Engineering's opinion that Sensequake was a helpful tool in evaluating the deterioration observed by traditional means. The Sensequake testing showed that the remaining internal continuity of several of the deck panels in Severe condition is currently sufficient to allow for repairs as opposed to replacement-in-kind. The use of Sensequake modeling assisted ESN Engineering in our decision to revise our original recommendation to replace 13 panels to replace 4 panels and repair the remaining 9 panels with a combination

of both FRP laminate strengthening and traditional spall repair and epoxy crack injection methods. ESN Engineering does not feel that Sensequake testing on its own can adequately identify all defects and areas of deterioration, nor can it adequately classify the level of deterioration as it relates to required repairs or specific reductions in load capacity. Sensequake cannot identify specific structural members requiring repair or the type and nature of the required repair; however, Sensequake can assist in determining the remaining interior continuity of areas that are not visible.

5. COST / BENEFIT ANALYSIS

The following summarizes the anticipated repair projects required to maintain the pier over the next 45 years, the cost for a new replacement pier, the assumptions used in the development of the cost estimates and schedules, our comparison of the costs to maintain the existing pier vs. a full pier replacement, and our recommendation for the optimal time to replace the pier.

5.1. Existing Pier: Maintenance / Repairs

The following table provides a summary of the maintenance and repair costs that are anticipated to be required to maintain the pier over the next 45 years. The repairs have been grouped into reasonable projects that will typically occur in 5-year increments to reduce the number of individual construction mobilizations and minimize public impact. The budgetary cost estimates for each construction project include the costs of Routine and Design-Level Inspections, Design, Geotechnical Investigation, Environmental Permitting, Contract Administration, and Construction Support efforts (see **Appendix E** for line-item cost estimates for near term projects & **Appendix G** for line-item cost estimates and schedules for each recommended future repair project).

Existing Pier Repair Costs (2025 – 2070)

Year	Estimated Repair Costs including Inflation	Cumulative Repair Costs including Inflation	See Appendices for Detailed Cost Estimates
2027	$ 3,511,000	$ 3,511,000	Pages E-2 & E-3
2030	$ 3,916,000	$ 7,427,000	Pages E-4 & E-5
2035	$ 6,490,000	$ 13,917,000	Pages G-2 & G-3
2040	$ 9,459,000	$ 23,376,000	Pages G-4 & G-5
2045	$ 12,641,000	$ 36,017,000	Pages G-6 & G-7
2050	$ 17,654,000	$ 53,671,000	Pages G-8 & G-9
2055	$ 23,706,000	$ 77,377,000	Pages G-10 & G-11
2060	$ 31,676,000	$ 109,053,000	Pages G-12 & G-13
2065	$ 43,512,000	$ 152,565,000	Pages G-14 & G-15
2070	$ 57,670,000	$ 210,235,000	Pages G-16 & G-17

5.2. Replacement Pier: Cost Estimate

The cost of the new replacement pier is anticipated to be $44.5 million (in 2025 Dollars) (see **Appendix G**, Pages G-18 and G-19 for full cost estimate and schedule). The budgetary cost estimate includes the cost for the demolition of the existing pier and construction of a full

replacement pier. The budgetary cost estimate includes the costs of Planning, Surveying, Design, Geotechnical Engineering, Environmental Permitting, Contract Administration, and Construction Support efforts. The schedule assumes that the planning, public outreach, and environmental assessment efforts will take several years to complete prior to the design, permitting, and construction of the new pier.

5.3. Analysis Assumptions

The following assumptions have been used in the preparation of the budgetary cost estimates for the existing pier repairs and new replacement pier construction.

i. All recommended future repairs have been grouped into projects that will typically occur at 5-year intervals to reduce the number of individual construction mobilizations and minimize public impact.
ii. A 30% Construction Contingency Cost has been applied to all cost estimates.
iii. All costs were developed based on 2025 estimated construction costs and have been adjusted for inflation using a 4% average inflation increase.
iv. The analysis assumes that the existing pier will be maintained at the current load rating with no major changes to use and that the recommended projects will be carried out at the recommended intervals.
v. The new pier will have approximately the same dimensions as the existing pier (1,140' long x 20' wide with widened end) which is approximately 25,000 square feet. For an apples-to-apples comparison, upgraded features (such as a larger footprint, additional amenities on the pier, etc.) have not been incorporated into this analysis.
vi. The new pier will have the same approximate height as the existing pier, which adequately accounts for future Sea Level Rise concerns.
vii. This analysis assumes that maintaining some pier access during the construction of a new pier is important. An allotment for anticipated phasing costs has been included in the new pier cost estimate. The details of how phasing will be implemented, and the alignment of the new pier are not a part of this analysis.
viii. Local economic impact of pier closures has not been considered in this analysis. The City may choose to adjust the timing of the pier replacement to consider the detrimental value which pier closures for repairs have on public access and economic impact to the community.
ix. After the new pier is built and in service, the piles of the existing pier will be cut-off at the current seafloor elevation (as opposed to being fully removed or cut-off a foot or two below the mudline, which would incur additional cost)
x. A full CEQA Environmental Assessment will be required for the new pier and will likely be a 2-3 year long process.
xi. Repair costs will be very low to zero for the new pier during the first 15 to 20 years of its life.

xii. Notable repair projects will cease once the planning for the new pier begins in anticipation of the new structure, i.e., once it is determined that the pier will be replaced, repairs will only be performed to maintain the pier capacity until the new pier is constructed. The costs of those repairs as well as alternative approaches which consider partial pier access restrictions and temporary structural improvements have been included in the analysis. Repairs that would extend the life of the pier beyond construction of a new facility will not be performed.

xiii. The Budgetary Costs are based upon commonly prescribed repair methods and the historical cost estimating experience of the estimators. For validation, costs have been compared to previous bidding information available for similar pier repair work. The Budgetary Costs and Engineering Estimates are not guarantees of contractor pricing for future work.

xiv. The analysis and cost estimates cannot and do not predict future global and economic effects on the inflation of materials and labor nor do they address acts of accidental overload or Acts-of-God such as high surf or seismic events which can partially or destroy a pier.

xv. Modification of the approach roadway alignment and pierhead plaza improvements are outside the scope of this pier cost/benefit analysis.

xvi. Modifications, upgrades and replacement of the LA County Fire Department building & Lifeguard tower, garage and parking are outside the scope of this pier cost/benefit analysis.

xvii. The analysis assumes that the City will seek grants to assist with the funding of the new pier and that the grant research and applications will be prepared by City staff; the cost of minimal consultant assistance has been added to the new pier cost estimate. All cost estimates show the full anticipated cost with no reduction for external funding sources and do not consider how funding will be provided.

xviii. The analysis uses a 45-year evaluation period to compare maintenance, repair and new construction costs.

xix. The analysis assumes that regular minor monthly maintenance (outside of major capital improvement project repairs) is minimal and likely similar for both the existing pier and a new pier. As such, minor routine maintenance costs have not been included in the analysis. For the planning of a future replacement pier, we recommend incorporating lessons learned from maintaining the current pier into the design.

xx. The primary goal of this analysis is to determine the optimal economic timing for replacement of the pier.

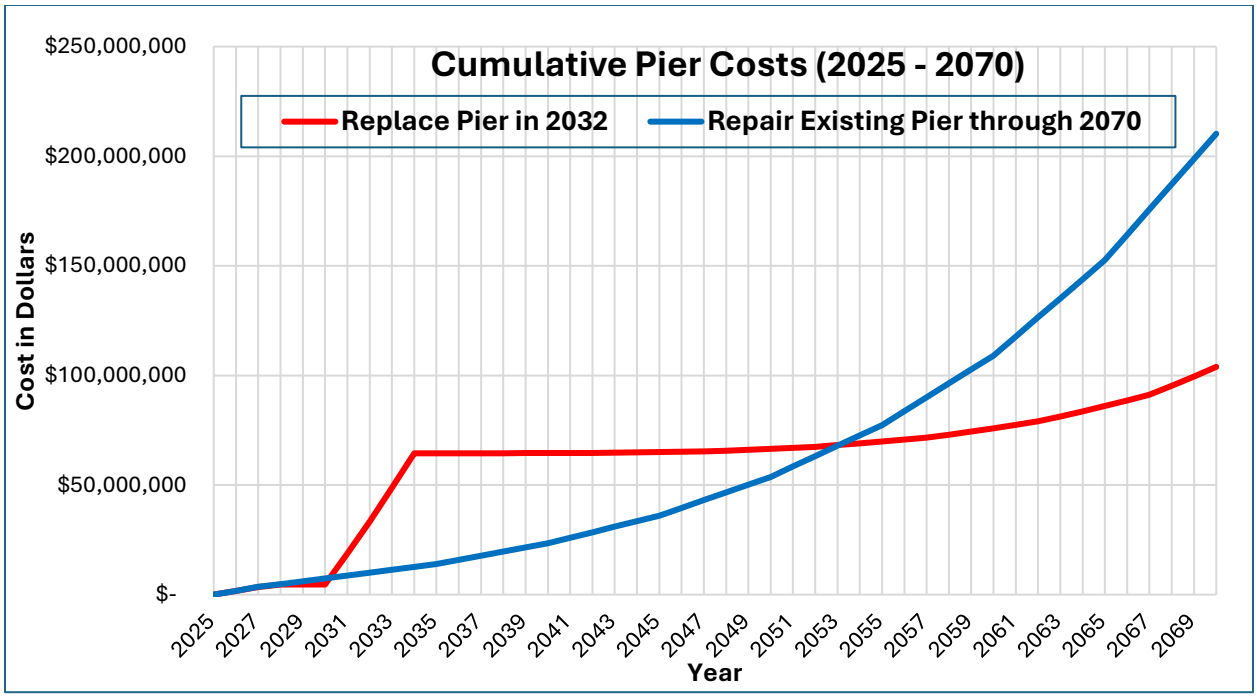
5.4. Analysis Summary

To determine the most cost-efficient timing for the City to replace the pier with new construction, we created a spreadsheet which compares the anticipated maintenance and

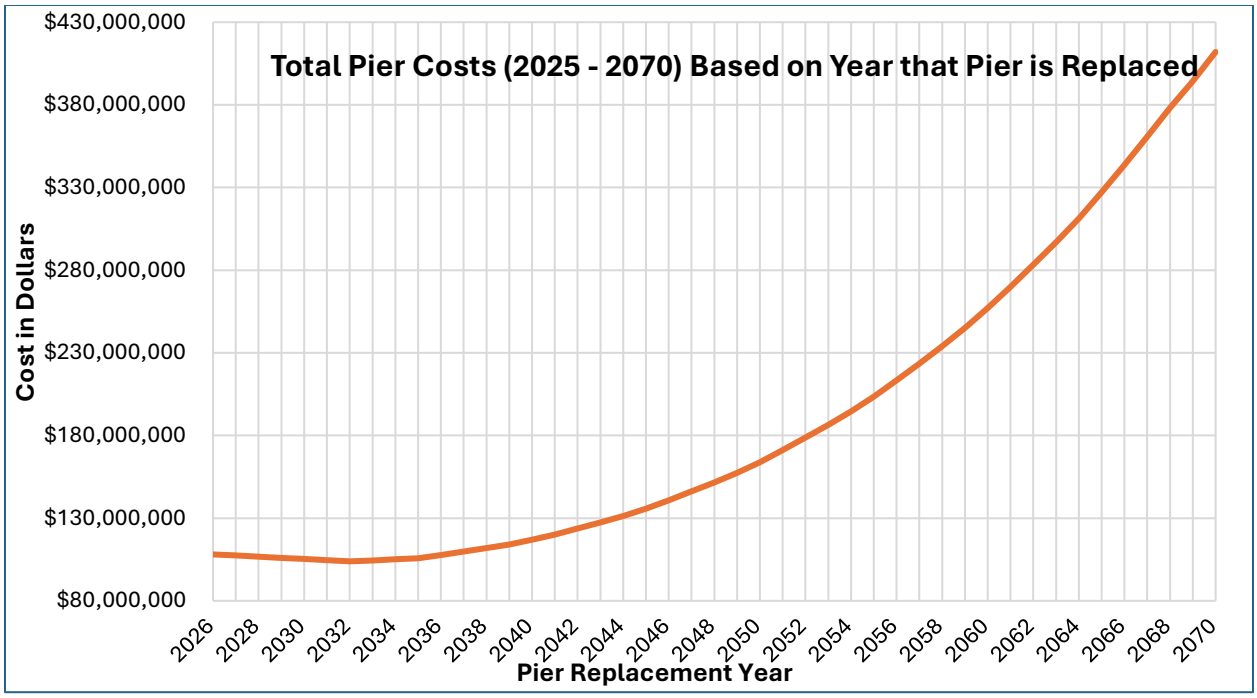
construction costs for the pier each year for the next 45 years based on what year the pier is replaced. We analyzed 45 different scenarios, one for each calendar year from 2026 to 2070, determining the total costs over the next 45 years if the pier is replaced in that year (see **Appendix G, Pages G-34 to G-37**). The costs include maintenance projects for the current pier, the cost of a new facility, and the costs of maintaining the new facility (which are very low for the first 15 to 20 years following new construction).

The analysis shown on **Pages G-34 to G-37** shows the estimated pier costs (including estimated inflation for the year the cost will occur) for each year over the next 45 years (green vertical axis) for 45 different scenarios – each scenario is for the replacement of the pier in that year (blue horizontal axis). The total estimated pier cost for each replacement year scenario is shown at the top of each column in orange and is a sum of the 45 annual costs in that column. The analysis incorporates engineering judgement based on carefully calculated unit prices and individual project estimates. The costs are derived from the detailed cost estimates shown on **Pages E-2 to E-5 and G-2 to G-33** for the recommended maintenance projects to maintain the existing pier, the cost of a new pier, and the cost of maintenance projects on the new pier after the pier is replaced (very minor to begin and becoming more notable approximately 15 years after new pier construction). To refine the analysis by year, the cost of maintenance projects that typically occur every five years are divided into yearly costs over the period between maintenance projects. Similarly, the cost of the new pier construction is spread across several years since most of the soft costs will occur years prior to construction and the construction costs themselves will be distributed over a 2-to-3-year period. Repair projects on the existing pier are applied typically until 5 years before the pier is replaced. Engineering judgment is applied to adjust the costs for the last major project prior to replacement to focus on maintaining safety until replacement and minor maintenance costs have been included where appropriate.

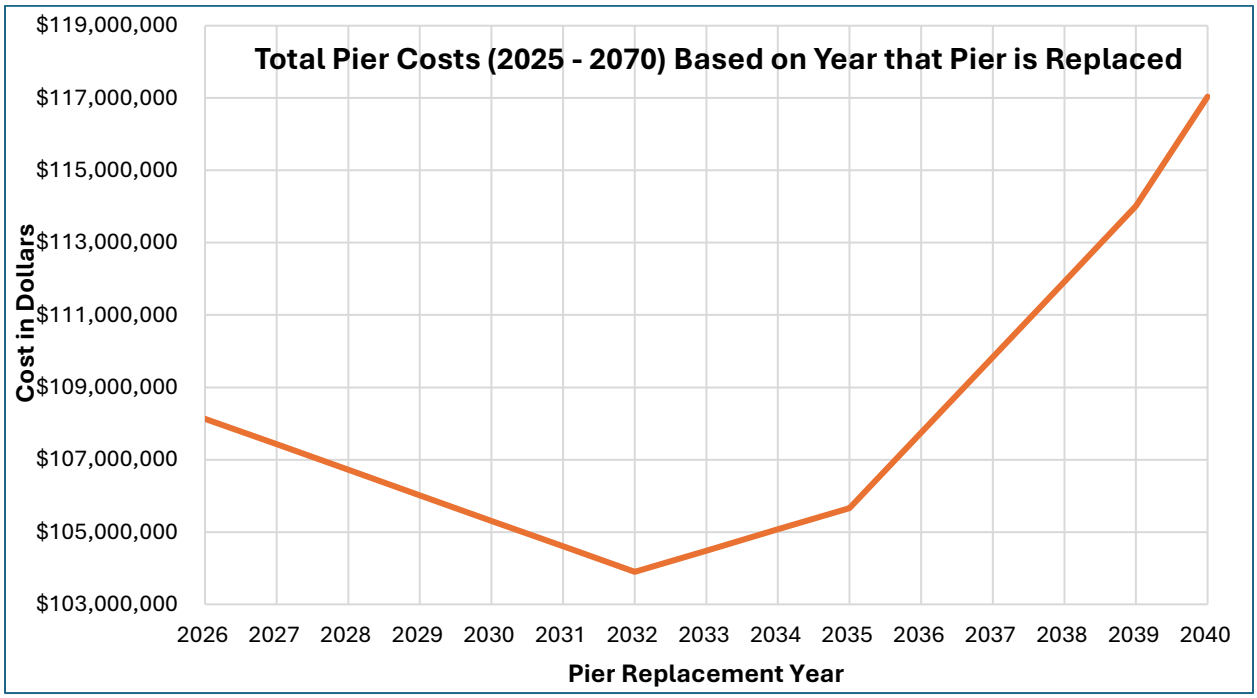
The overall savings of new construction are typically not fully seen until approximately 15 to 20 years after construction of the new facility as shown in the following graph, which compares total pier costs for the scenario where the pier is replaced in 2032 vs. the scenario where the pier is not replaced. It should also be noted that in the year 2070 the existing pier will reach an age of 105 years and will likely have no remaining useful service life.



The following two graphs show the total pier costs for the next 45 years based on what year the pier is replaced. The first graph includes all the replacement years considered (2026 through 2070) and shows that the total costs are relatively similar for pier replacement within the next 10 years but will start to significantly increase in 2039. This shows that the existing pier has approximately 10 years of cost-efficient life remaining and the City has flexibility over the next 10 years to select a replacement year without a notable cost increase. The second graph focuses on 2026 through 2040 and is helpful in visualizing costs over the next 10 years.



The graph below shows that the total pier costs through 2070 are estimated to be $103.9 million if the pier is replaced in 2032. For comparison, the total pier cost is $106.1 million if the pier is replaced in 2030, $105.7 million if the pier is replaced in 2035, and $114.0 million if the pier is replaced in 2039.



5.5. Conclusions

It is our recommendation that existing pier maintenance projects cease after the 2027 repair project is completed and the pier be replaced with new construction in the year 2032. The Near Term – High Priority 2027 repair project must be completed as planned to avoid a reduction in the current pier load rating, restriction of vehicle weight, or localized deck area closures. To break ground for construction of a new pier in 2032, planning studies, public outreach tasks, and environmental assessment studies will likely need to be started as early as 2026 to avoid partial pier closures.

It is important to note that there is only a 4% total cost difference of pier replacement over the next 10 years, which gives the City flexibility in choosing to replace the pier any year before 2036 without significant additional cost over replacement in the optimal year 2032.

If the pier is replaced in 2032, we recommend that the 2030 Near Term – Medium Priority recommended repair project not be fully implemented as outlined but instead the responsible Design Engineer should review the list of repairs and recommend a reduced scope of repairs with the only goal being to maintain public safety of the pier prior to demolition. The plan may include some isolated repairs, restricting access to parts of the pier, reducing the size of vehicles allowed on the pier, or temporary structural improvements.

APPENDIX

Appendix A: Location and Vicinity Maps

Appendix B: Typical As-Built Drawings

Appendix C: Photographs

Appendix D: Field Notes

Appendix E: Budgetary Cost Estimate & Estimated Repair Quantities

Appendix F: Inspection Procedure

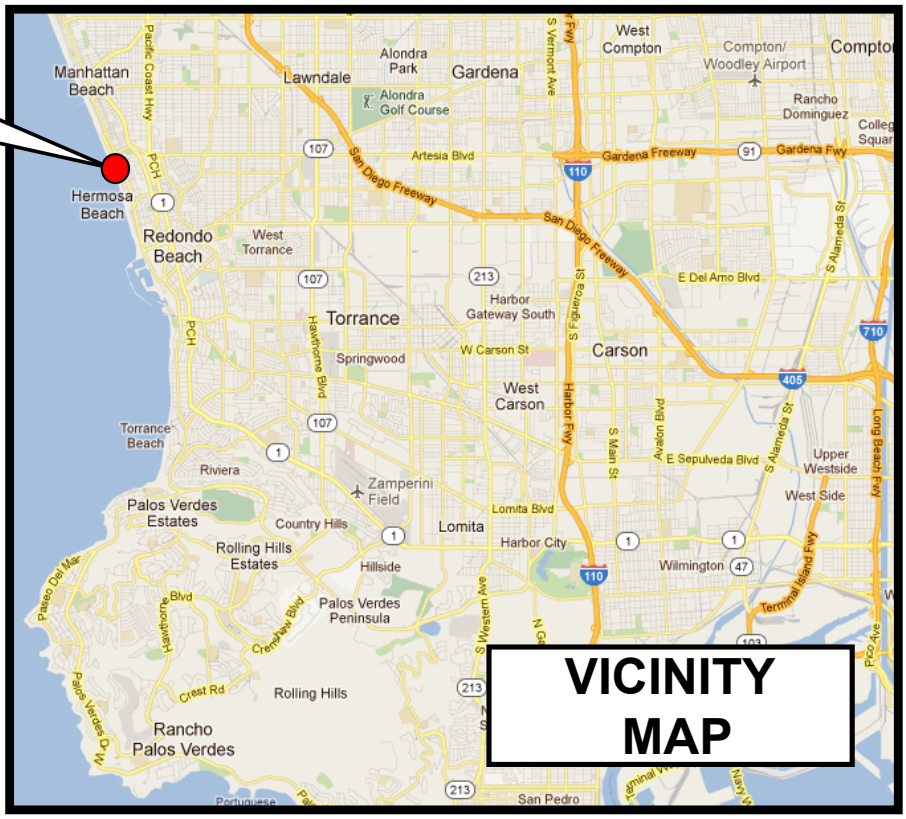
Appendix G: Cost / Benefit Analysis – Cost Estimates & Schedules

Appendix H: Sensequake Panel Testing (October 2025)

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APPENDIX A: LOCATION AND VICINITY MAPS

Municipal Pier
Hermosa Beach, CA



VICINITY MAP

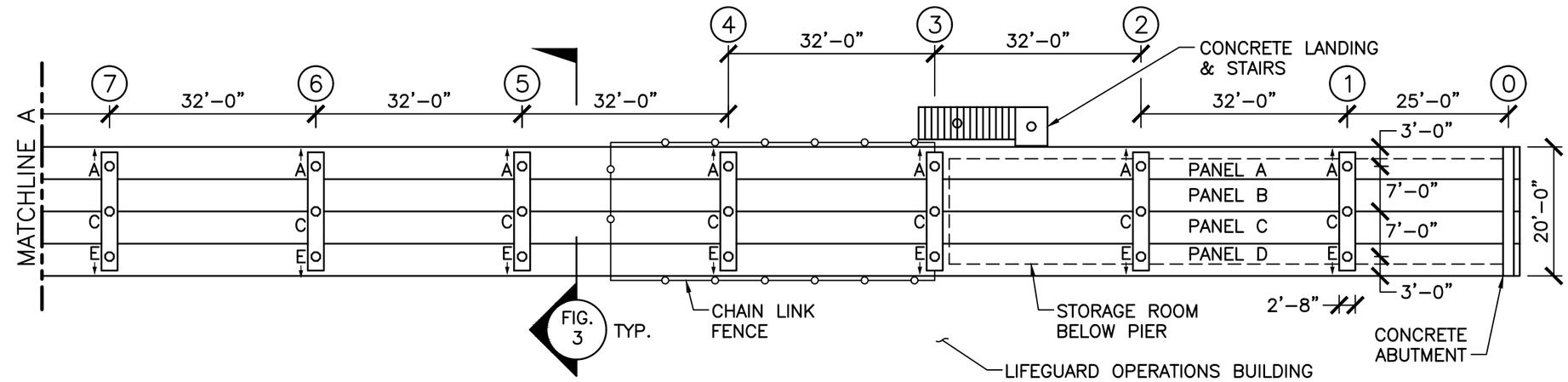


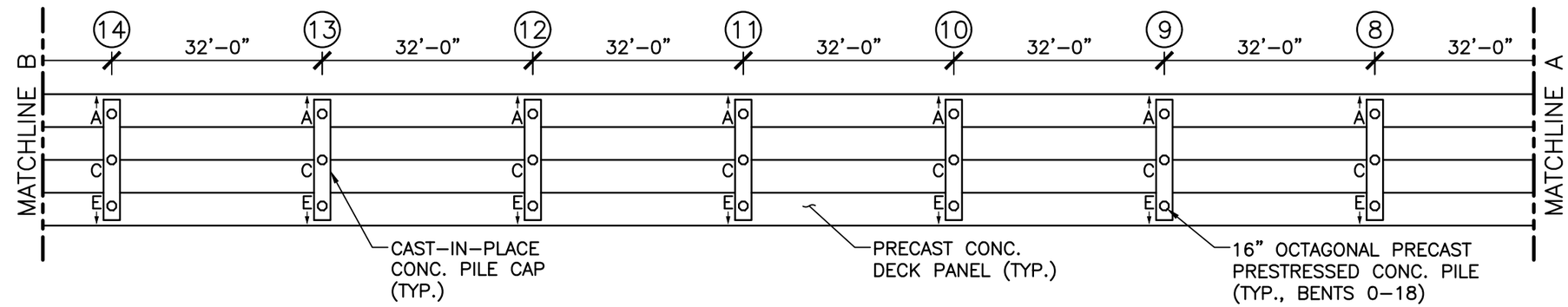
LOCATION MAP

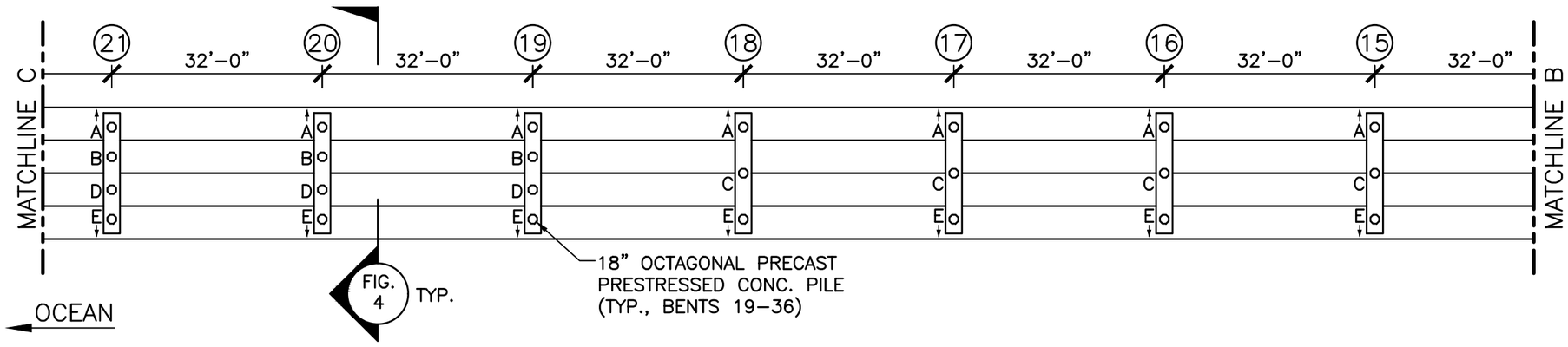
LOCATION AND VICINITY MAPS

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APPENDIX B: TYPICAL AS-BUILT DRAWINGS







ESN
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35 NEWBERRY CT
MORTON, IL 61550
508-954-3091

CONSULTANTS

2024 ASSESSMENT
MUNICIPAL PIER
HERMOSA BEACH, CA

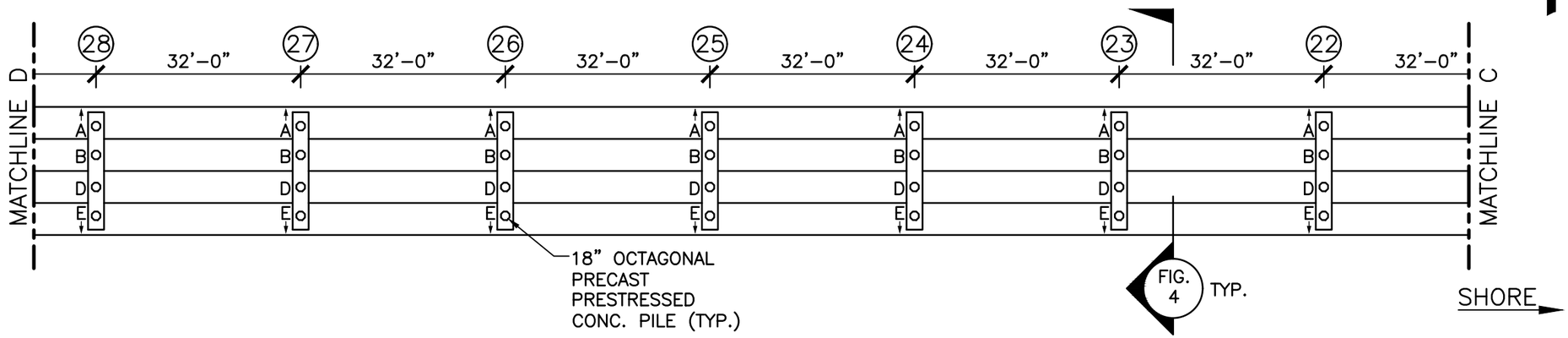
MARK	DATE	DESCRIPTION

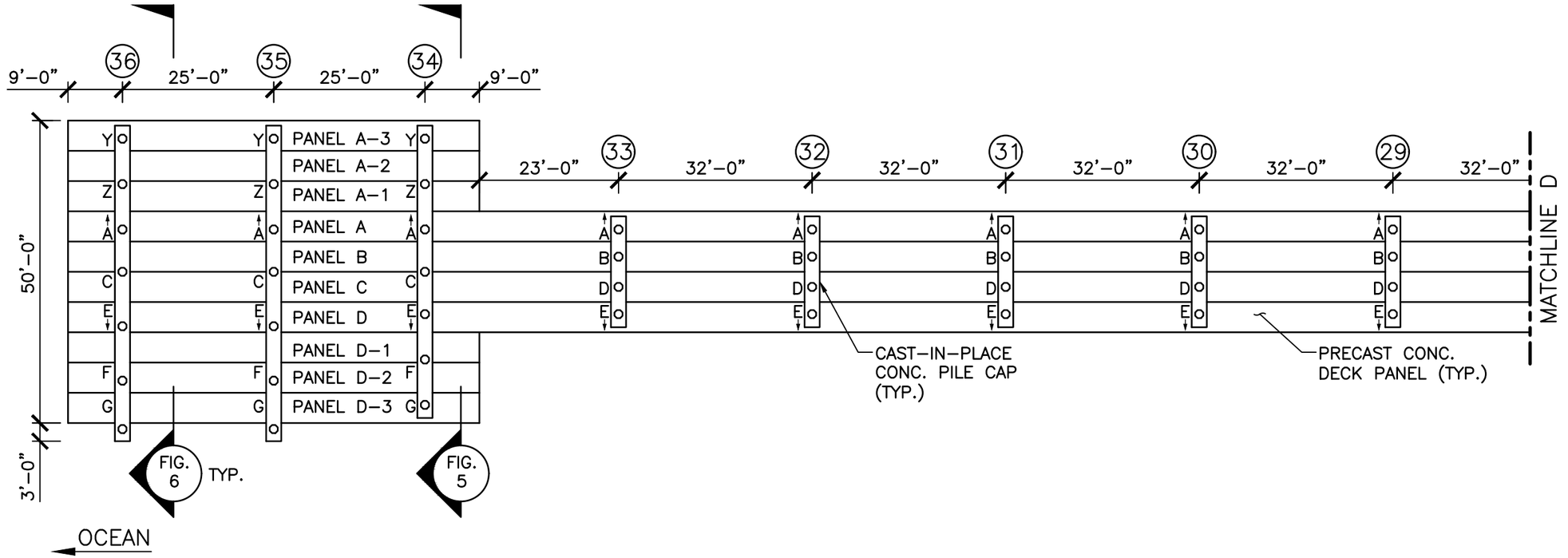
PROJ NO:
SCALE: 1" = 20'
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

REFLECTED DECK PLAN
[BENTS 0 – 21]

FIGURE 1





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CONSULTANTS

2024 ASSESSMENT
MUNICIPAL PIER
HERMOSA BEACH, CA

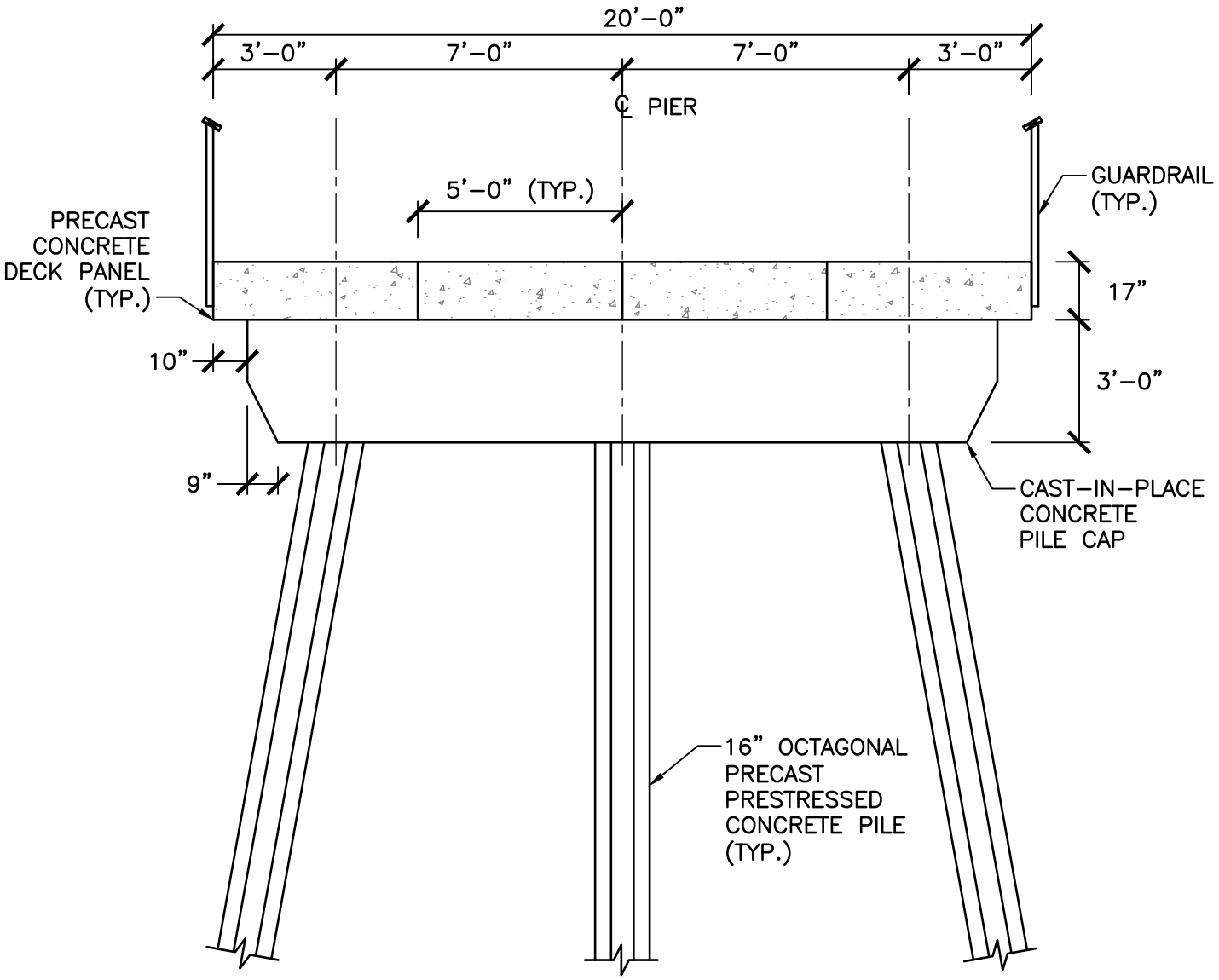
MARK	DATE	DESCRIPTION

PROJ NO:
SCALE: 1" = 20'
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

REFLECTED DECK PLAN
[BENTS 22 – 36]

FIGURE 2



ESN
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35 NEWBERRY CT
MORTON, IL 61550
508-954-3091

PROJ NO:
SCALE: 1/4" = 1'-0"
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

PIER CROSS SECTION

[BENTS 1 – 18]

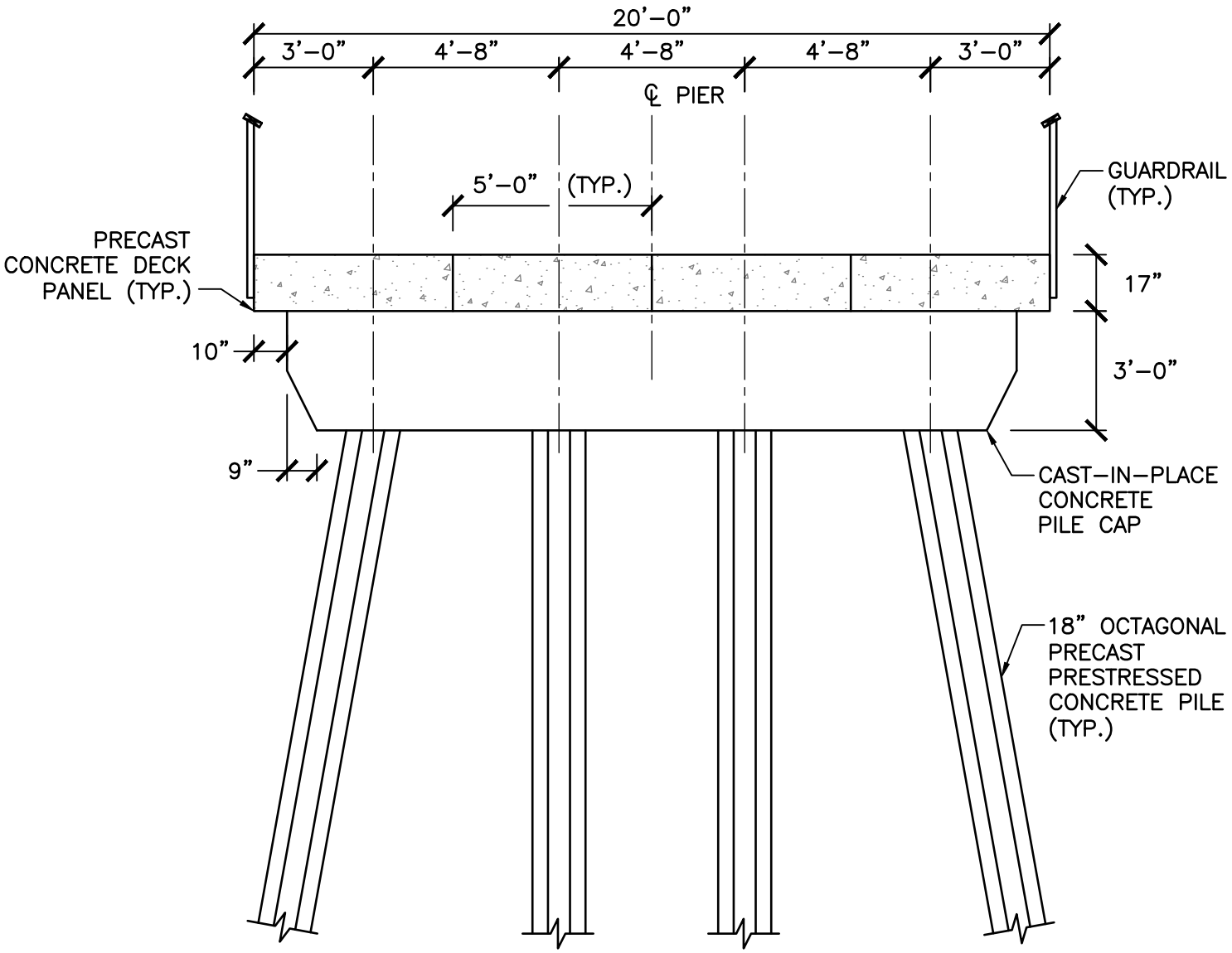
PROJECT

2024 ASSESSMENT

MUNICIPAL PIER

HERMOSA BEACH, CA

FIGURE 3



ESN
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35 NEWBERRY CT
MORTON, IL 61550
508-954-3091

PROJ NO:
SCALE: 1/4" = 1'-0"
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

PIER CROSS SECTION

[BENTS 19 – 33]

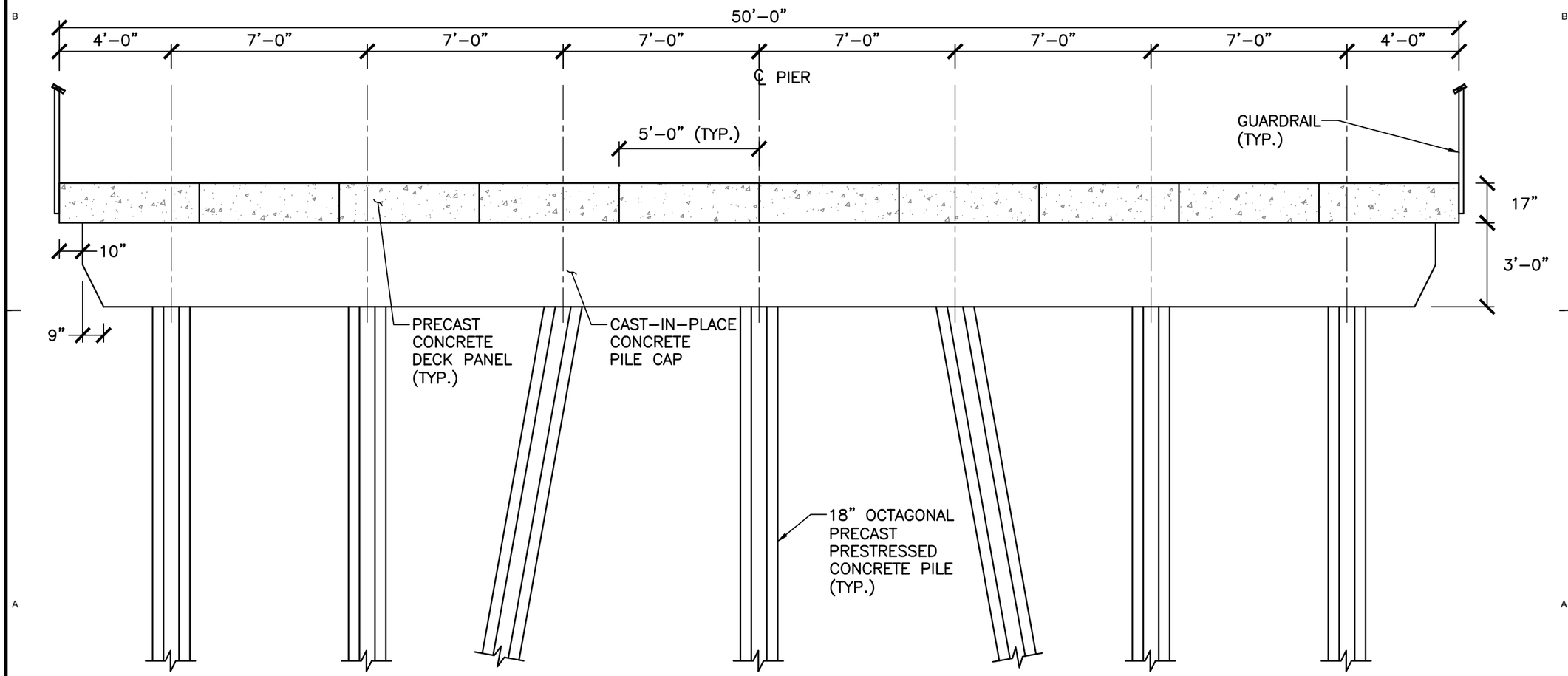
PROJECT

2024 ASSESSMENT

MUNICIPAL PIER

HERMOSA BEACH, CA

FIGURE: 4



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MORTON, IL 61550
508-954-3091

CONSULTANTS

2024 ASSESSMENT
MUNICIPAL PIER
HERMOSA BEACH, CA

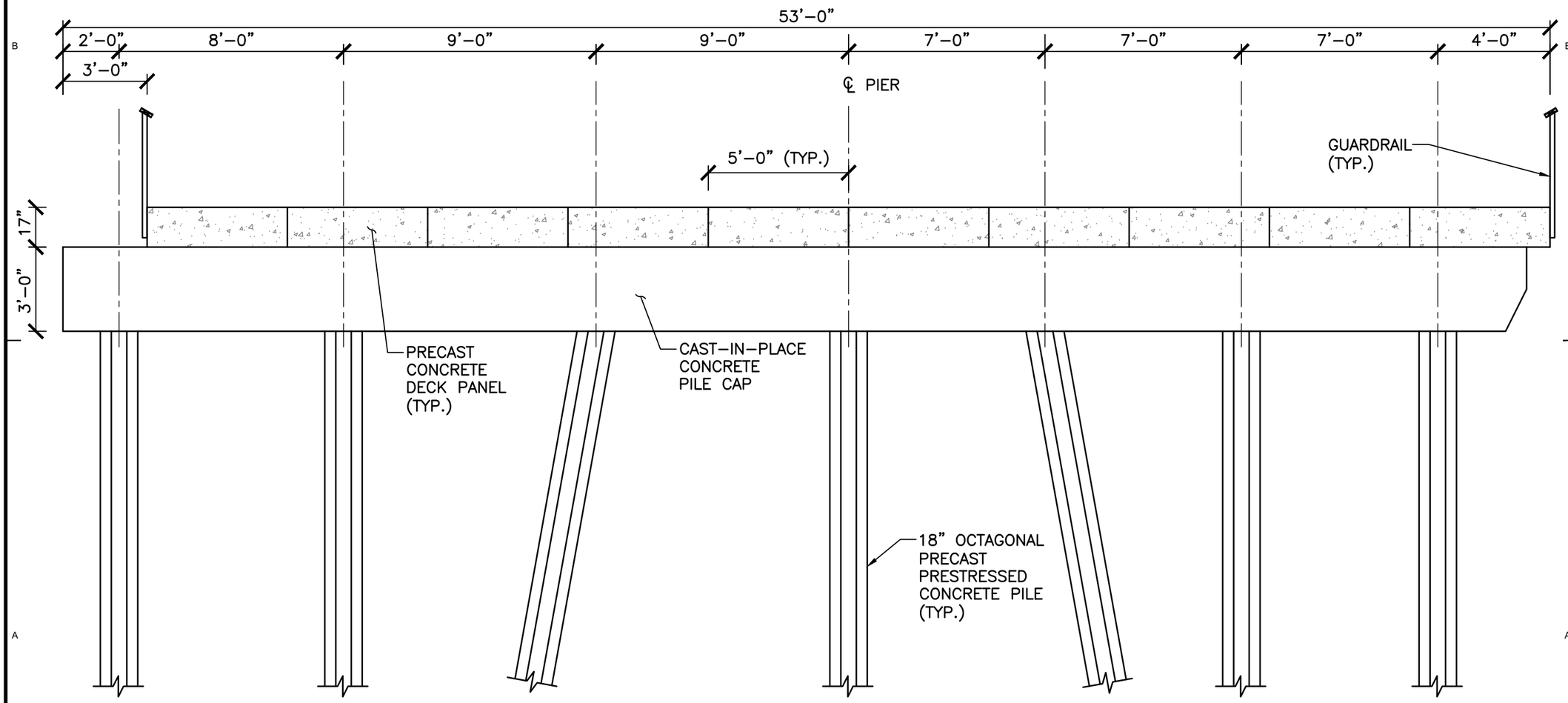
MARK	DATE	DESCRIPTION

PROJ NO:
SCALE: 1/4" = 1'-0"
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

PIER
CROSS SECTION
[BENT 34]

FIGURE 5



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508-954-3091

CONSULTANTS

2024 ASSESSMENT
MUNICIPAL PIER
HERMOSA BEACH, CA

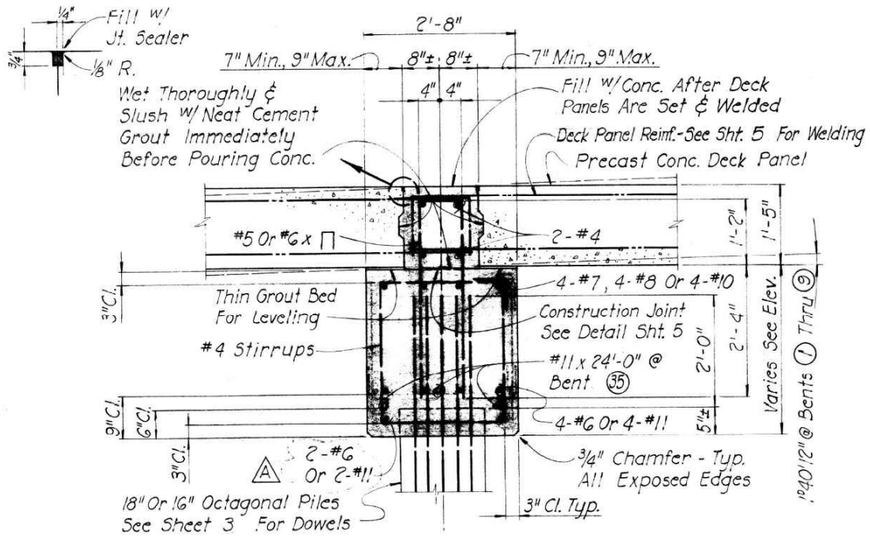
MARK	DATE	DESCRIPTION

PROJ NO:
SCALE: 1/4" = 1'-0"
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

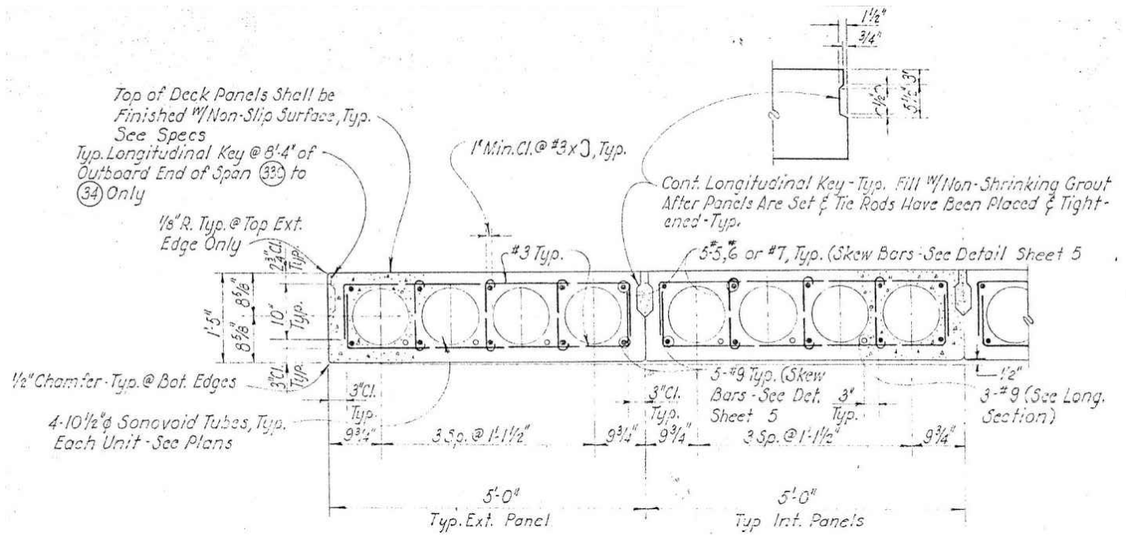
SHEET TITLE

PIER
CROSS SECTION
[BENTS 35 – 36]

FIGURE 6

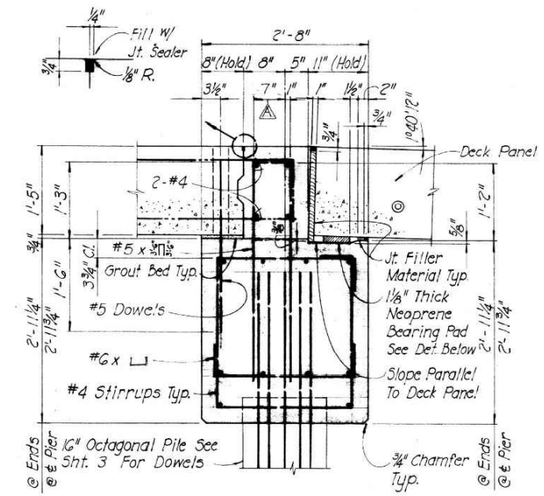


TYPICAL DECK POUR JOINT SECTION

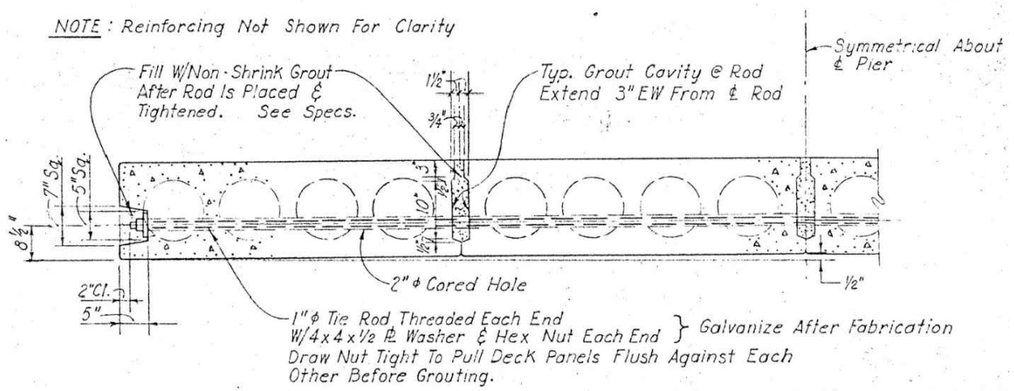


TYPICAL DECK SECTION

ALL DETAILS THIS SHEET COPIED FROM AS-BUILT DRAWINGS DATED 7/13/1965 BY MOFFATT & NICHOL



TYPICAL DECK EXPANSION JOINT SECTION



TYPICAL DECK SECTION AT TIE ROD

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MORTON, IL 61550
508-954-3091

CONSULTANTS

2024 ASSESSMENT
MUNICIPAL PIER
HERMOSA BEACH, CA

MARK	DATE	DESCRIPTION

PROJ NO:
SCALE: NOT TO SCALE
DATE: 1-16-2025
DESIGNED BY:
DRAWN BY: ESN
CHECKED BY: CDD

SHEET TITLE

DECK PANEL TYPICAL DETAILS

FIGURE 7

ESN Engineering, PLLC

APPENDIX C: PHOTOGRAPHS



Photo 1: Looking Southwest along the Hermosa Beach Pier.



Photo 2: Looking Southwest along the Hermosa Beach Pier during the Beach Soffit Inspection.



Photo 3: Looking West at Bent 29 showing 3 Fiberglass Jacket Pile Repairs completed in 2023.



Photo 4: Looking West at Bent 31 showing an older generation Fiberglass Jacket Pile Repair.



Photo 5: Looking West at Pile 15:A, Cleaned of Marine Growth at Mudline for Level II Inspection.



Photo 6: Looking East at Octagonal Pile Wrap at Pile 3:A and Closed Corrosion Spall in Pile Cap.



Photo 7: Looking Southeast at Steel Pile Jacket at Pile 16:A.



Photo 8: Looking East at Steel Strap Repair at Split Fiberglass Jacket on Pile 11:E.



Photo 9: Looking Southeast at Deterioration in Bottom of Fiberglass Jacket at Pile 35:G



Photo 10: Looking Southeast at Open Corrosion Spall at Top of Pile 34:F



Photo 11: Looking Southeast at Open Corrosion Spall at Top of Pile 23:B.



Photo 12: Looking West at Closed Corrosion Spall at top of Pile 36:C.

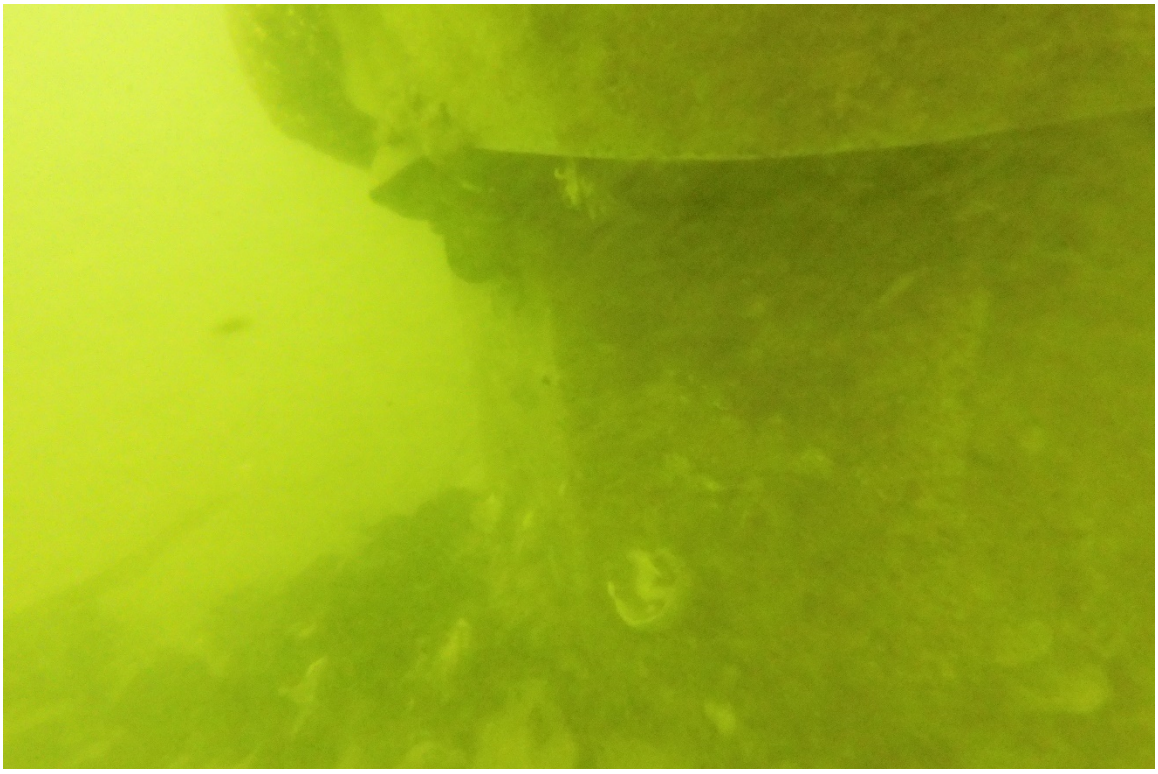


Photo 13: Looking at Bottom of Fiberglass Jacket at Pile 32:A, 1' above Mudline.

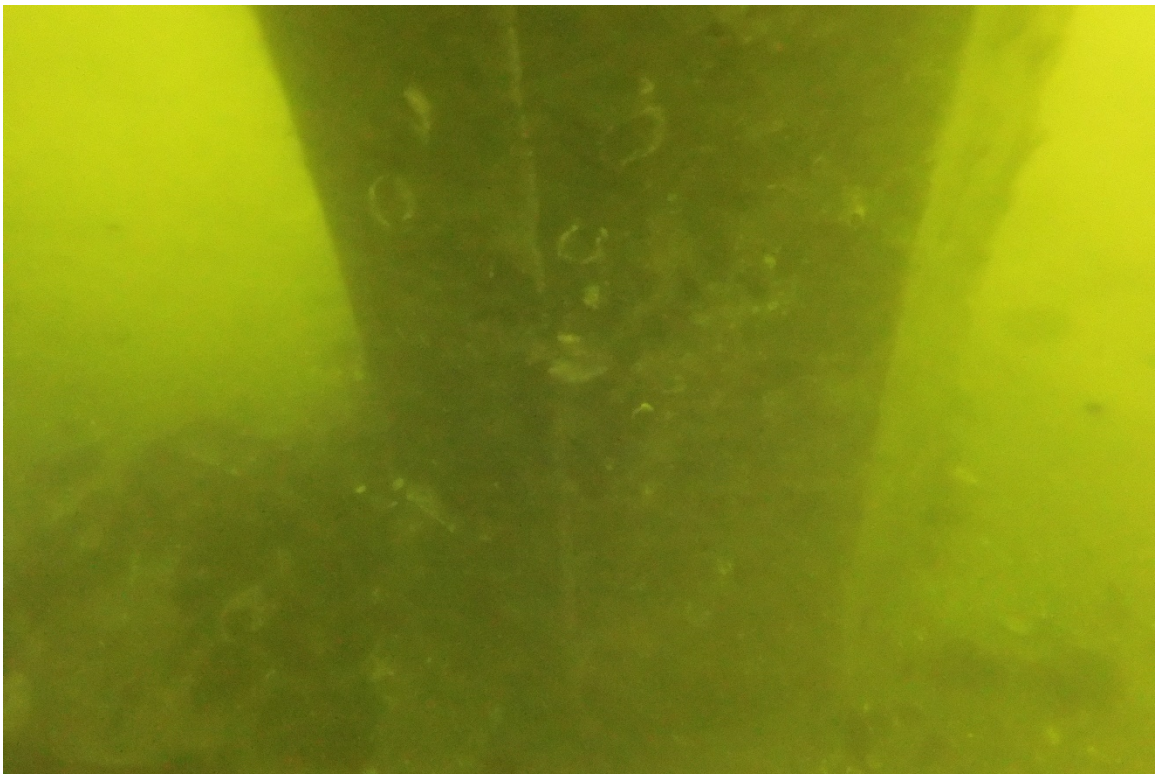


Photo 14: Looking at Bottom of Concrete Pile 34:Z at Mudline, Clean of Marine Growth.



Photo 15: Looking Southeast at Closed Corrosion Spall in Pile Cap above Pile 13:A at Northwest end.



Photo 16: Looking Southwest at Open Corrosion Spall in Pile Cap above Pile 13:A at Northeast end.



Photo 17: Looking East and Up at Closed Corrosion Spall and Delamination in Soffit of Panel 21-22:B.



Photo 18: Looking North and Up at Closed Corrosion Spall and Delamination in Soffit of Panel 21-22:B.



Photo 19: Looking East at Fracture with Spall in Soffit of Panel 15-16:B.



Photo 20: Looking East at Fracture with Spall in Soffit of Panel 15-16:B.



Photo 21: Looking Southeast at Longitudinal Fracture in Panel 32-33:C.



Photo 22: Looking Southeast and Up at Longitudinal Fracture in Panel 32-33:C.



Photo 23: Looking Up at Internal Fracture, Delamination and Vertical Deflection in Panel 30-31:C.



Photo 24: Looking South at Internal Fracture, Delamination and Vertical Deflection in Panel 30-31:C.



Photo 25: Looking Up at Internal Fracture, Delamination and Vertical Deflection in Panel 30-31:C.



Photo 26: Looking Up at Internal Fracture, Delamination and Vertical Deflection in Panel 30-31:C.



Photo 27: Looking West and Up at Open Corrosion Spall in Soffit of Panel 35-36:B at West End.



Photo 28: Looking West and Up at Open Corrosion Spall in Soffit of Panel 35-36:B at West End.



Photo 29: Looking Southeast and Up at Closed Corrosion Spall in Soffit of Panel 10-11:B at West end.



Photo 30: Looking West and Down at Delamination and Transverse Cracking in Top of Panel 1-2:C.



Photo 31: Looking West at Transverse Cracking and Delamination in Top of Panel 29-30:C.



Photo 32: Looking West and Down at Transverse Cracking in Top of Panel 8-9:A at East end.

ESN Engineering, PLLC

APPENDIX D: FIELD NOTES

Hermosa Beach Pier - 2024 Condition Assessment

Pile Inspection Field Notes

ESN Engineering, PLLC

Bent	Pile	Jacket?	Notes	Photos	Repairs?
1	A	OFG, full height			
1	C	OFG, full height			
1	E	OFG, full height			
2	A	OFG, full height			
2	C	OFG, full height			
2	E	OFG, full height			
3	A	OFG, full height			
3	C	OFG, full height			
3	E	OFG, full height			
4	A	OFG, full height			
4	C	OFG, full height			
4	E	OFG, full height			
5	A	OFG, full height			
5	C	OFG, full height			
5	E	OFG, full height			
6	A	OFG, full height			
6	C	OFG, full height			
6	E	OFG, full height			
7	A	OFG, full height			
7	C	OFG, full height			
7	E	OFG, full height			
8	A	OFG, full height			
8	C	OFG, full height			
8	E	OFG, full height			
9	A	FG, bot. at ML, top at PC	1/4" x 8' long split in jacket, VCR, L	10/17: 3069-3072	Repair in 5 years
9	C	FG, 9' long, bot. 2' abv. ML, top at PC	3/8" x 7' long split in jacket, 1/16" VCR, O	10/17: 3073-3076	
9	E				
10	A		CCS, RO, top 4'		
10	C		CCS, RO, top 3'		

Bent	Pile	Jacket?	Notes	Photos	Repairs?
10	E	2023 FG, 14' long, bot. at ML, top at PC		10/17: 3077	
11	A	OFG, top 1' blw PC to FG top 2' abv ML, bot. at ML		10/17: 3087-3088	
11	C		CCS, L, I, top 8'	10/17: 3082-3086	
11	E	FG, bot. at ML, top at PC	7/16" x 7.5' long split in jacket w/ (5) DCR visible in grout across gap, 8 steel straps	10/17: 3078-3081	Repair in 5-10 years
12	A	2023 FG, 22' long, bot. at ML, top at PC		10/17: 3089-3090	
12	C	2023 FG, 22' long, bot. at ML, top at PC		10/17: 3093	
12	E	FG, bot. at ML, top 1' blw PC		10/17: 3096	
13	A	2023 FG, 13' long, bot. 13' blw PC, top at PC; FG, 5' Long, bot 1' abv ML		10/17: 3091-3095	
13	C		CCS, R, RO, bot. 4.5' CCS, RO, top 5'	10/17: 3096-3100	
13	E	2023 FG, 13' long, bot. at ML, top 7' blw PC			
14	A	2023 FG, 20' long, bot. 0.5' abv ML, top at PC		10/17: 3112-3114	
14	C	FG, 13' long, bot. 9' abv. ML, top at PC	CCS, L, LI, bot. 8' L2 @ ML: M, 4' abv ML: M	10/17: 3101-3111, 3117-3118	
14	E	2023 FG, 22' long, bot. 0.5' abv ML, top at PC		10/17: 3101-3102	
15	A		(2) VCR, R, O, 1/16" x 5' starts 4' abv ML CCS, O, RO, R, top 6' L2 @ ML: M, 5' abv ML: M	10/17: 3112-3114, 3121-3127 10/30: 18-21, 29-31	Repair in 5 years
15	C	2023 FG, 22' long, bot. 1' abv. ML, top at PC	L2 @ ML blw jacket: M	10/17: 3113, 3128-3131, 3143	
15	E	2023 FG, 11' long, bot. 2' abv. ML, top 10' blw PC	CCS, O, top 5'	10/17: 3121, 3127, 3143	
16	A	Steel Jacket, 15' long, bot. at ML, top 7' blw PC		10/17: 3141-3143	
16	C		CCS, I, L, LO, 9' at MTL L2 @ ML: M, 4' abv ML: M	10/17: 3140, 3145-3152	
16	E	FG, bot. at ML, top 4' blw PC	Jacket ripped top 4', RI, I CCS, LI, L, LO, O,top 4'	10/17: 3134-3140, 3143 10/30: 74-78, 83-85	
17	A		VCR, L, LO, O, 8' long at El. +10' CCS, I, O, top 5'	10/30: 140-144, 159-160 12/17: 4927-4930	
17	C		VCR, RO, 4' long at El. +8'	12/17: 4931-4932	

Bent	Pile	Jacket?	Notes	Photos	Repairs?
17	E		VCR, R, RO, 5' long at El. +6'	12/17: 4933-4934	
18	A	FG, 10' long, top at PC	Jacket ripped top 5', 6 steel straps	10/31: 21-23	
18	C		VCR, I, LI, 4' long at El. +5'		
18	E	2023 FG, 8' long, top at PC over FG, 4' long top 8' blw PC	VCR, RI, I, 5' long at El. +5'	10/31: 149	
19	A		VCR, RI, LI, 5' long at El. +5'		
19	B	2023 FG, 9' long, top at PC	VCR, R, 10' long at MSL		
19	D		VCR, I, L, LO, LI, 8' long at El. +5'		
19	E		CCS, I, top 4'	10/31: 50-51	
20	A	2023 FG, 10' long, top 6' blw PC	VCR, L, 3' long at MTL, below jacket	10/31: 90	
20	B		VCR w/ bleeding, LO, L, 8' long at EL. +6'		
20	D		OK		
20	E		OK		
21	A		OK		
21	B		OK		
21	D		VCR w/ bleeding, O, 8' long at EL. +6'		
21	E	2023 FG, 10' long, top at PC	OK		
22	A		OK		
22	B		OK		
22	D		CCS, O, top 4'	11/1: 82-84	
22	E		OK		
23	A	2023 FG, 9' long, top at PC	OK		
23	B		OCS, O, top 4'	11/1: 129-132	Repair in 5 years
23	D		OK		
23	E		OK		
24	A	2023 FG, 6' long, top at PC	OK		
24	B		OK		
24	D		OK		
24	E		CCS, O, top 3'	11/4: 10-12	
25	A	2023 FG, 9' long, top at PC	OK		
25	B		OK		
25	D		CCS, I, O, top 5'	11/4: 52-57, 63-65	
25	E	FG, 8' long, top at PC	Jacket ripped top 3.5', 5 steel straps	11/4: 47-51, 65-67	

Bent	Pile	Jacket?	Notes	Photos	Repairs?
26	A		OK		
26	B		(2) VCR, O, 1' long + HCR, 1' below top, OK	11/4: 103-106	
26	D	2023 FG, 9' long, top at PC	OK		
26	E	2023 FG, 9' long, top at PC	VCR, 2' long at EL. +5'		
27	A		VCR, LI, L, LO, 4' long at EL. +4'		
27	B		VCR, LI, L, top 3'	11/4: 136-139	
27	D	2023 FG, 8' long, top at PC	OK		
27	E		VCR, R, RO, 2' long at El. +5'		
28	A		OK		
28	B	FG, 10' long, top at PC	Jacket ripped top 6', 8 steel straps	11/4: 161, 192-194 11/5: 12-14	
28	D	OGFG, bot. 10' abv ML, top at PC		11/4: 160 11/5: 16-17	
28	E	FG, 10' long, top at PC	Jacket ripped top 6', 8 steel straps	11/4: 160, 200-201	
29	A	2023 FG, 7' long, top at PC	OK		
29	B	2023 FG, 7' long, top at PC	OK		
29	D	2023 FG, 8' long, top at PC	OK		
29	E		VCR, O, R, RO, 2' long at El. +5'		
30	A		OK		
30	B		CCS, I, Top 3.5'	11/5: 96-98	
30	D	2023 FG, 7' long, top at PC	L2 @ ML: F, OK		
30	E		L2 @ ML: F, OK		
31	A	2023 FG, 10' long, top at El. + 8', center at MSL		11/5: 112-113	
31	B	FG, 6' long, top at PC	Jacket ripped, RO, I, L, top 3'	11/5: 112-113, 160-162, 183-185	
31	D		HCR + VCR at Top, OK	11/5: 180	
31	E		OCS, O, RO + CCS L, LO, top 3' L2 @ ML: F, OK	11/5: 177-179	
32	A	2023 FG, top 11' blw PC, bot 1' abv ML	OK	11/5: 170-171, 208-209 12/18: 15-18	
32	B	OGFG, top at PC, continues blw MSL	Jacket ripped, R, I, top 2'	11/5: 170-171, 231	
32	D	2023 FG, 13' long, top at PC	Minor CCS, O, RO, EL. +5', 3' below jacket	11/5: 170-171, 208-209	
32	E		VCR, O, 3' long at EL. +5'	11/5: 170-171, 208-209	
33	A	2023 FG, top 10' blw PC, bot at ML		11/6: 17-18	

Bent	Pile	Jacket?	Notes	Photos	Repairs?
33	B	OFG, top at PC, continues blw MSL		11/6: 17-18	
33	D	FG, 14' long, top at PC	Jacket ripped, 13 steel straps	11/6: 17-18, 64-65	
33	E	FG, 14' long, top at PC	Jacket deteriorated, 13 steel straps	11/6: 17-18, 66-67	
34	Y		VCR, 3' long at EL. +5', L L2 @ ML: F, OK	11/6: 77-78	
34	Z		CCS, O, Top 3' L2 @ ML: F, OK	11/6: 77-78, 139-142, 150-153 12/18: 12-14	
34	A	2023 FG, top a EL. +15', bot. at ML	VCR, O, Top 3'	11/6: 77-78, 146 12/18: 9-11	
34	C		VCR, R, 3' long at EL. +3' L2 @ ML: F, OK	11/6: 73-76	
34	E	FG, 8' long, top at PC	6 steel straps	11/6: 73-76 11/7: 172	
34	F		OCS, O, Top 3'	11/6: 73-76 11/7: 172-174, 183-184	Repair in 5 years
34	G		L2 @ ML, F, OK	11/6: 73-76	
35	Y		OCS, O, R, top 5' L2 @ ML: F, OK	11/6: 157-158 11/7: 11-14, 101	Repair in 5 years
35	Z		OK	11/6: 157-158	
35	A		OCS O, R, Top 5'	11/6: 157-158 11/7: 17-20, 101	Repair in 5 years
35	C		OK	11/6: 157-158	
35	E	2023 FG, 8' long, top at PC	OK	11/7: 98-100	
35	F	2023 FG, 8' long, top at PC	OK	11/7: 98-100	
35	G	OFG, 6' long, top at PC'	Jacket unwrapping top 2', deterioration at bottom	11/7: 98-100, 127-128	
36	Y		L2 @ ML: F, OK	11/7: 23-25	
36	Z	2023 FG, 5' long, top at PC	OK	11/7: 23-25	
36	A	2023 FG, 12' long, top at PC	OK	11/7: 23-25	
36	C	2023 FG, top a EL. +6', bot. at ML	CCS, I, Top 4'	11/7: 23-25, 97, 98 12/18: 5-7	
36	E		Vertical Sawcuts, Top 6', O, LO, Possible attempted / aborted repairs	11/7: 23-25, 91-93 12/18: 1-4, 8	

Bent	Pile	Jacket?	Notes	Photos	Repairs?
36	F	2023 FG, 7' long, top at PC FG, 5 ' long, bot. at ML	OK	11/7: 23-25	
36	G	FG, oversized, bot. at ML, top 6' abv. ML	OK	11/7: 23-25	

Pile Inspection Abbreviations

2023 FG = Pile Repaired in 2023 with Gray Round Fiberglass Jacket and Grout Fill
FG = Pile Previously Repaired with White Round Fiberglass Jacket and Grout Fill
OFG = Pile Previously Repaired with White Octagonal Tight Fiberglass Jacket
OGFG = Pile Previously Repaired with White Octagonal Fiberglass Jacket and Grout Fill
bot. = bottom
abv. = above
ML = Mudline
PC = Bottom of Pile Cap
blw = Below
L = Left (looking inboard)
R = Right (looking inboard)
O = Outboard
I = Inboard
LI = Left Inboard Face
LO = Right Inboard Face
RI = Right Outboard Face
LI = Left Outboard Face
VCR = Vertical Crack
DCR = Diagonal Crack
HCR = Horizontal Crack
CCS = Closed Corrosion Spall
OCS = Open Corrosion Spall
L2 = Level II Close Pile Inspection with cleaning of marine growth
F = Firm Concrete based on L2 Pick Test
M = Medium Concrete based on L2 Pick Test
S = Soft Concrete based on L2 Pick Test
MSL = Mean Sea Level
EL = Elevation in MLLW datum

Hermosa Beach Pier - 2024

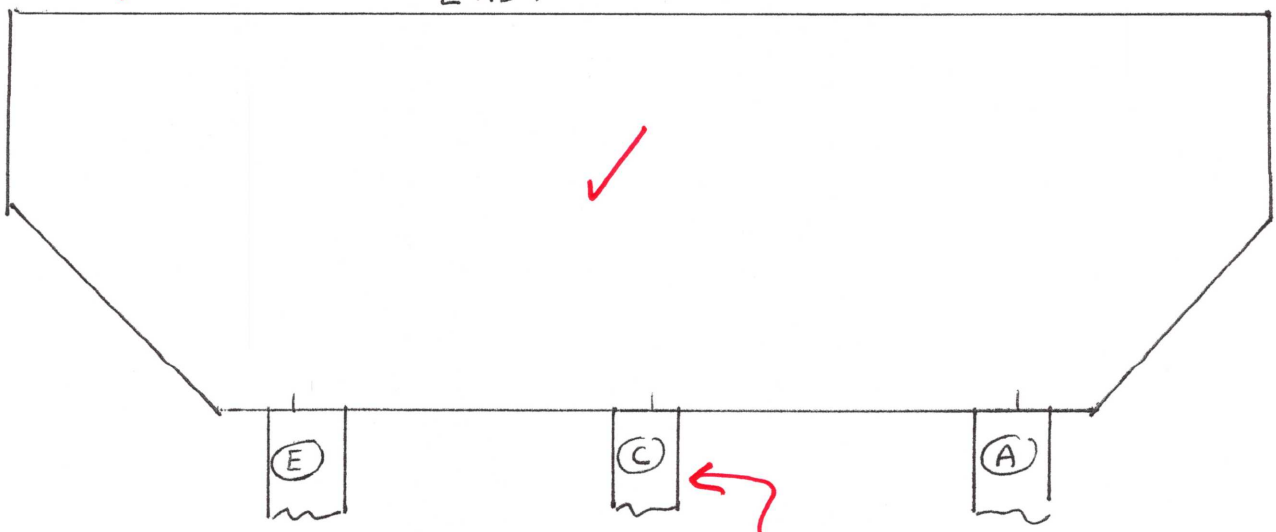
Pile Cap - 3 Pile Bent

10/17/2024

Bent 1

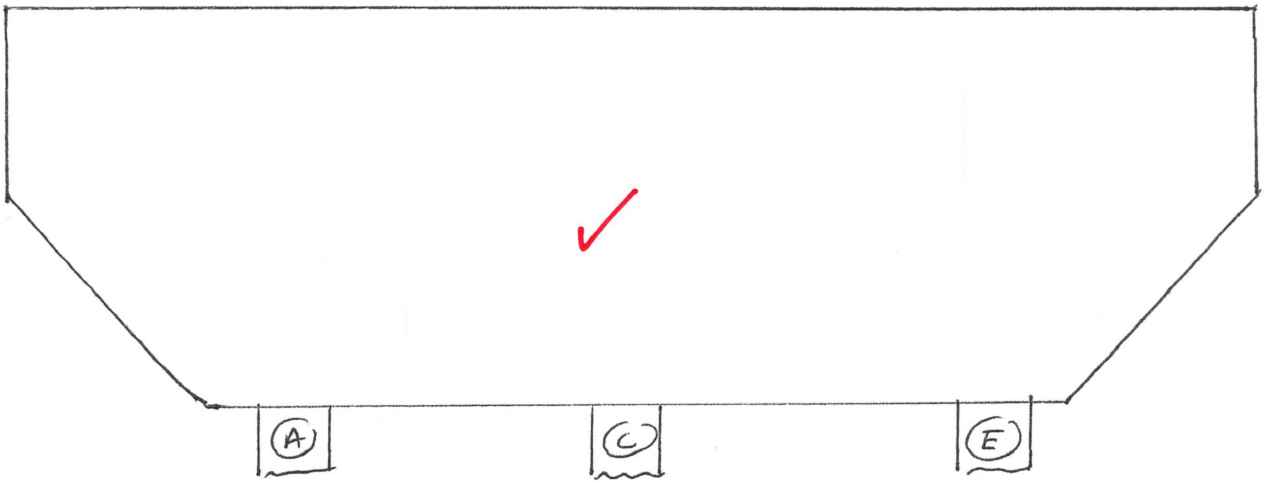
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East Face

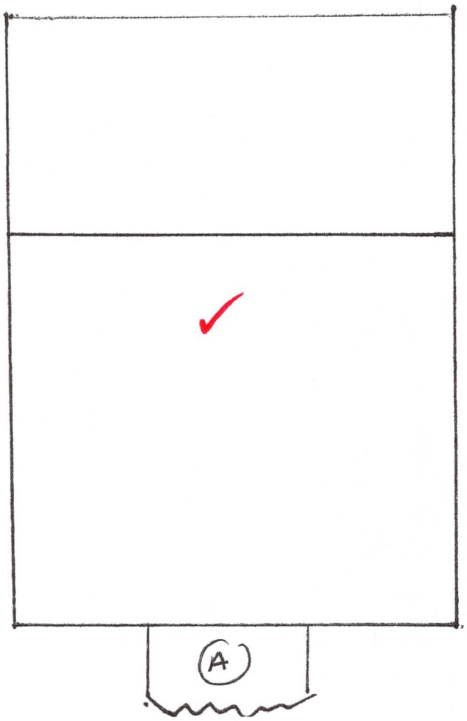


Octagonal Fiberglass Pile Wrap - OK! (Typ.)

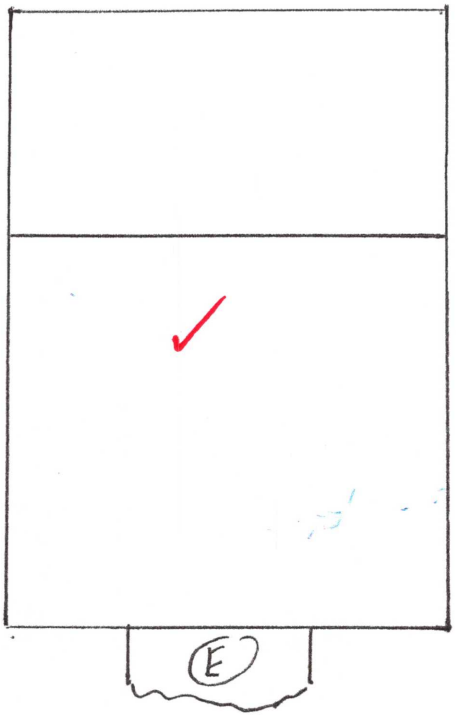
West Face



North End



South End



Hermosa Beach Pier - 2024

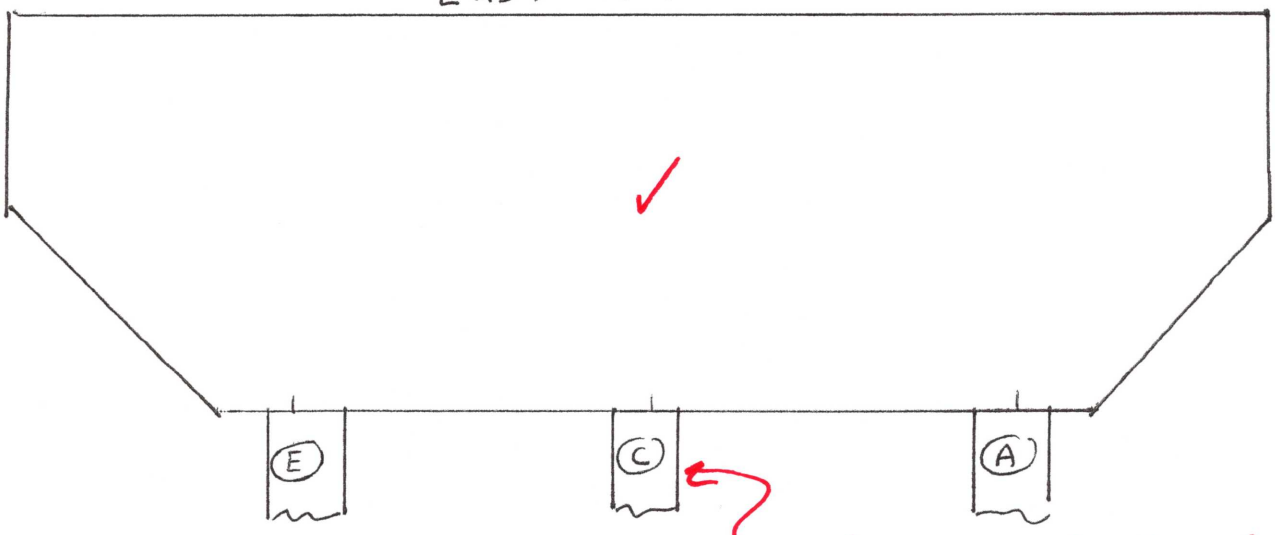
Pile Cap - 3 Pile Bent

10/17/2024

Bent 2

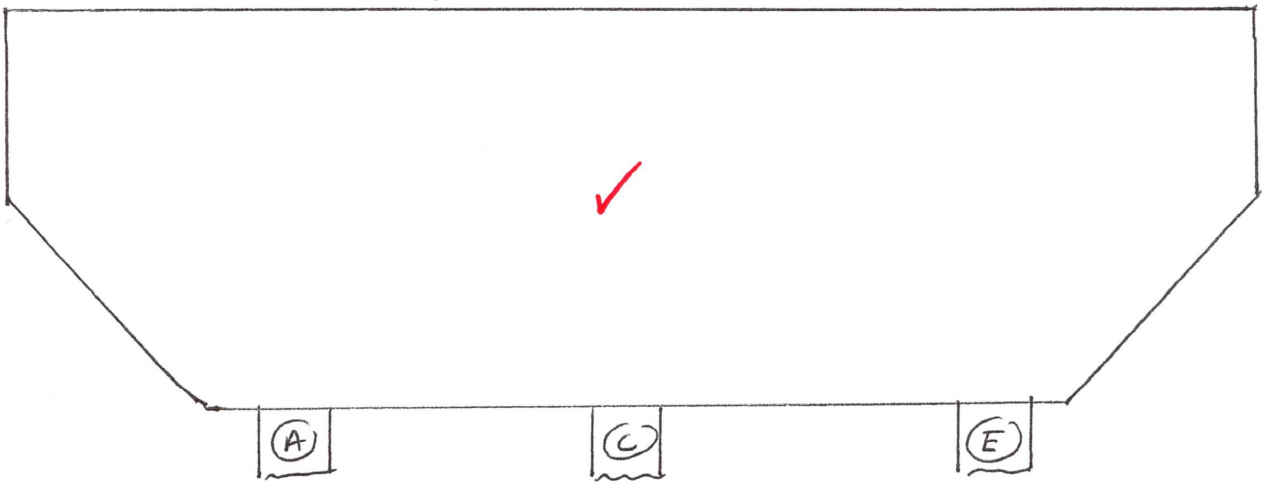
ESN Engineering, PLLC

East Face

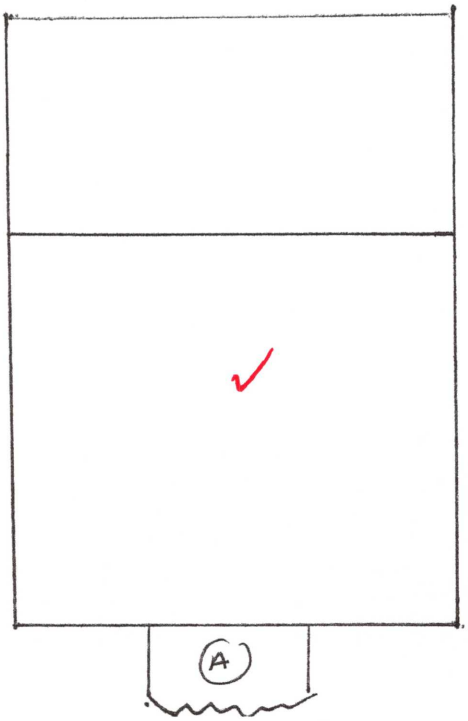


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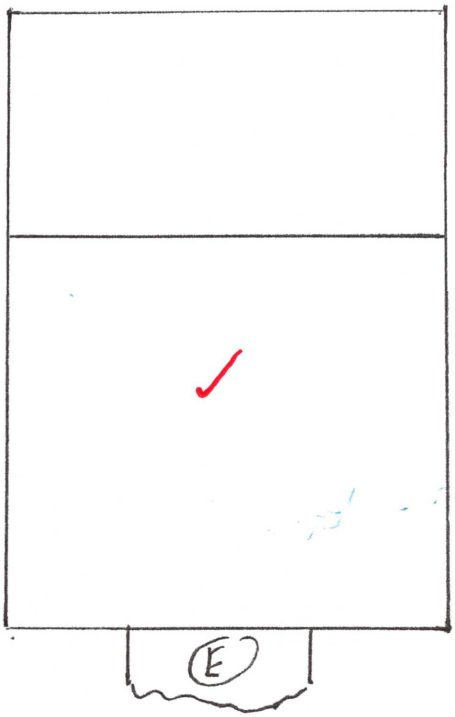
West Face



North End



South End



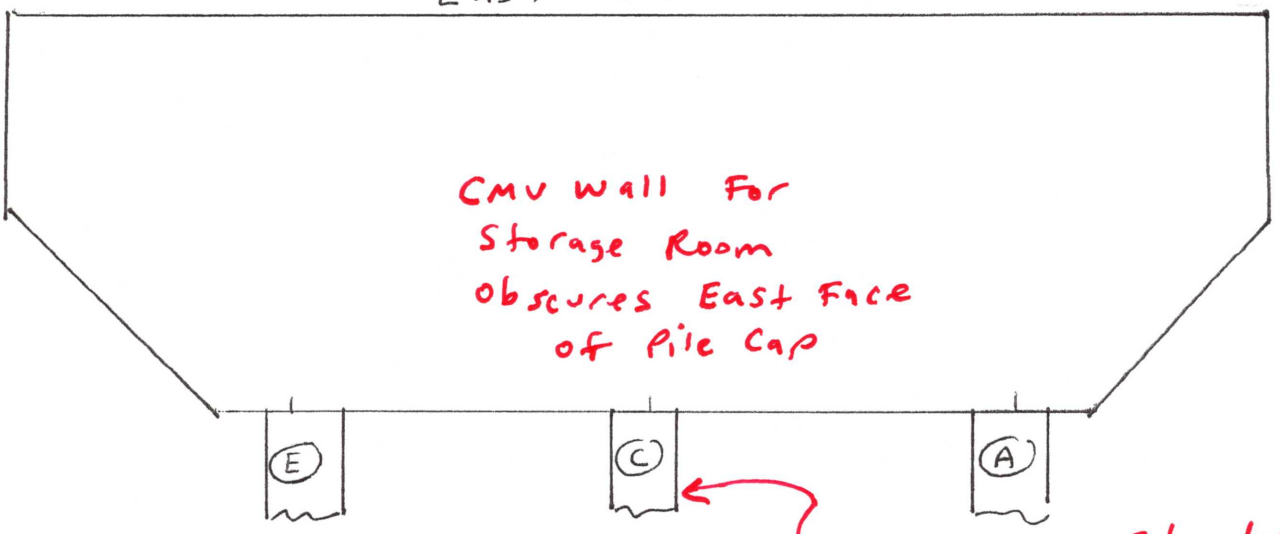
10/15/2024

Pile Cap – 3 Pile Bent

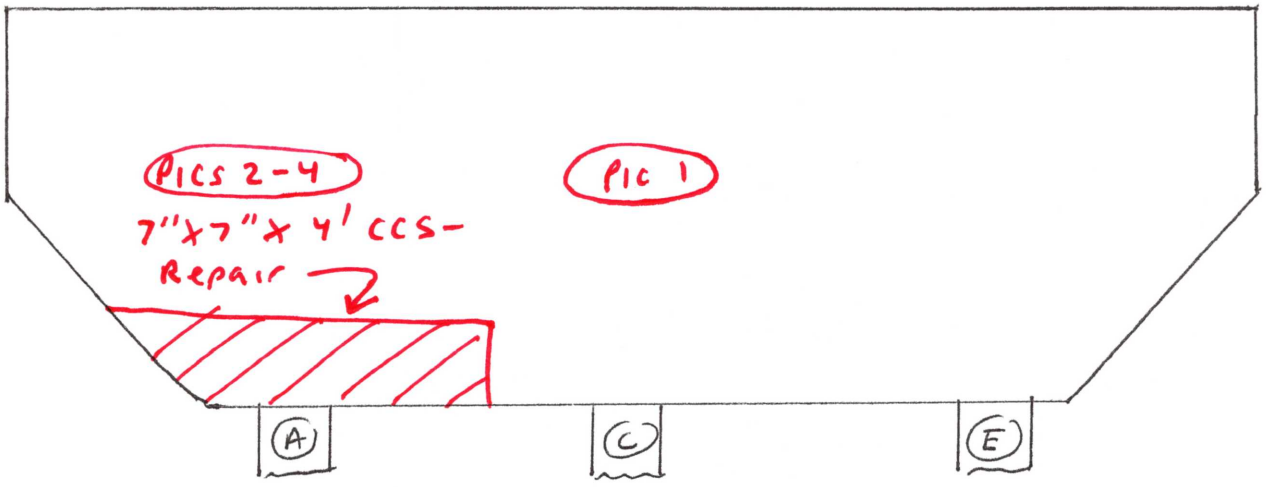
Bent 3

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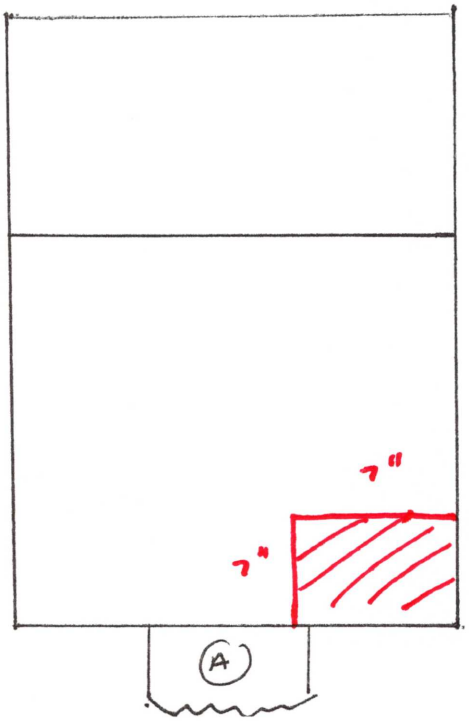
East Face



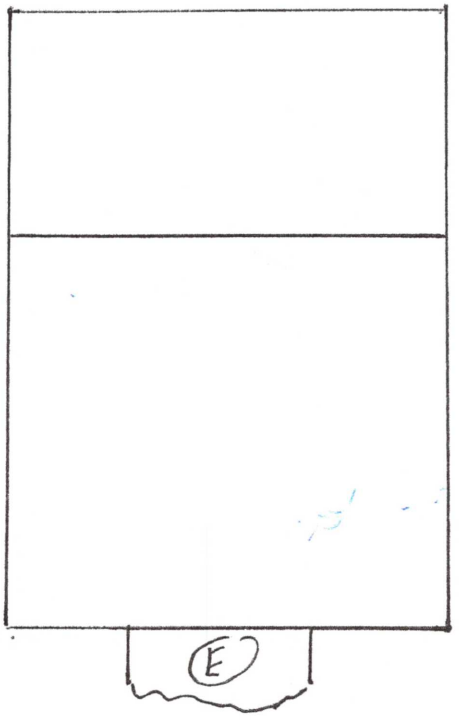
West Face



North End



South End



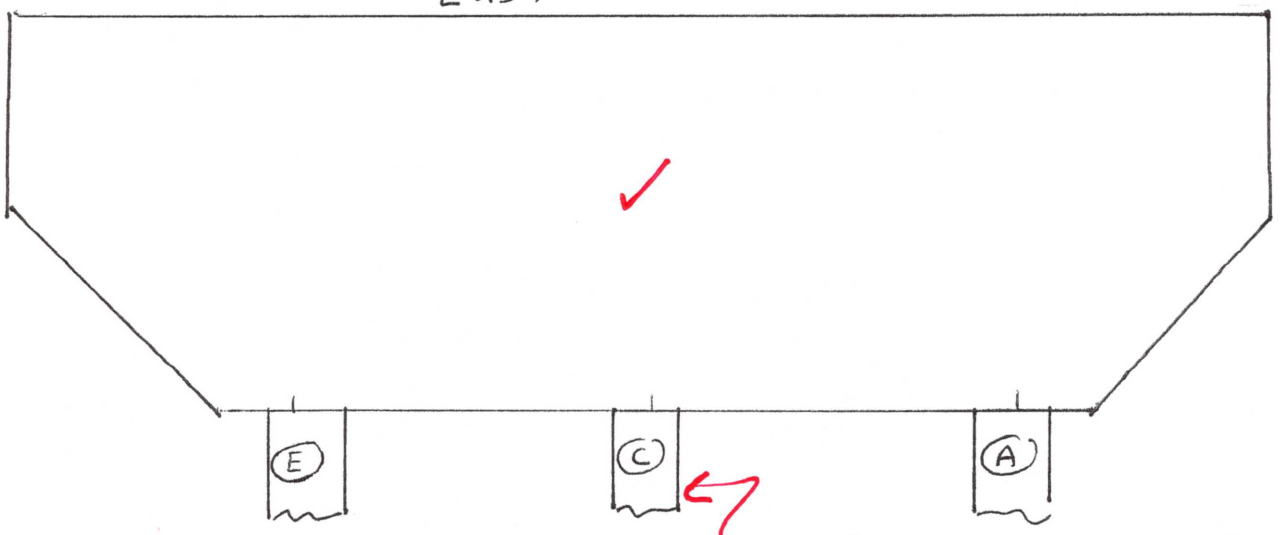
Pile Cap - 3 Pile Bent

10/15/2024

Bent 4

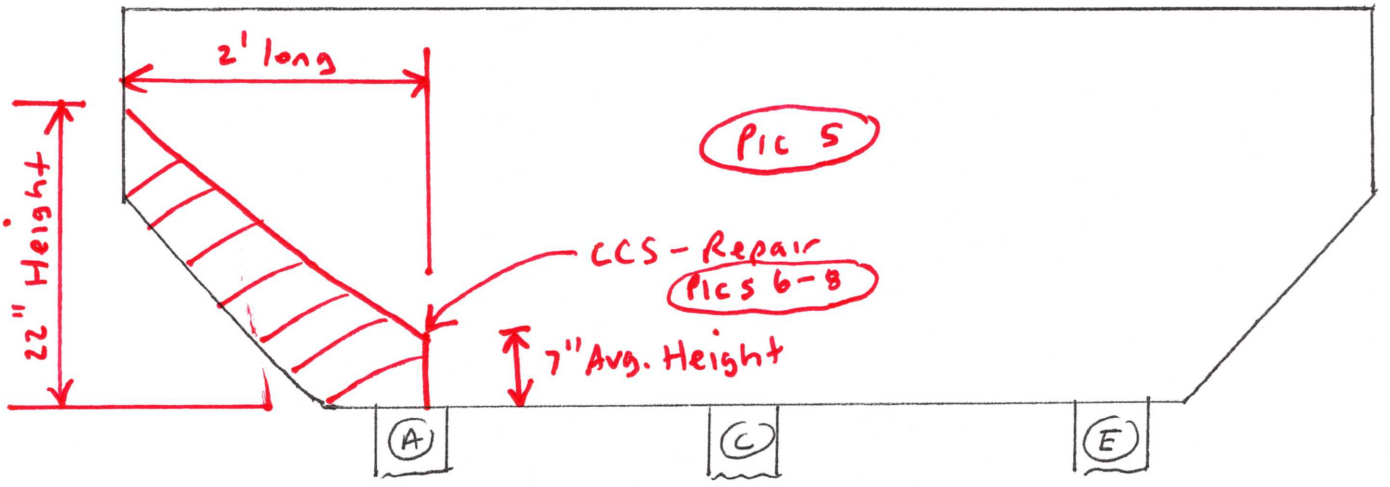
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East Face

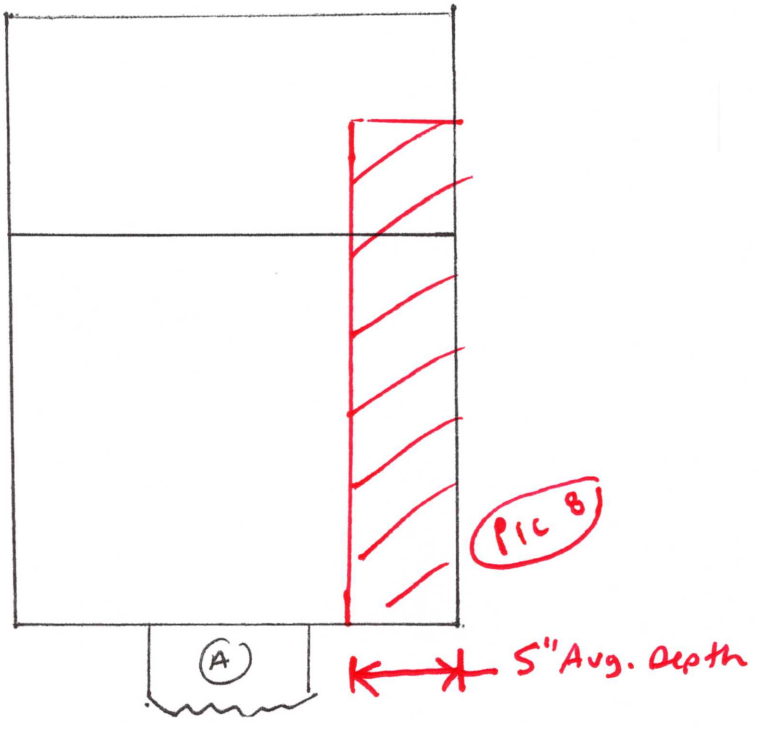


Octagonal Fiberglass Pile Wrap - ok! (Typ.)

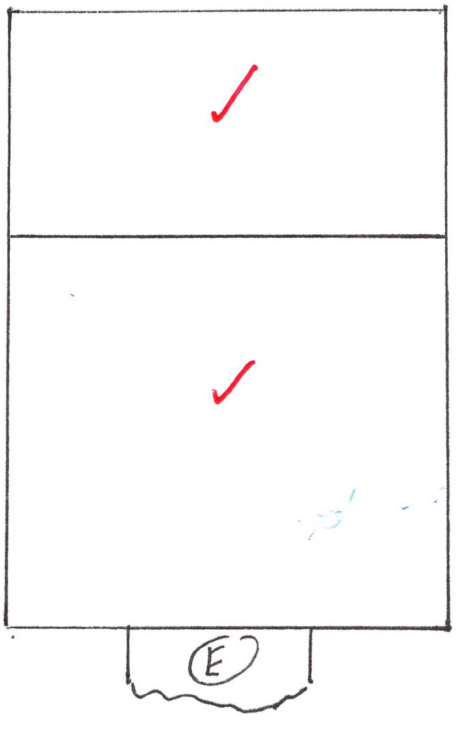
West Face



North End



South End

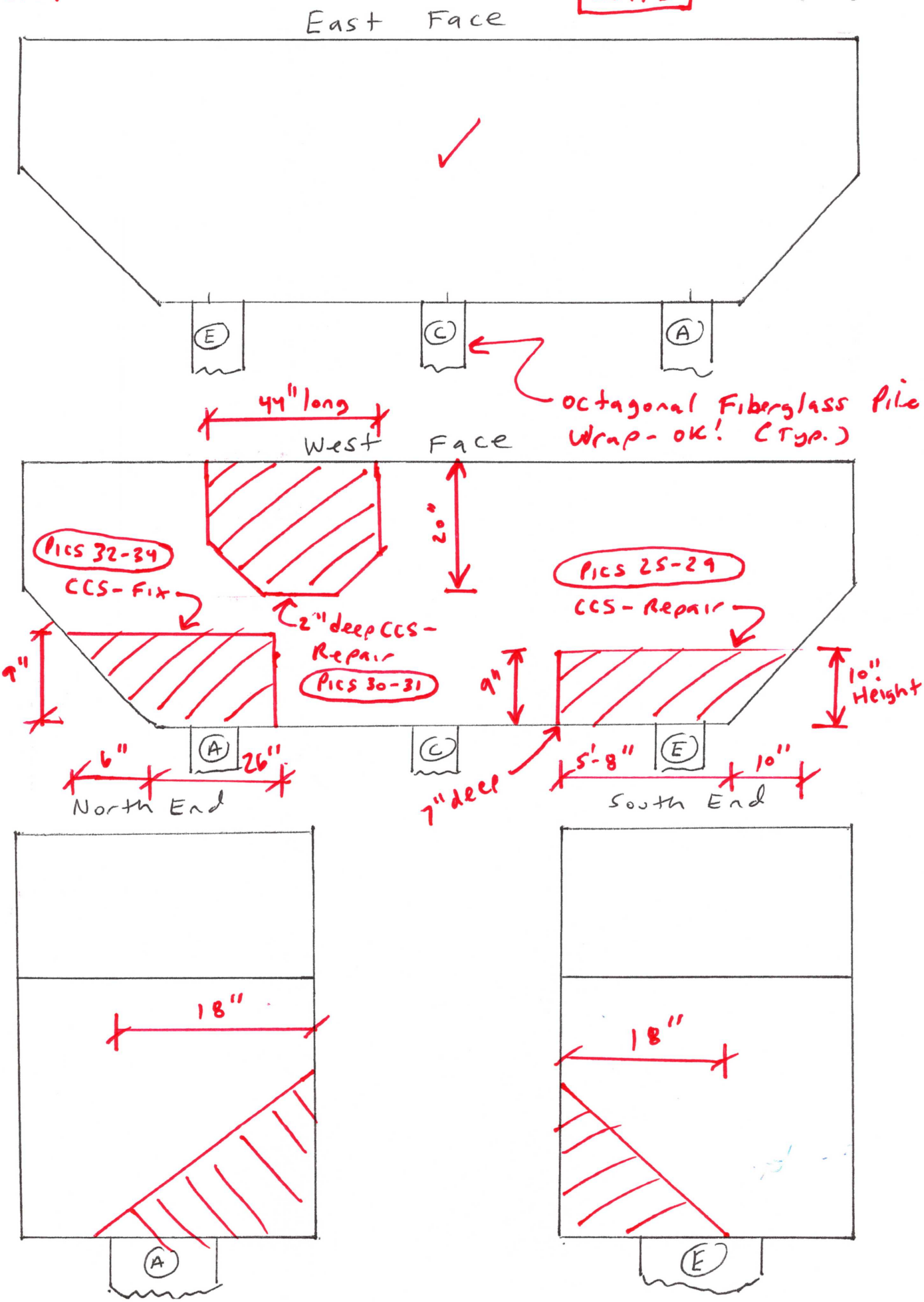


Pile Cap – 3 Pile Bent

10/15/2024

Bent 5

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Pile Cap – 3 Pile Bent

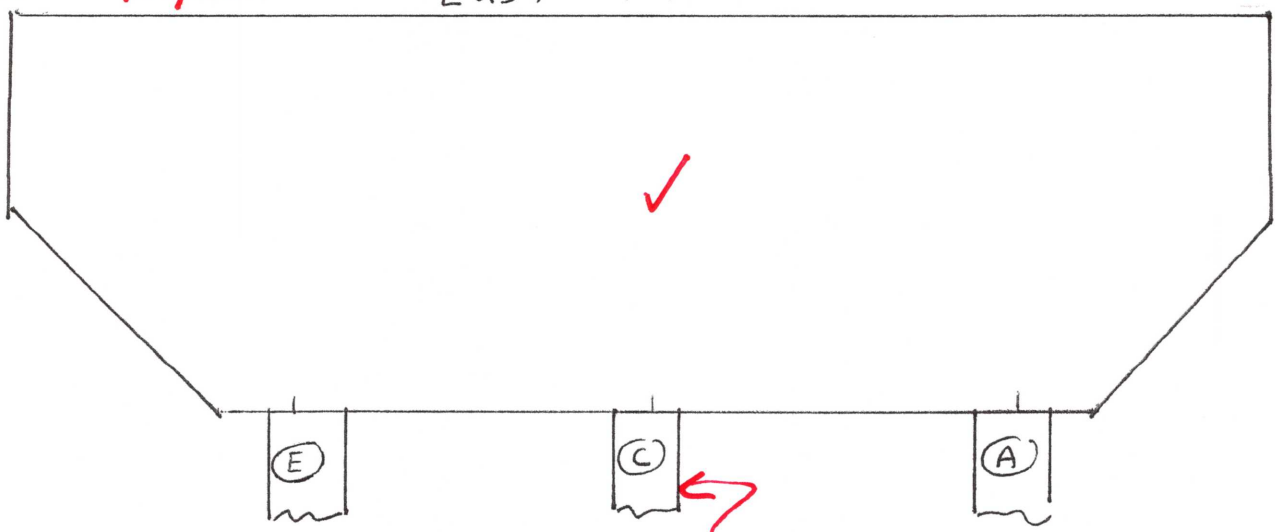
10/15/2024

East Face – 10/17/2024

Bent 6

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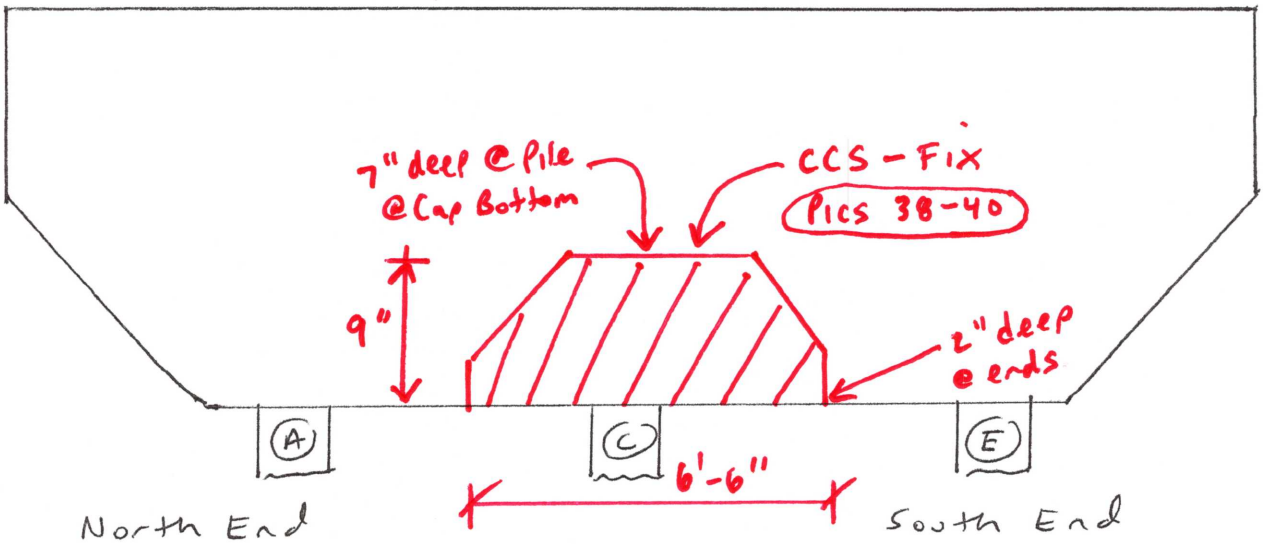
East Face



✓

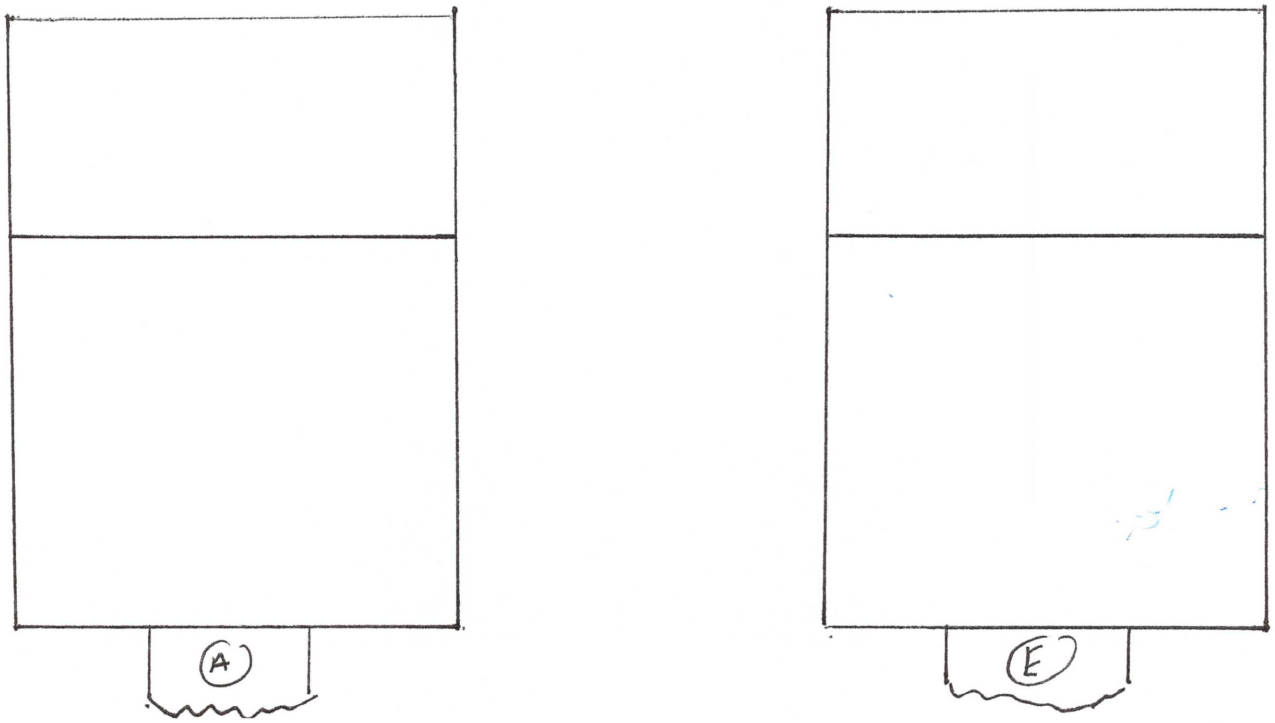
Octagonal Fiberglass Pile Wrap – OK! (Typ.)

West Face



North End

South End



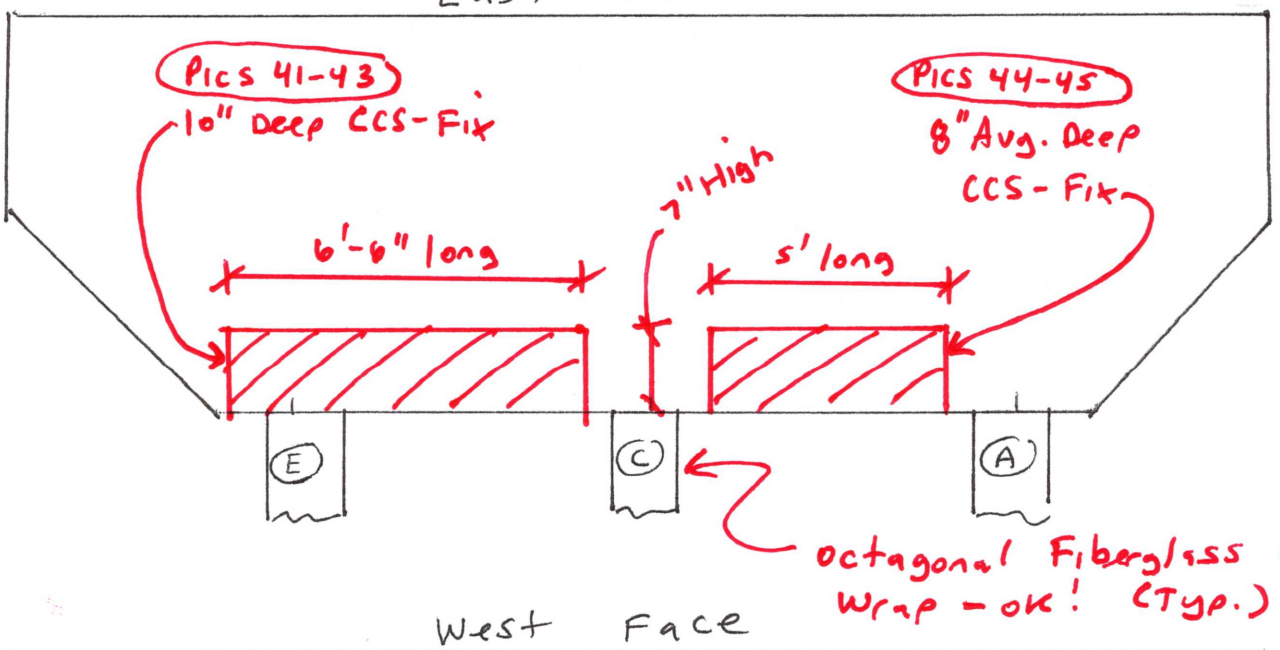
Pile Cap – 3 Pile Bent

10/15/2024

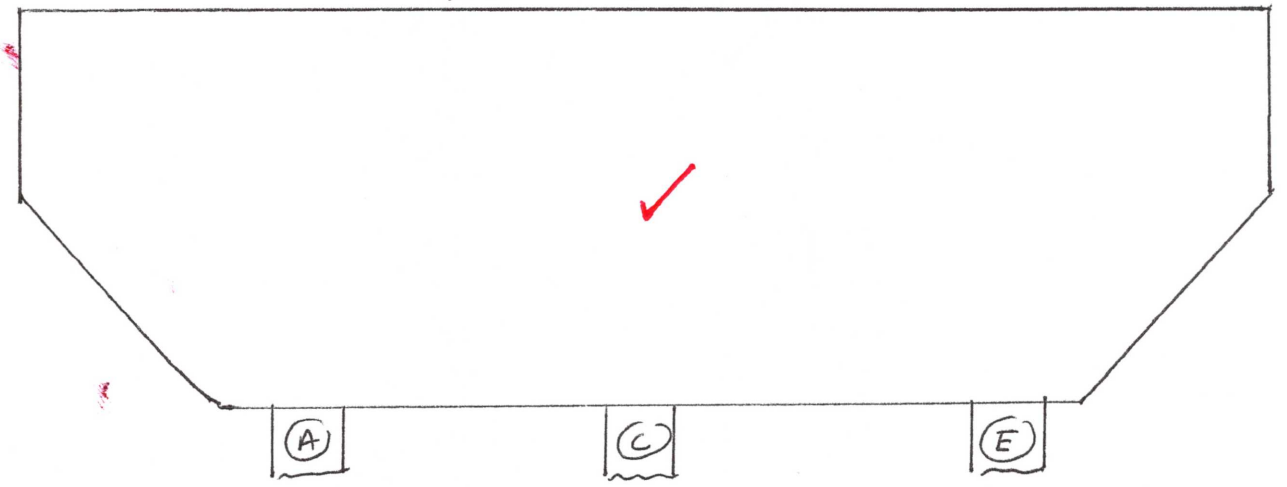
Bent 7

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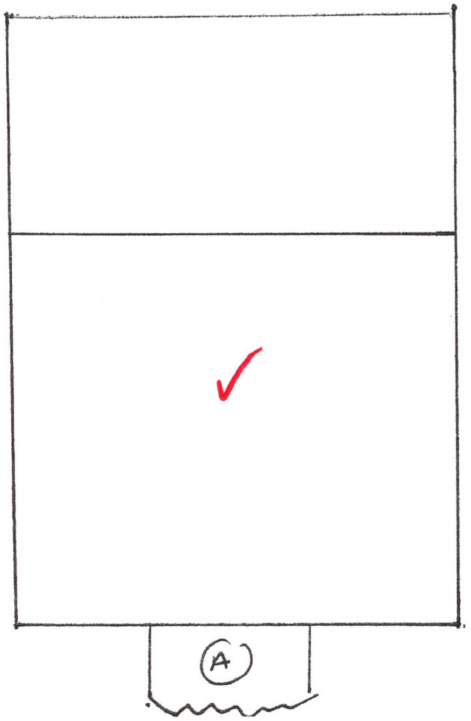
East Face



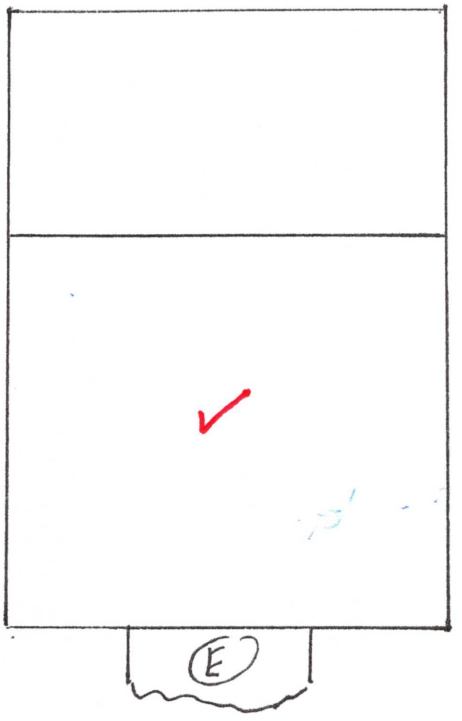
West Face



North End



South End



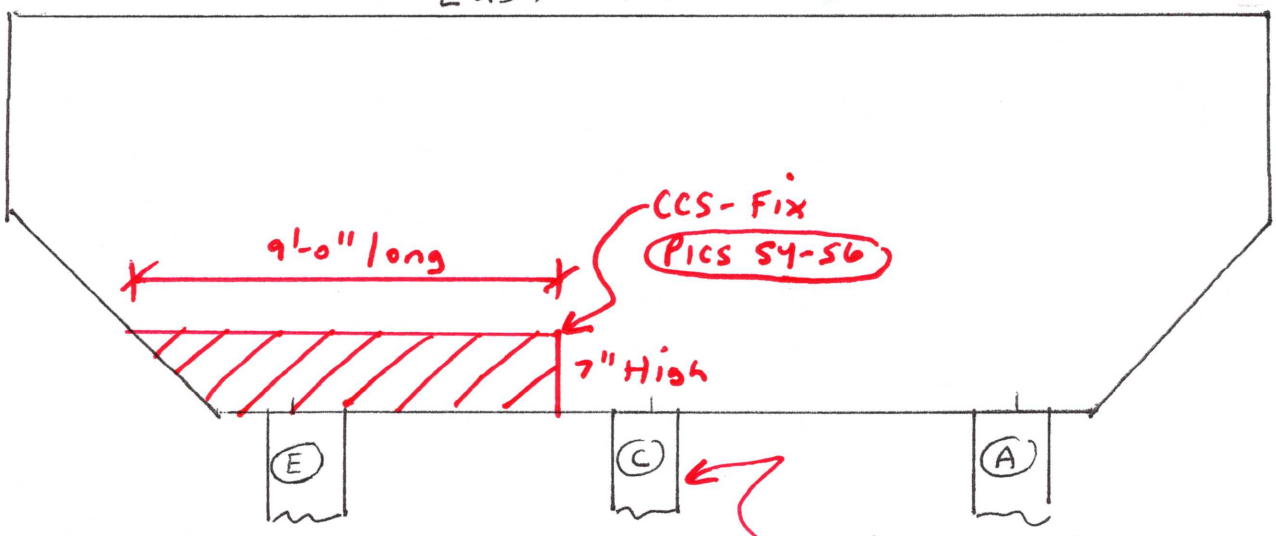
Pile Cap – 3 Pile Bent

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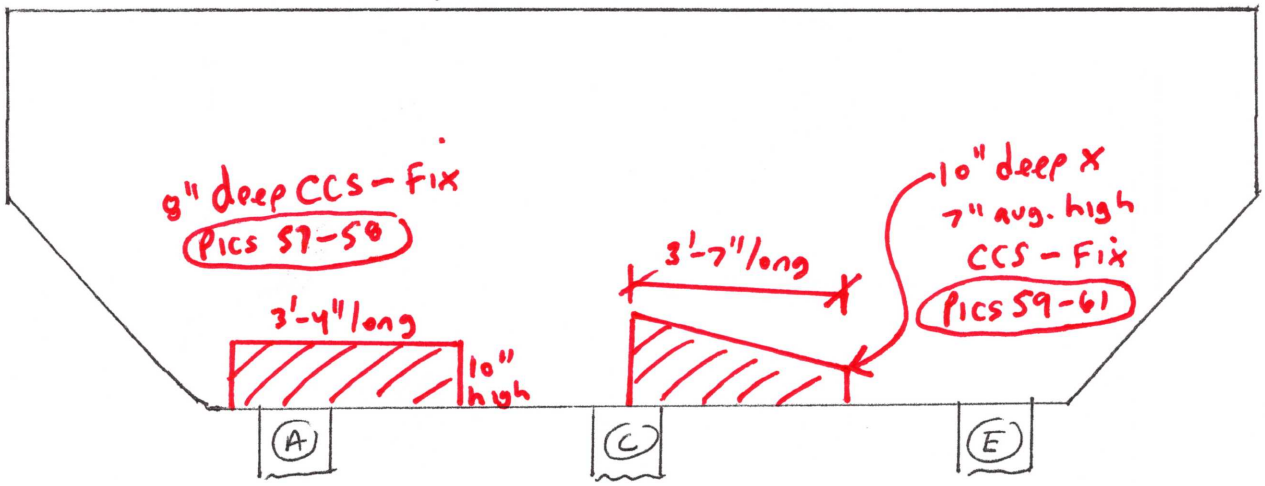
10/15/2024

Bent 8

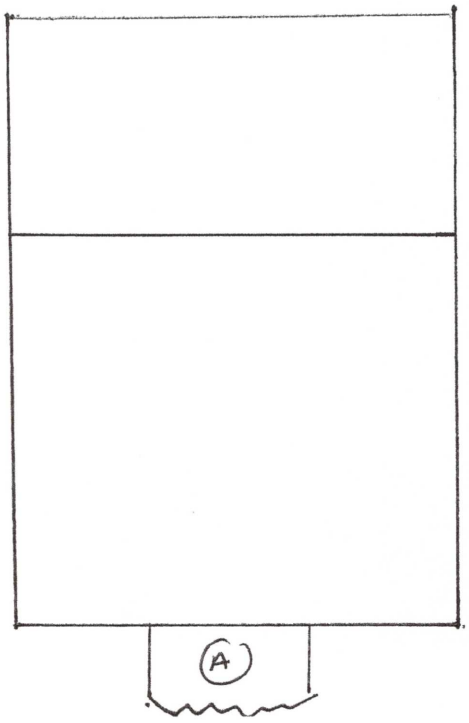
East Face



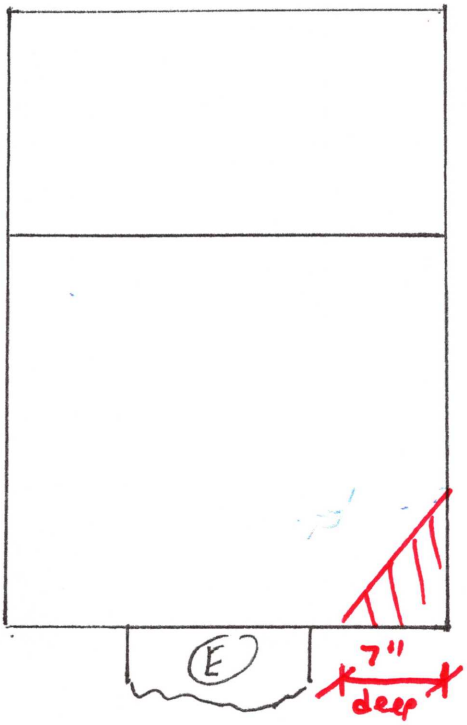
West Face



North End



South End



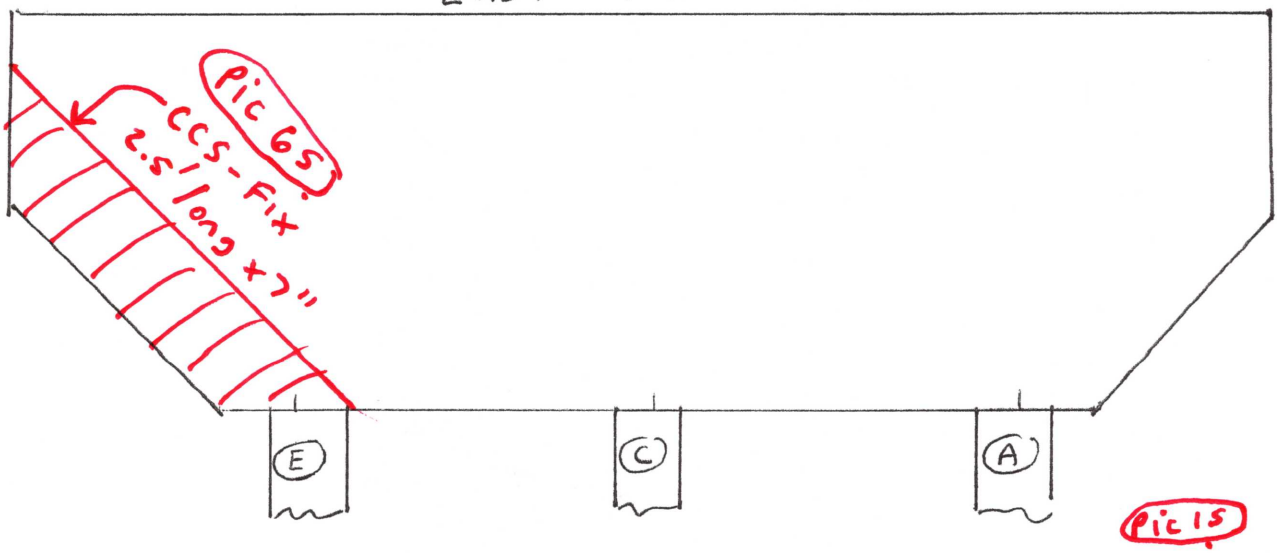
Hermosa Beach Pile Cap – 3 Pile Bent
Pier – 2024

ESN Engineering, PLLC

10/15/2024

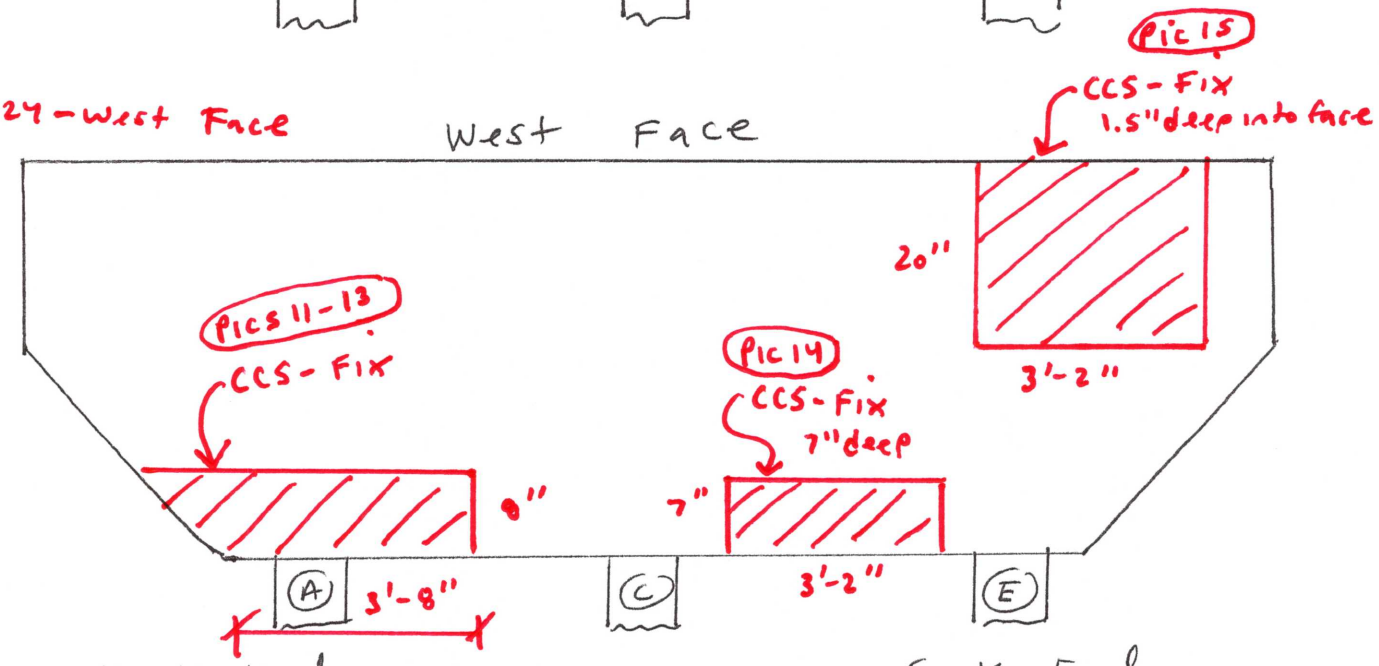
Bent 9

East Face

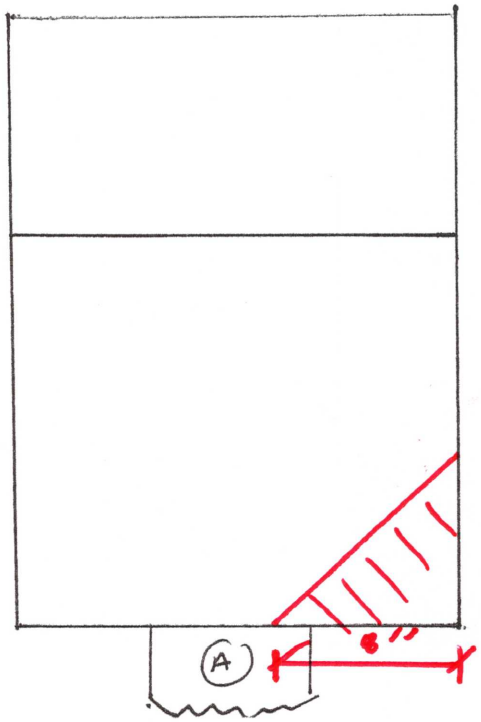


10/16/2024 – West Face

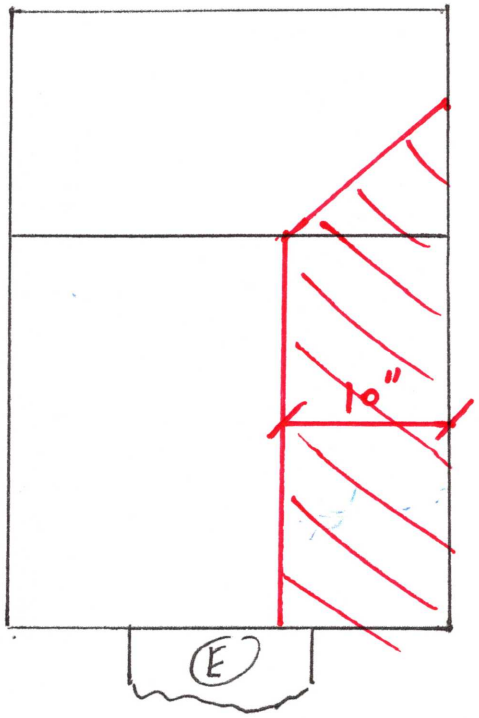
West Face



North End



South End



Hermosa Beach Pier - 2024

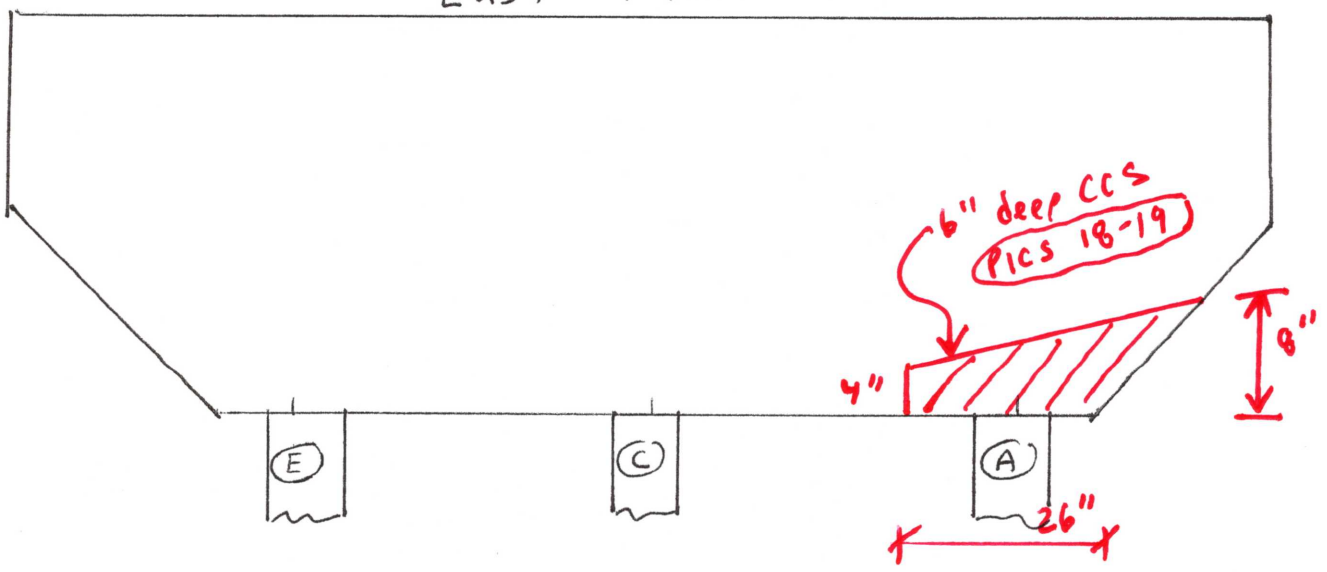
10/16/2024

Pile Cap - 3 Pile Bent

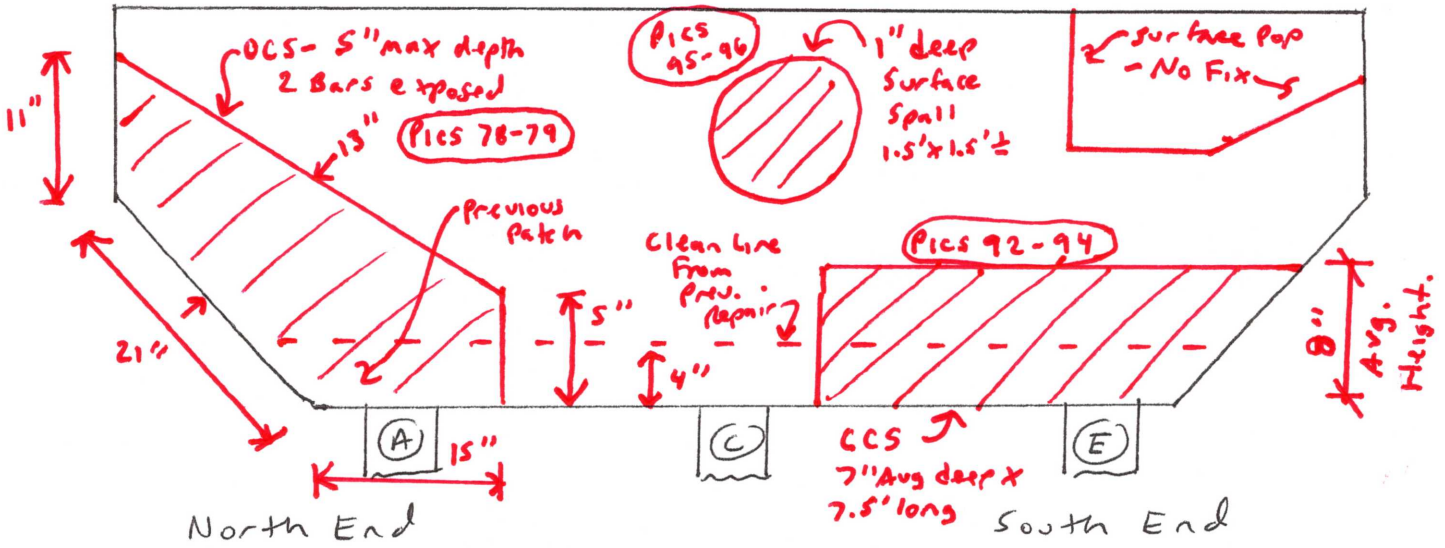
Bent 10

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East Face

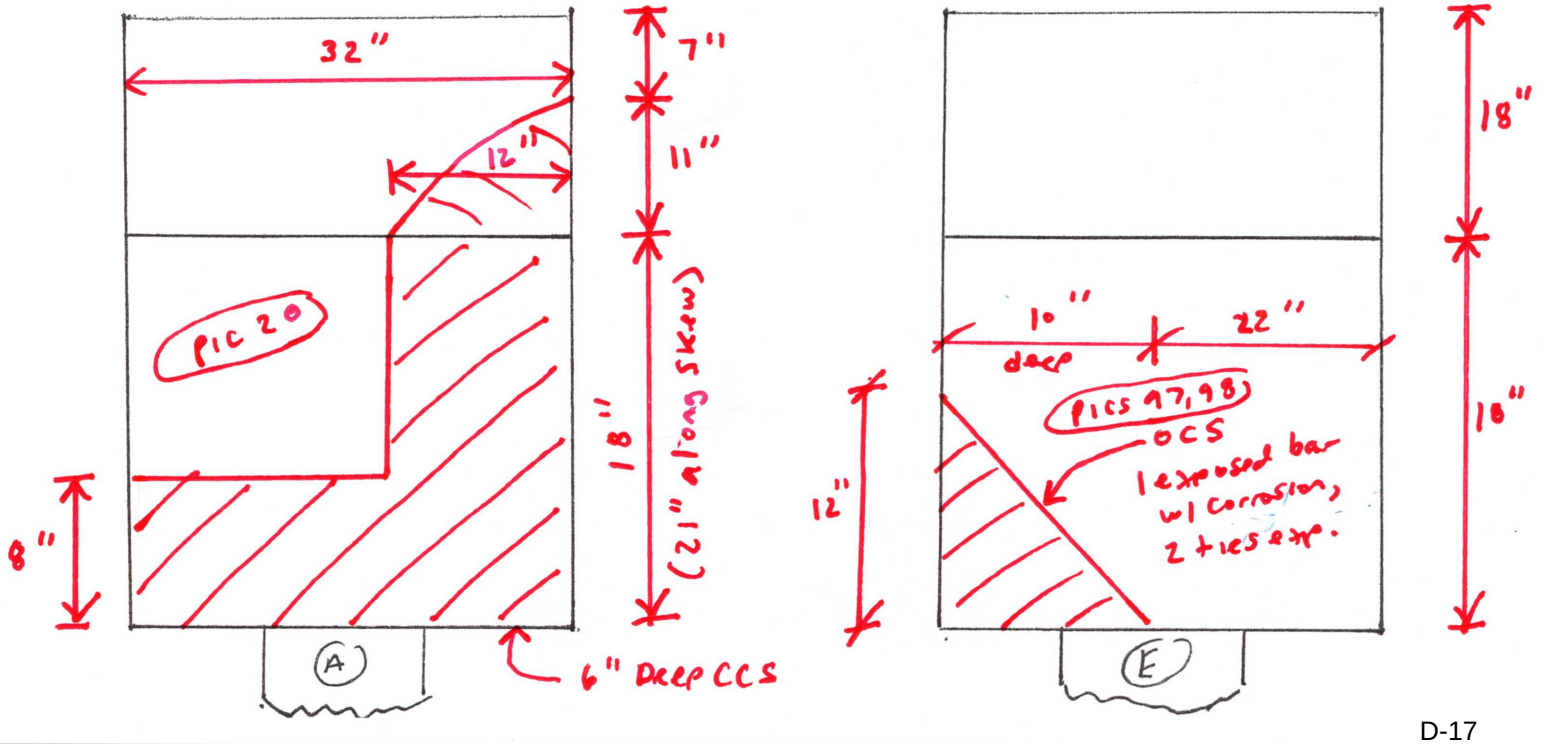


West Face



North End

South End



Hermosa Beach Pier - 2024

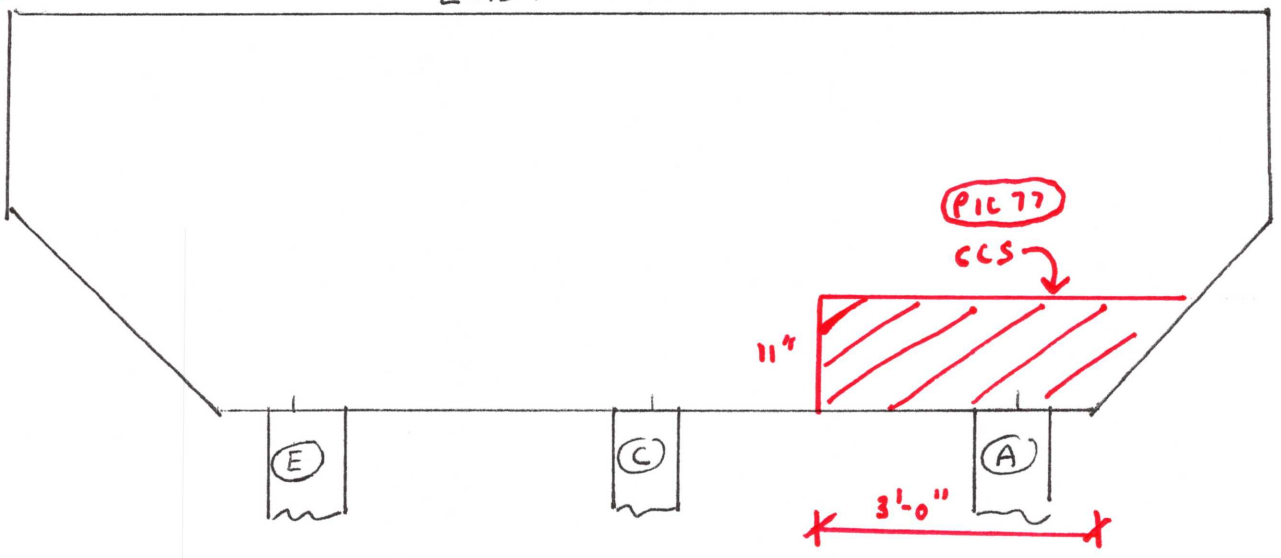
Pile Cap - 3 Pile Bent

Bent 11

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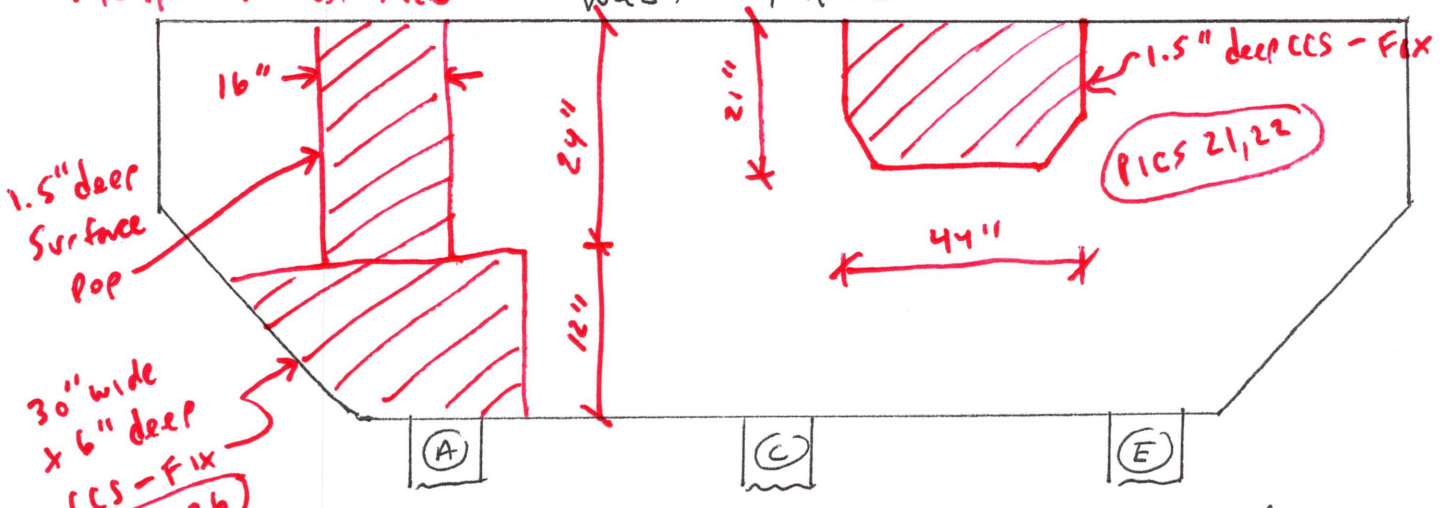
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East Face

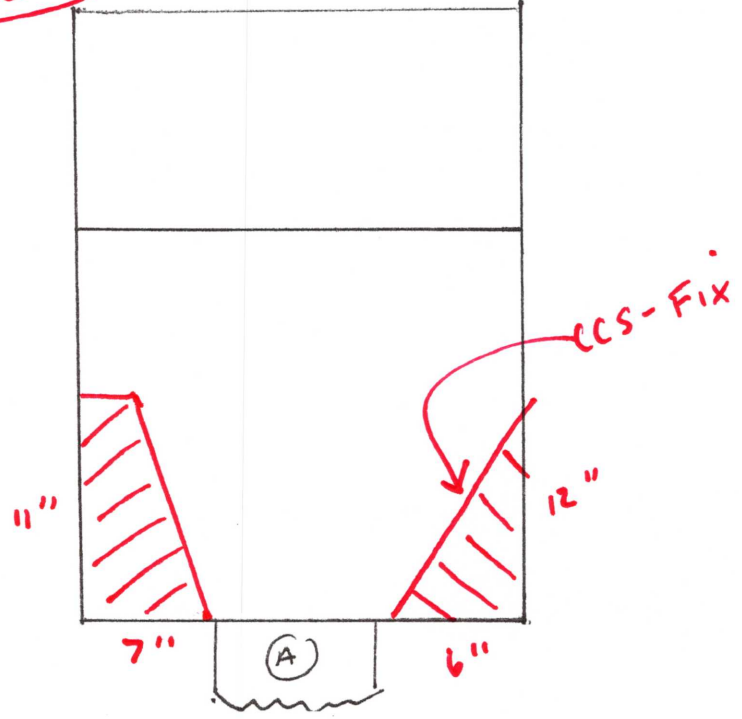


10/29/2024 West Face

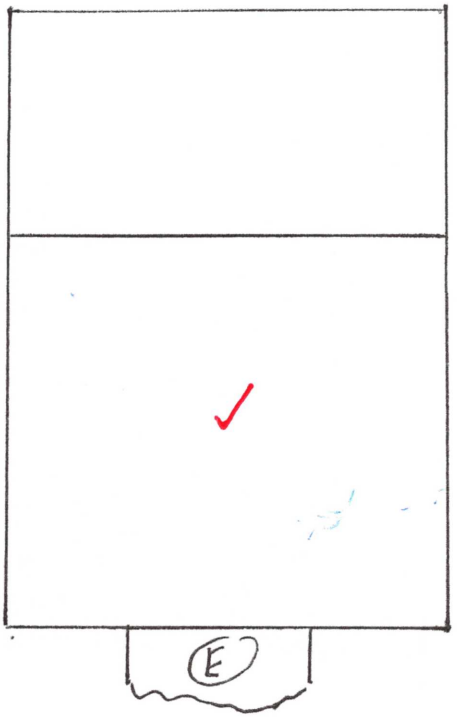
West Face



North End



South End



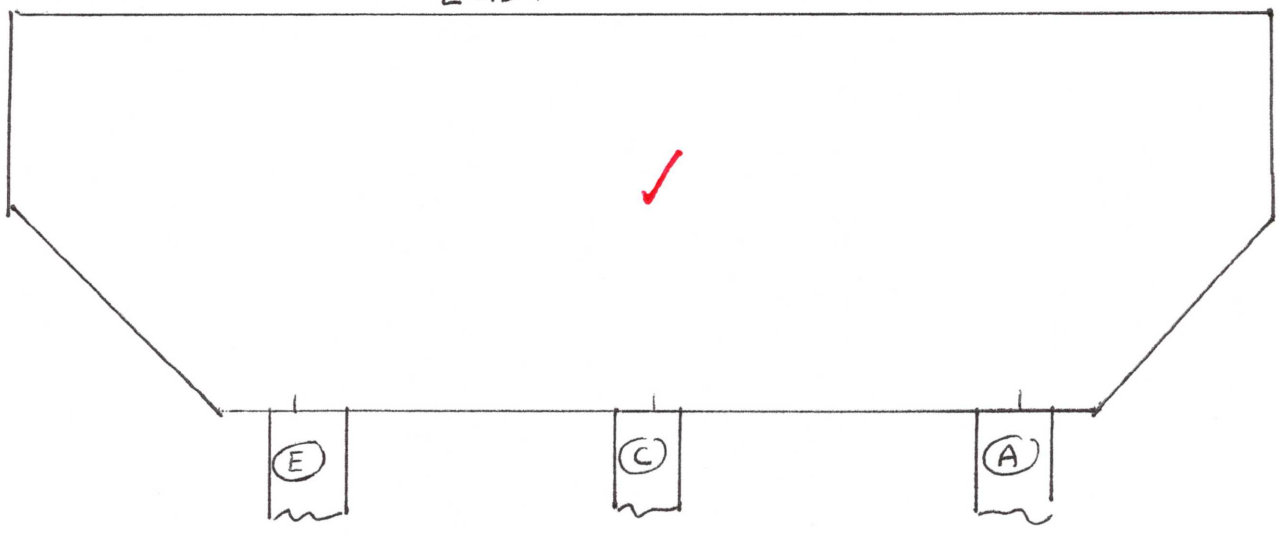
Hermosa Beach Pile Cap – 3 Pile Bent
Pier – 2024

10/29/2024

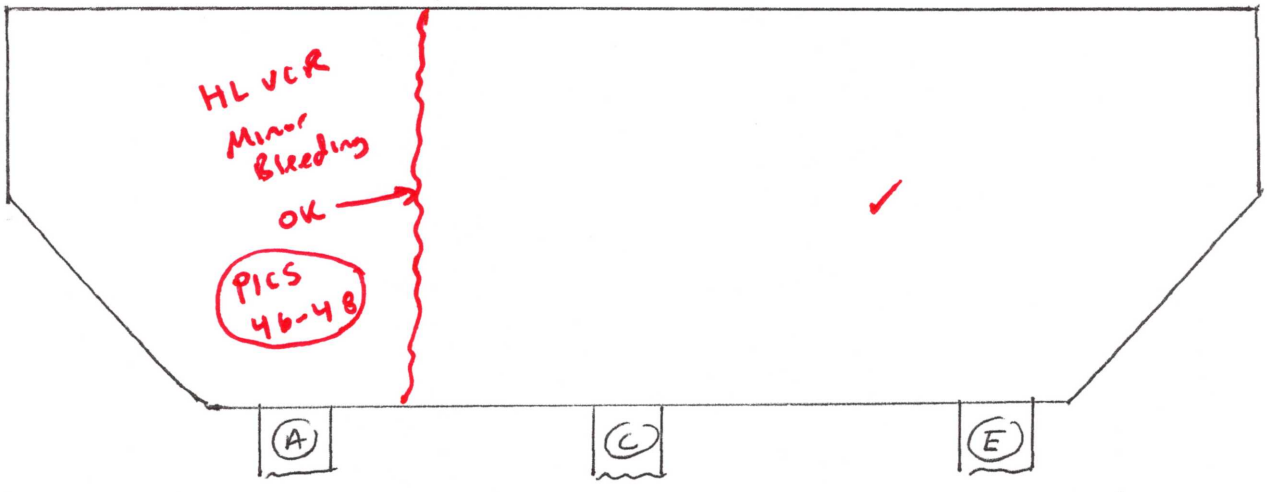
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Bent 12

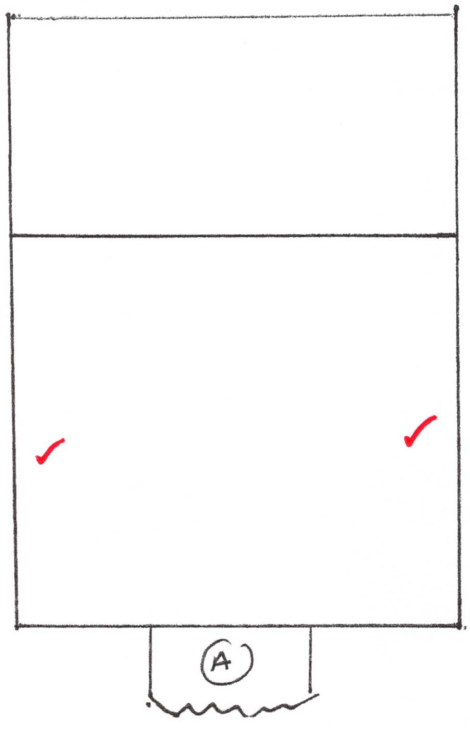
East Face



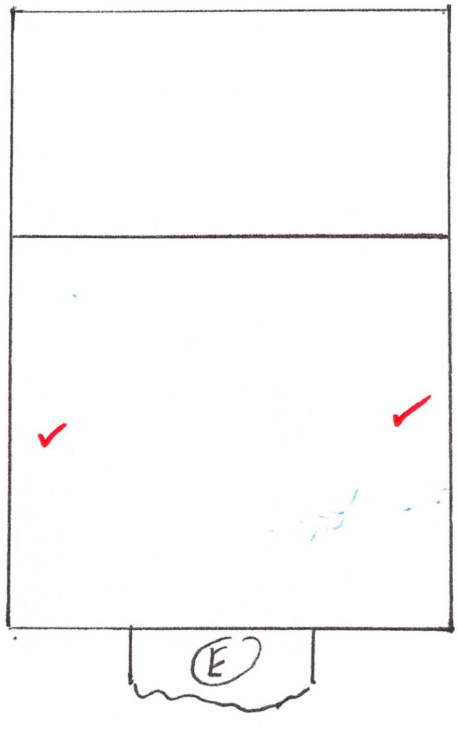
West Face



North End



South End

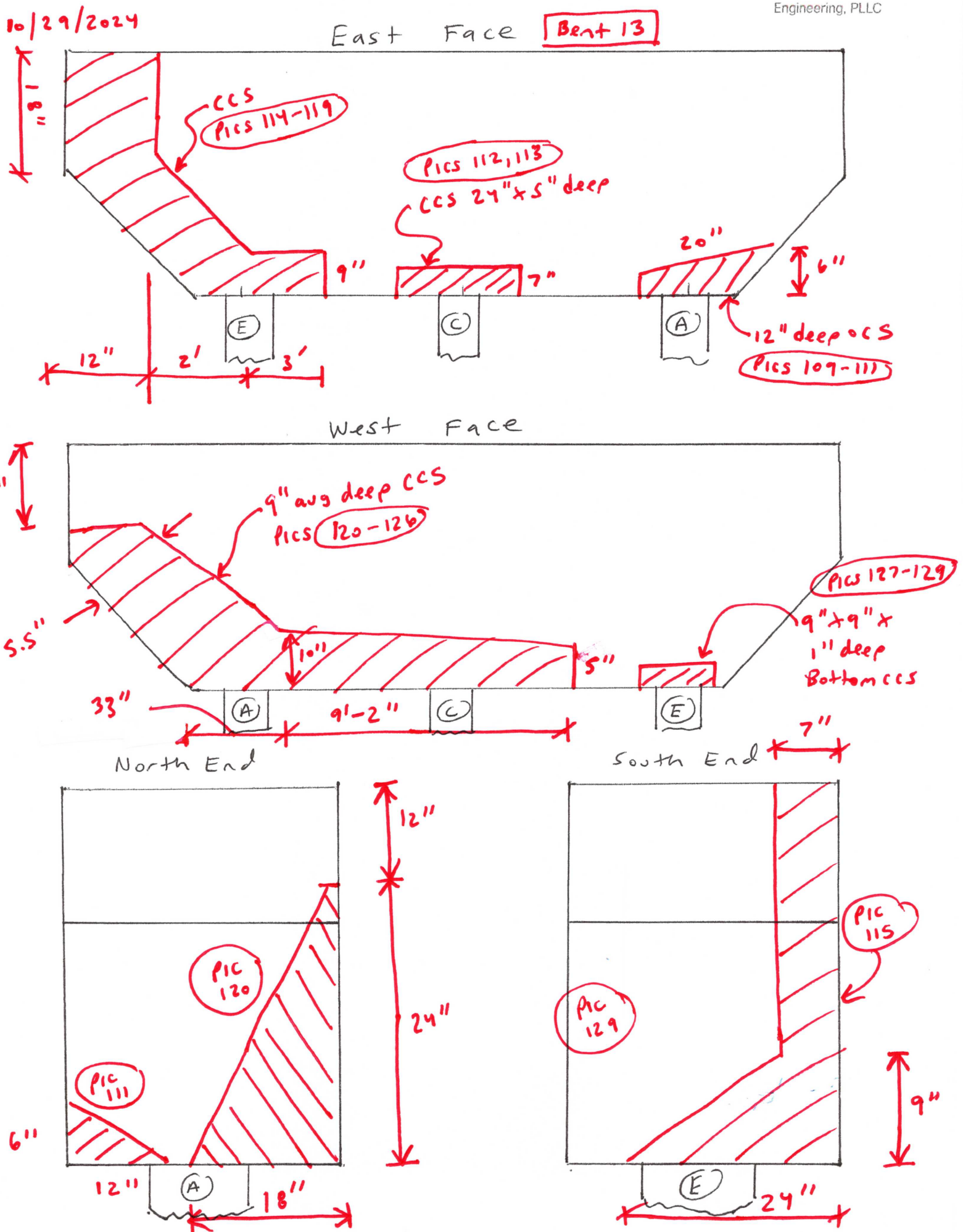


Hermosa Beach Pier - 2024

Pile Cap - 3 Pile Bent

ESN Engineering, PLLC

10/29/2024



Hermosa Beach Pier - 2024

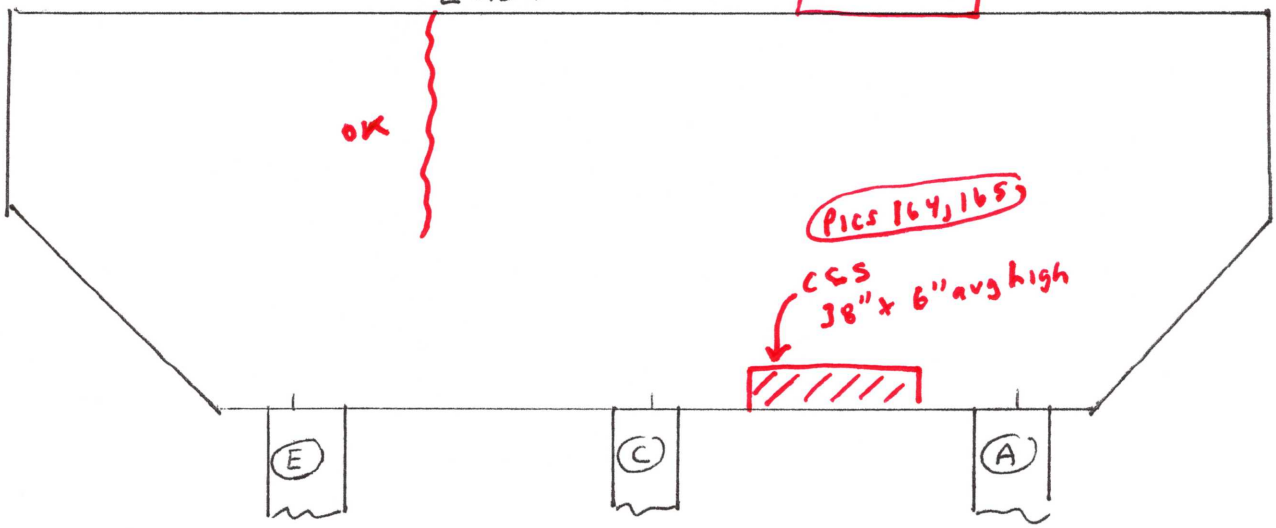
Pile Cap - 3 Pile Bent

ESN Engineering, PLLC

10/29/2024

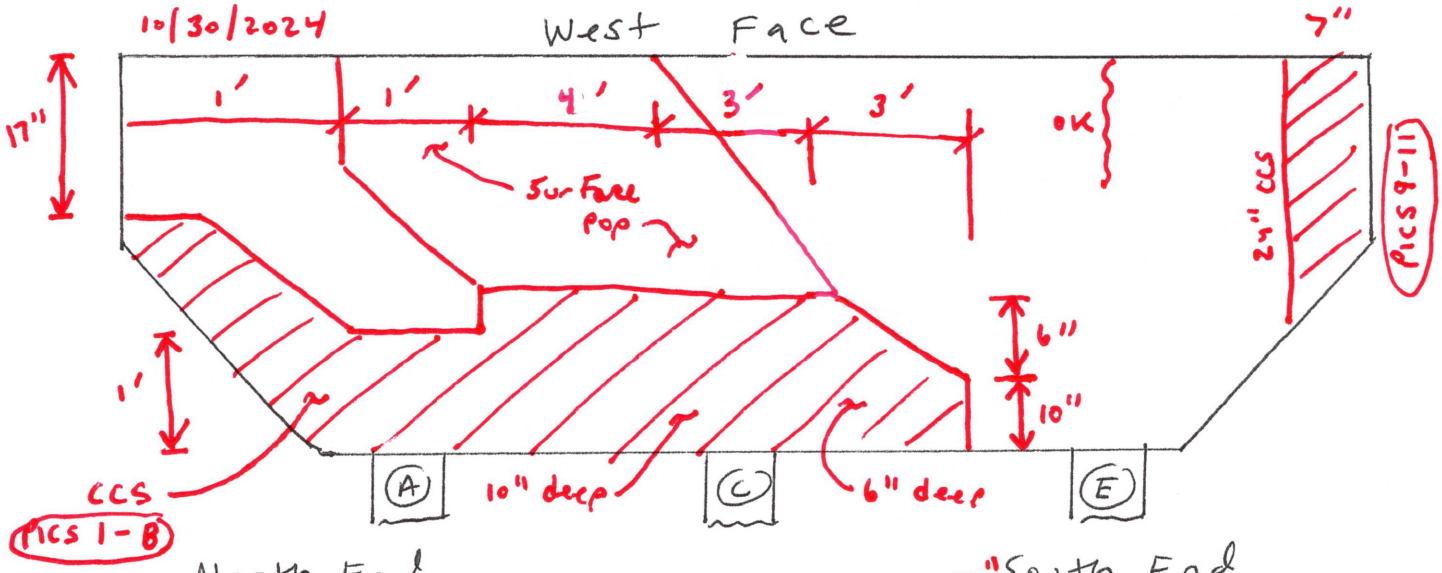
East Face

Bent 14

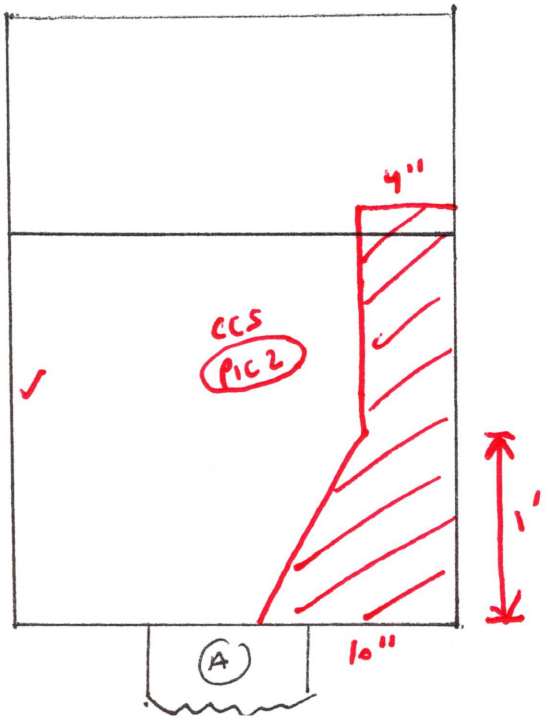


10/30/2024

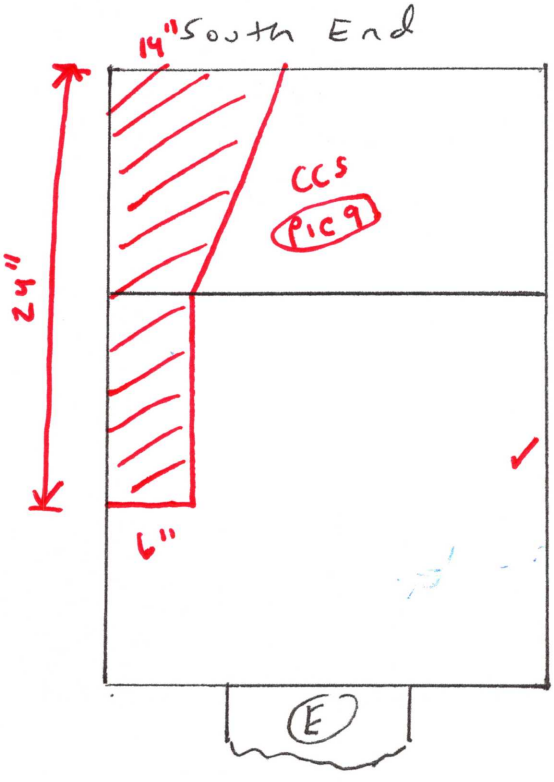
West Face



North End



South End



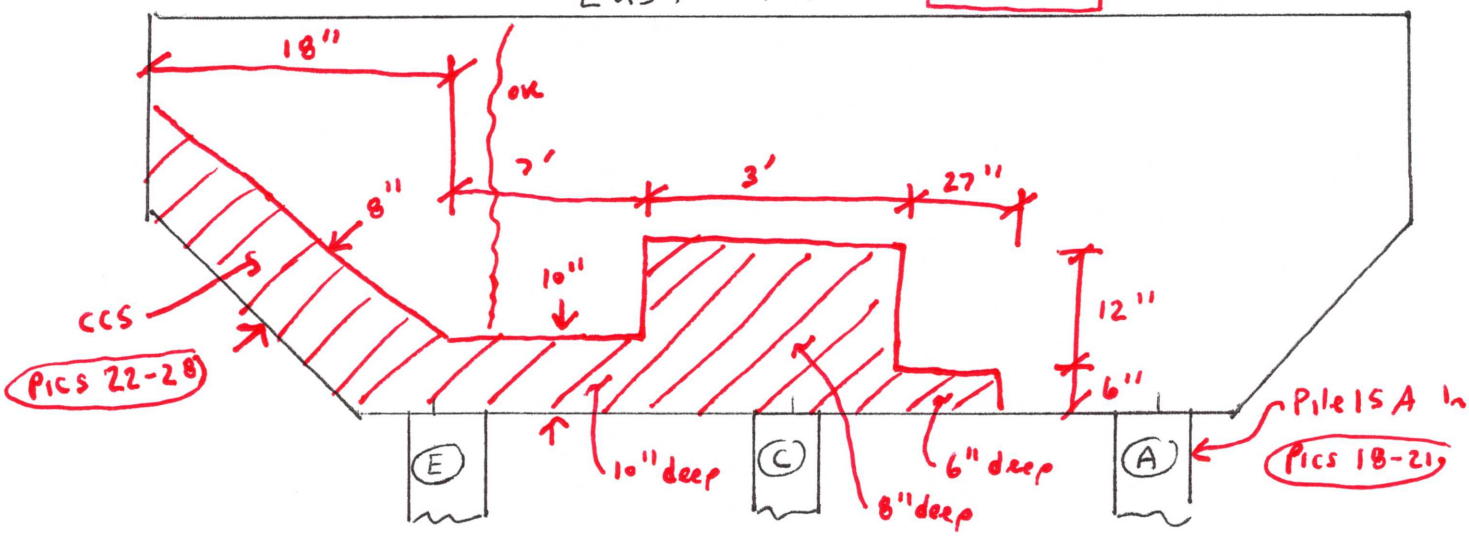
Hermosa Beach Pier - 2024

10/30/2024

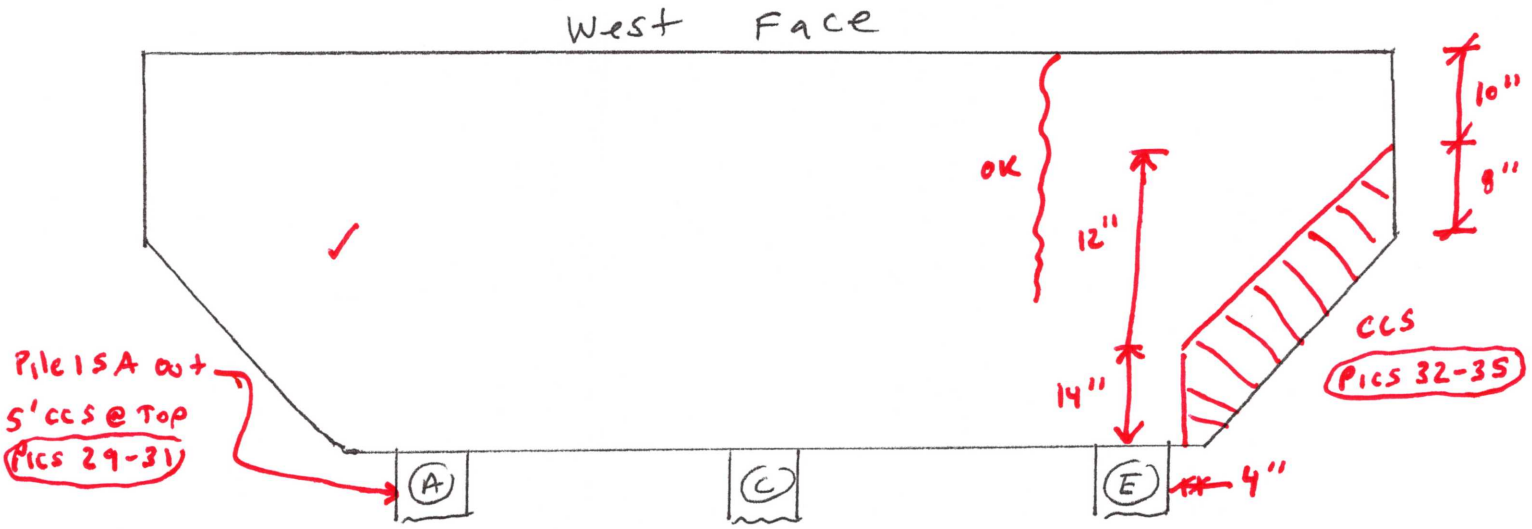
Pile Cap - 3 Pile Bent

ESN Engineering, PLLC

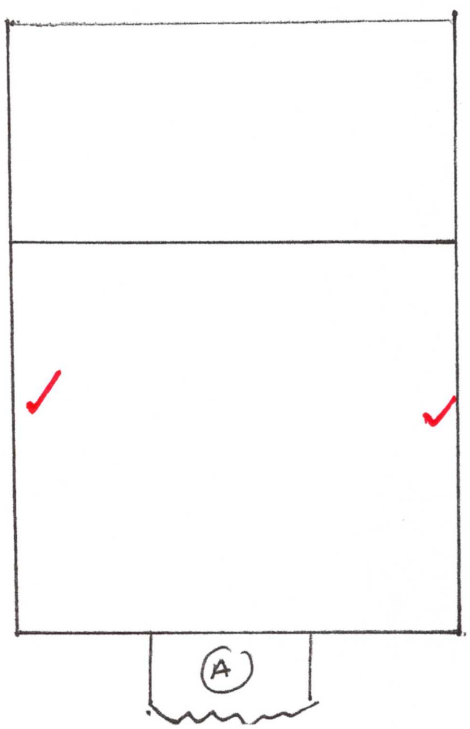
East Face Bent 15



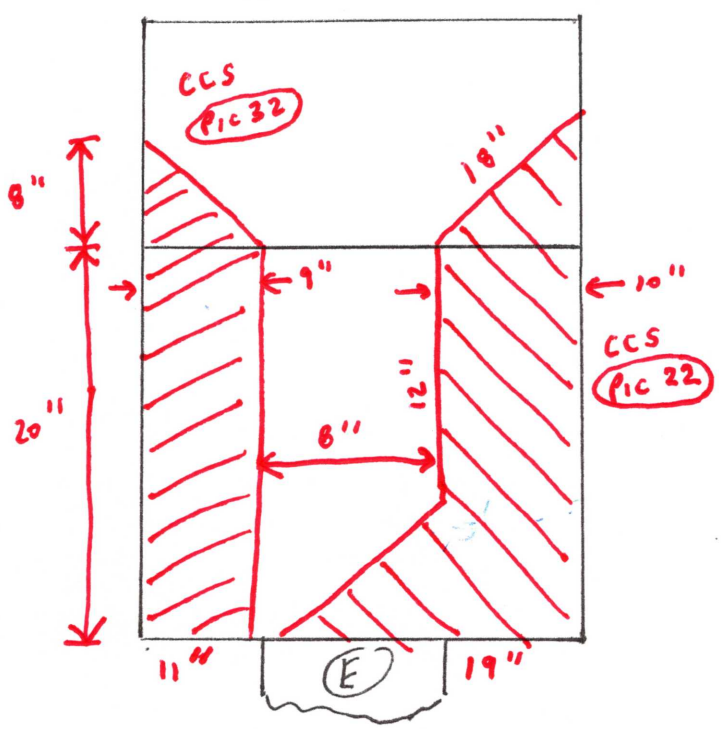
West Face



North End



South End



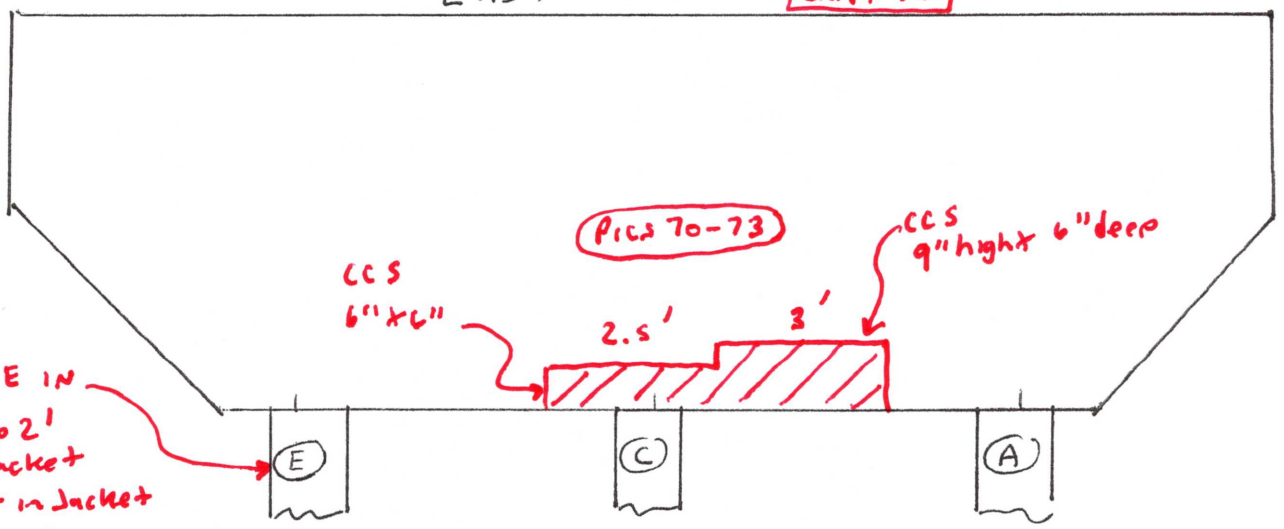
Hermosa Beach Pier - 2024

Pile Cap - 3 Pile Bent

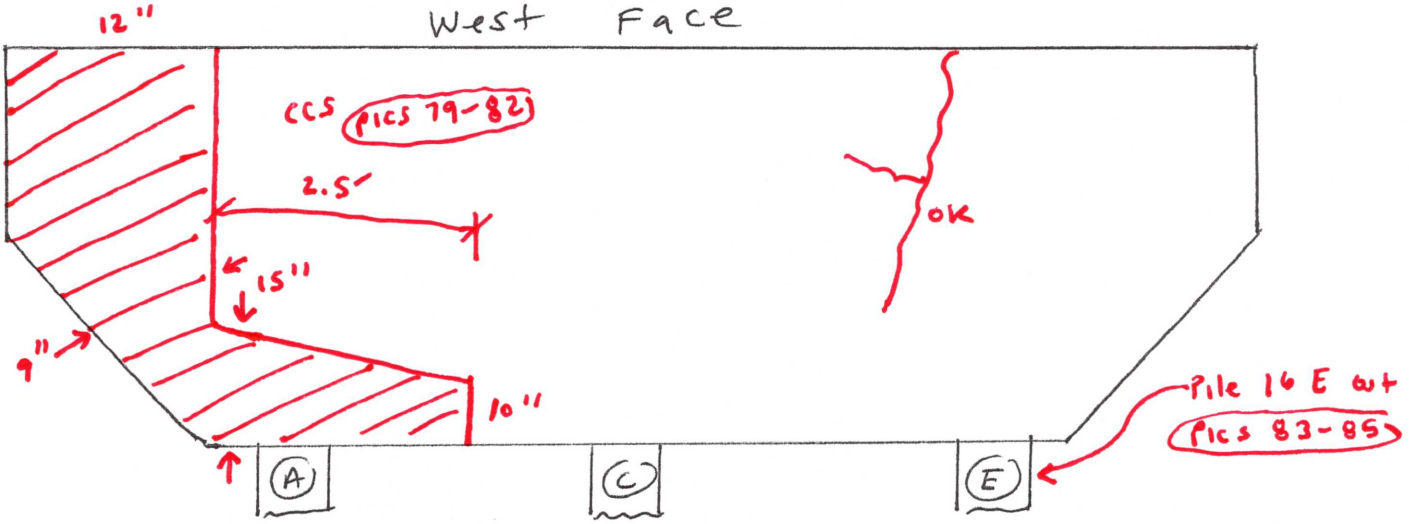
10/30/2024

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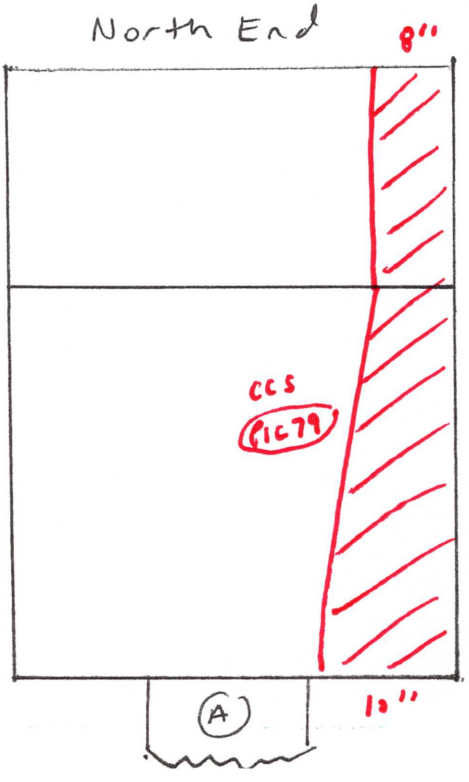
East Face Bent 16



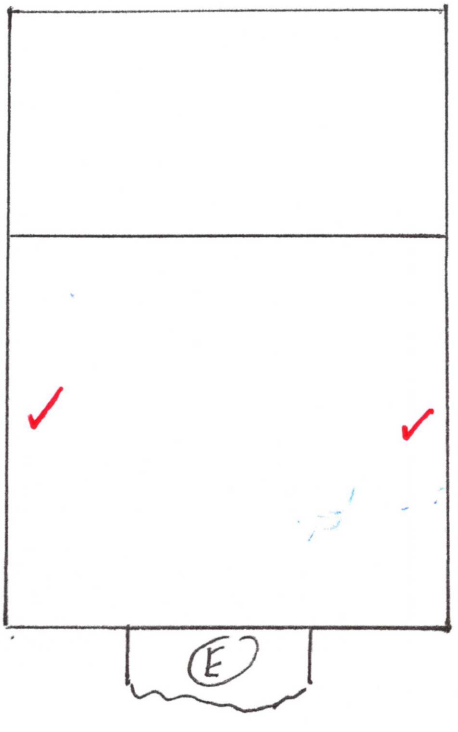
West Face



North End



South End



Hermosa Beach Pier - 2024

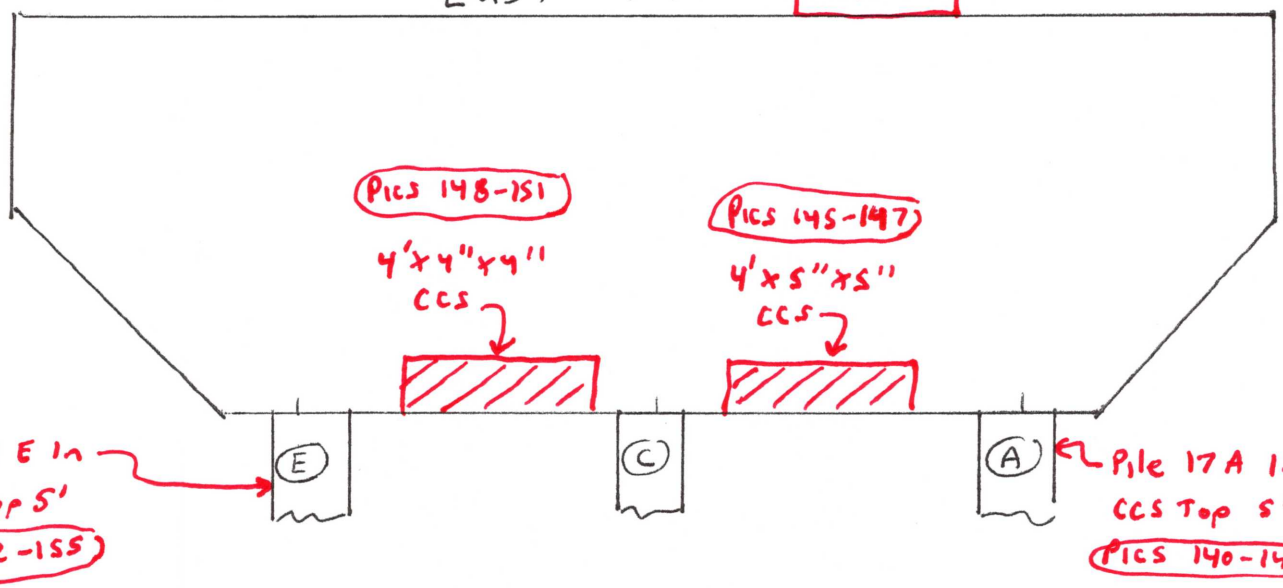
Pile Cap - 3 Pile Bent

ESN Engineering, PLLC

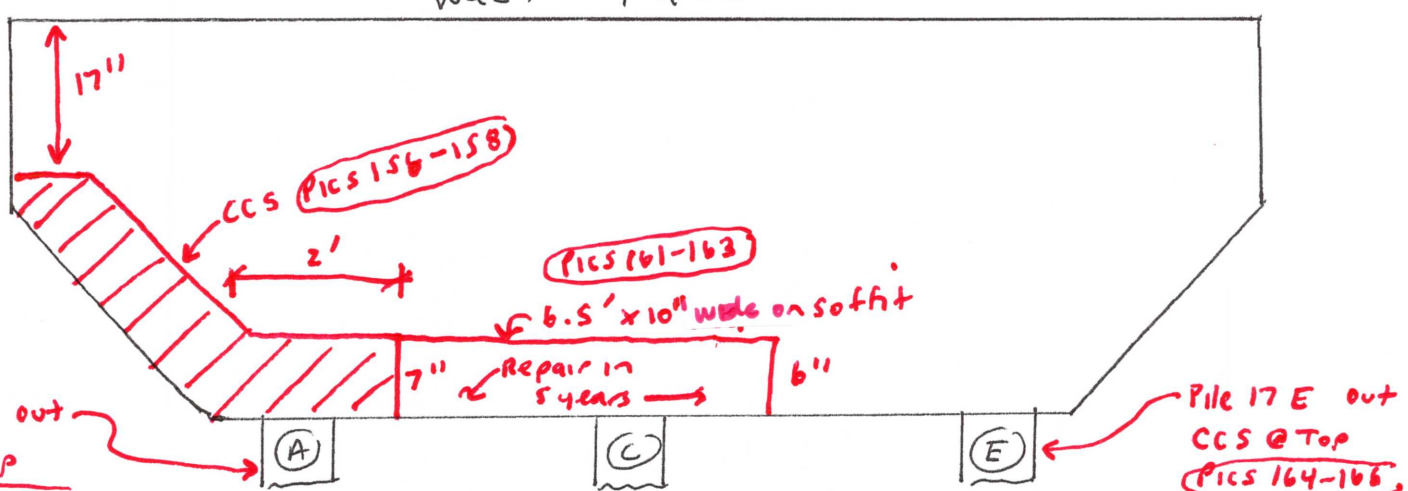
10/30/2024

East Face

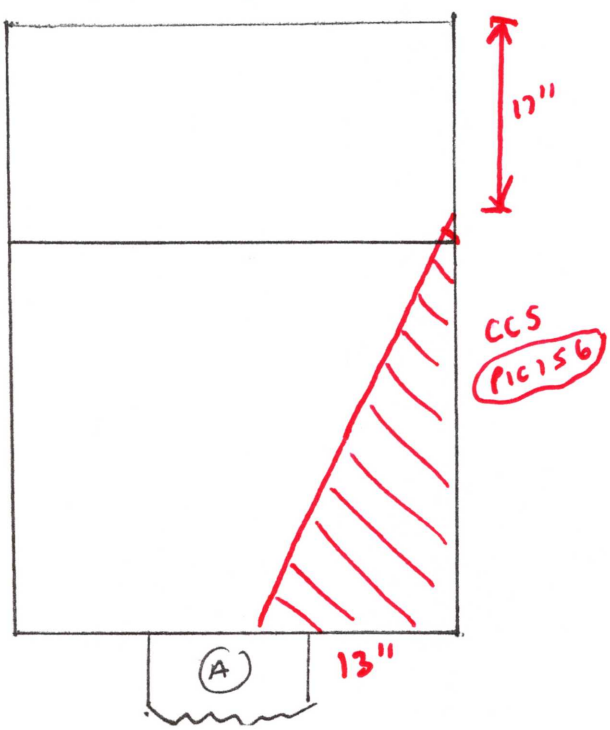
Bent 17



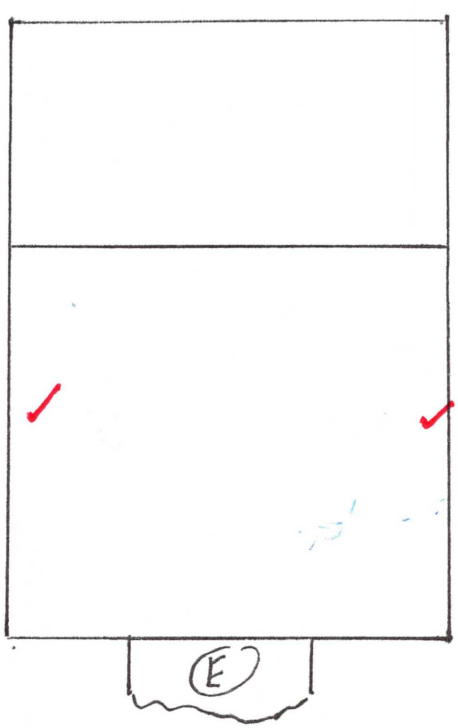
West Face



North End



South End



Hermosa Beach Pier - 2024

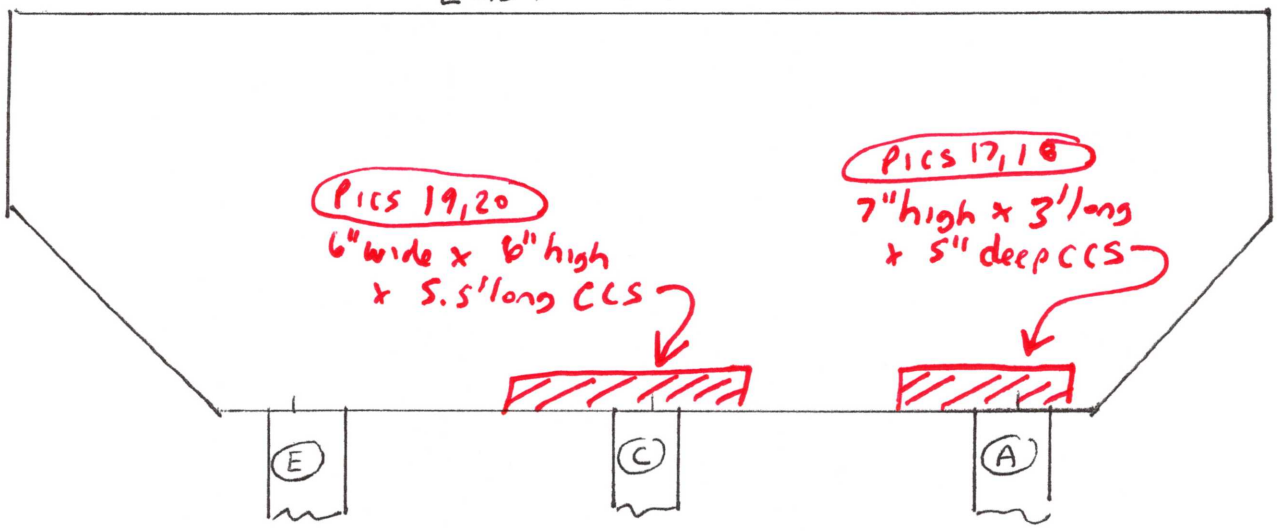
10/31/2024

Pile Cap - 3 Pile Bent

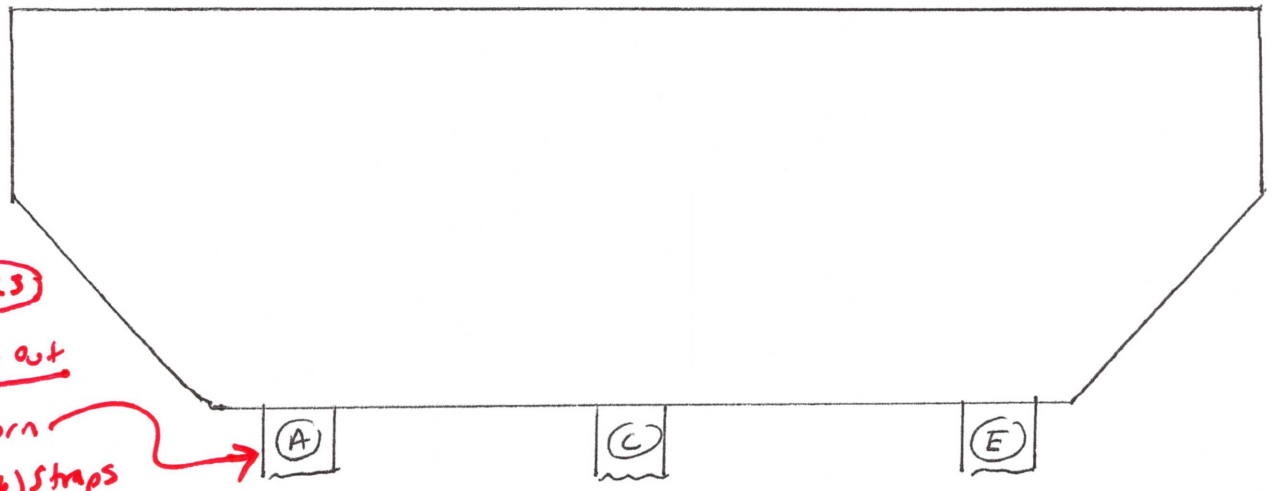
ESN Engineering, PLLC

East Face

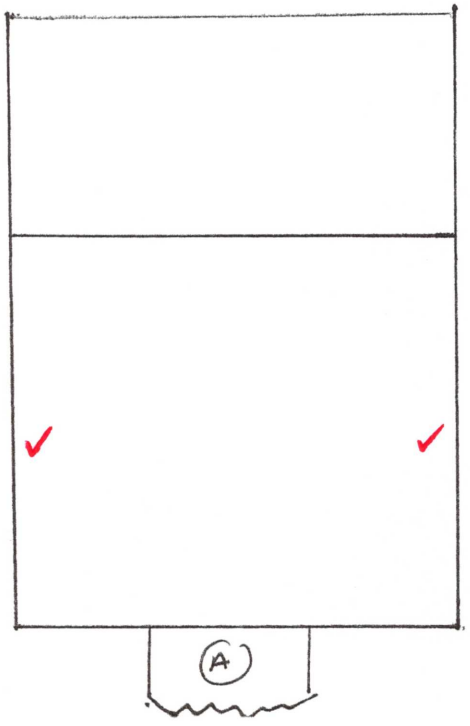
Bent 1B



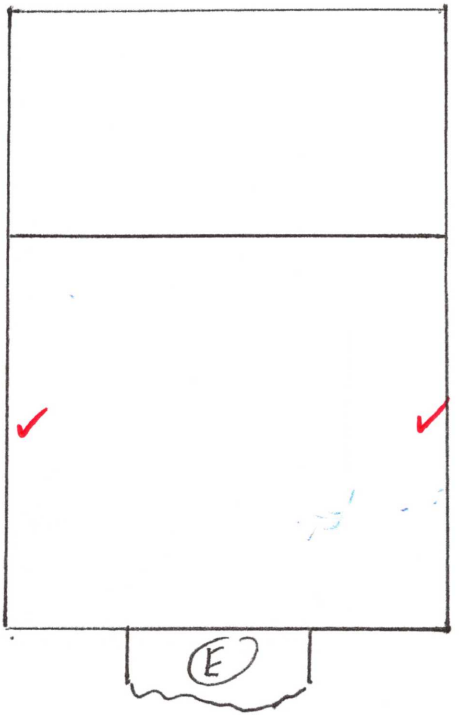
West Face



North End



South End



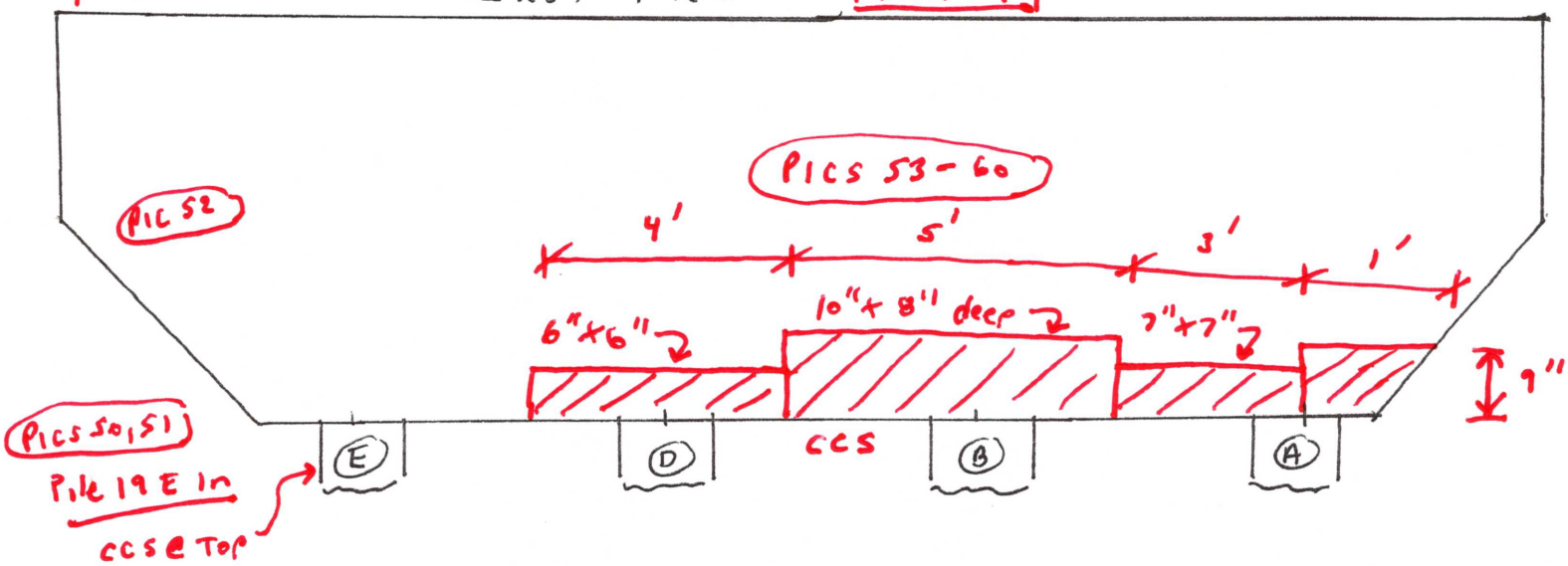
Hermosa Beach Pile Cap – 4 Pile Bent
Pier-2024

10/31/2024

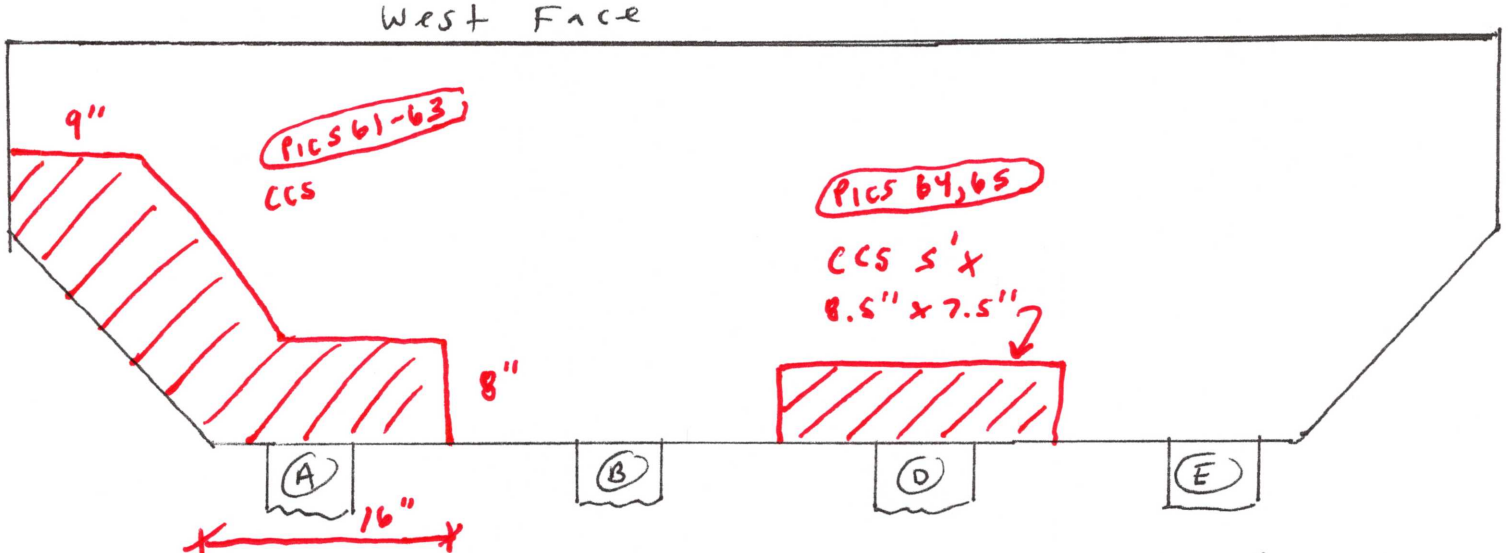
ESN
Engineering, PLLC

East Face

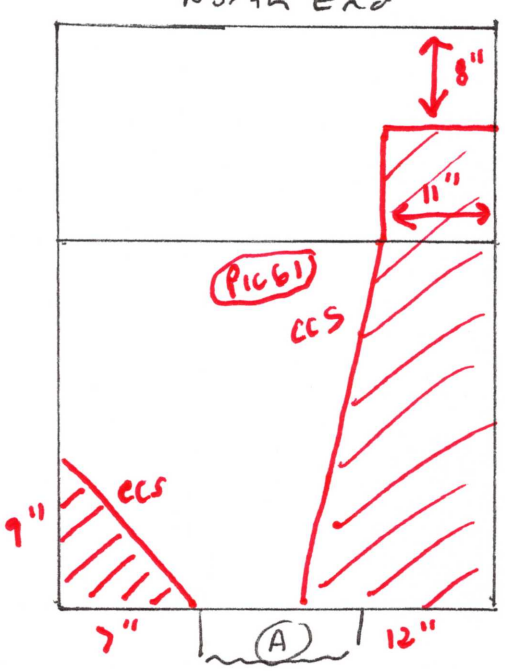
Bent 19



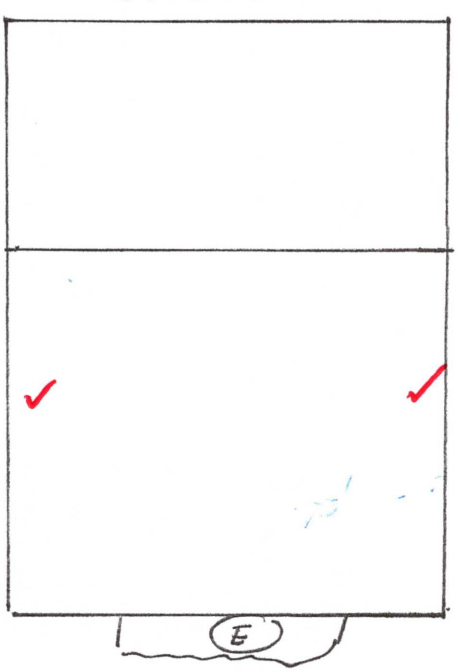
West Face



North End



South End

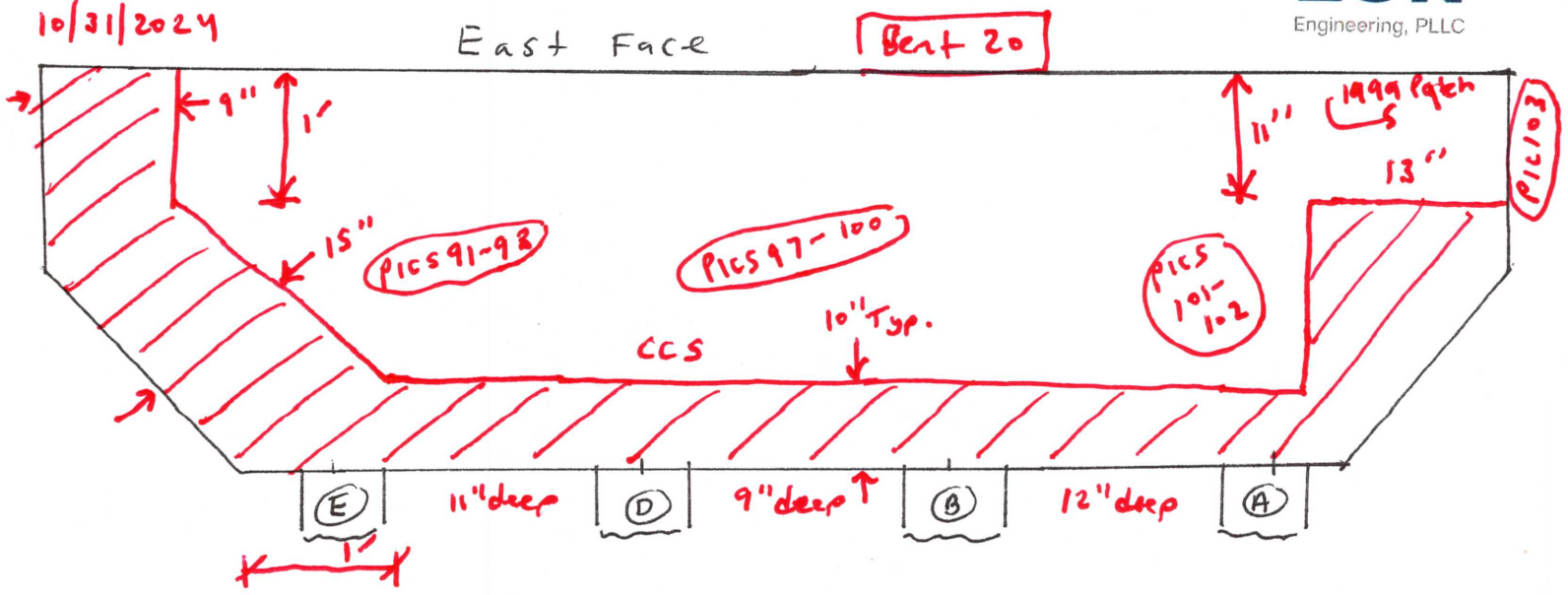


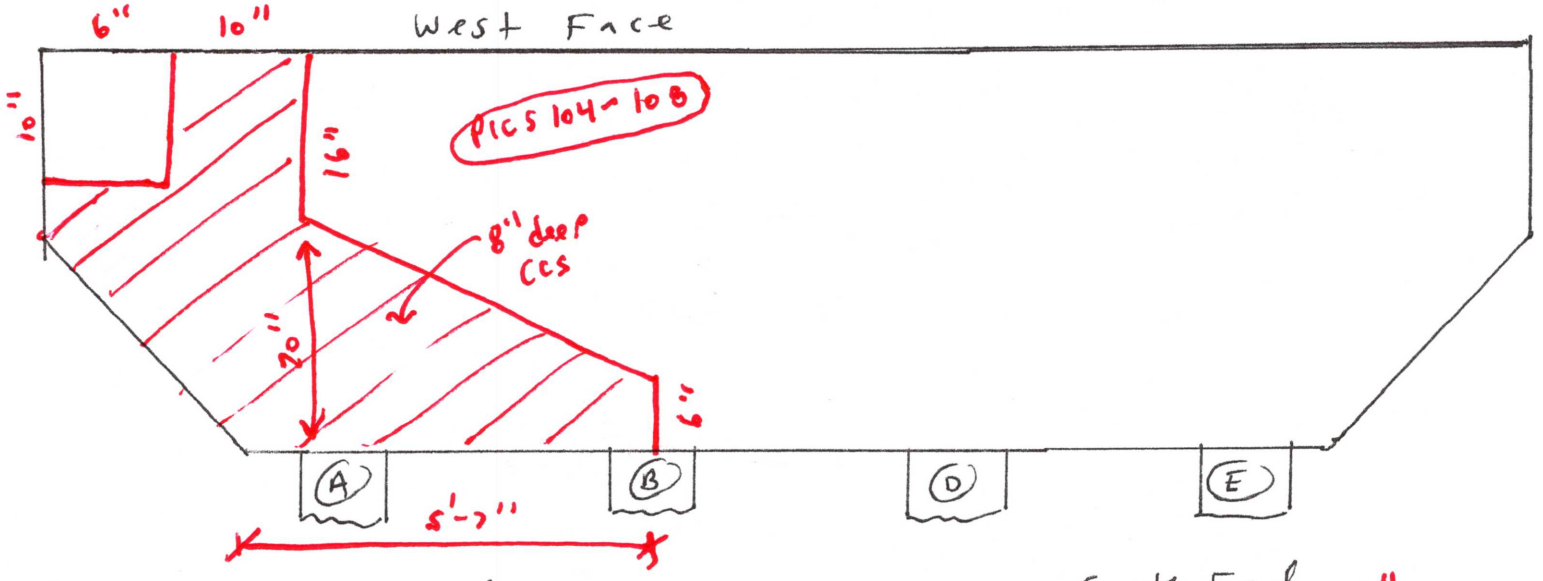
Hermosa Beach Pier - 2024

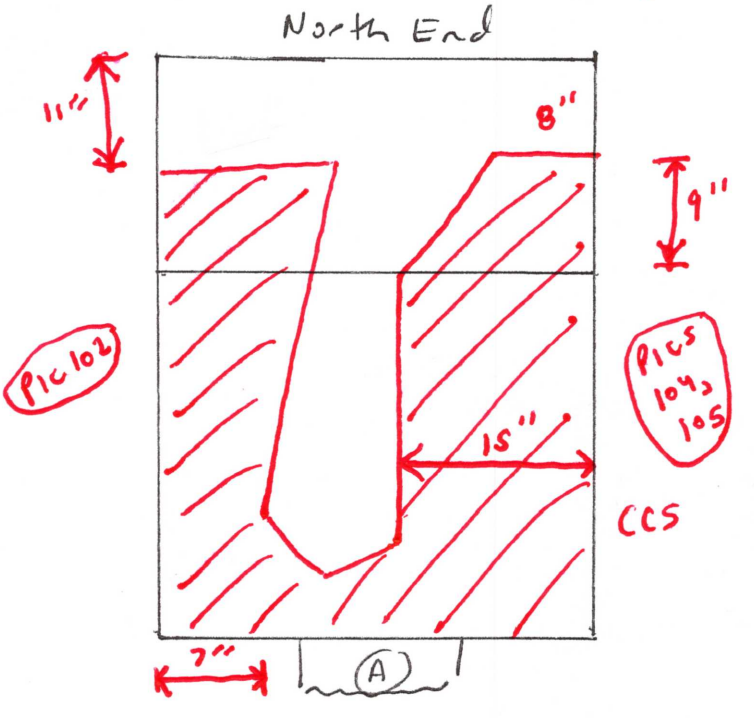
Pile Cap – 4 Pile Bent

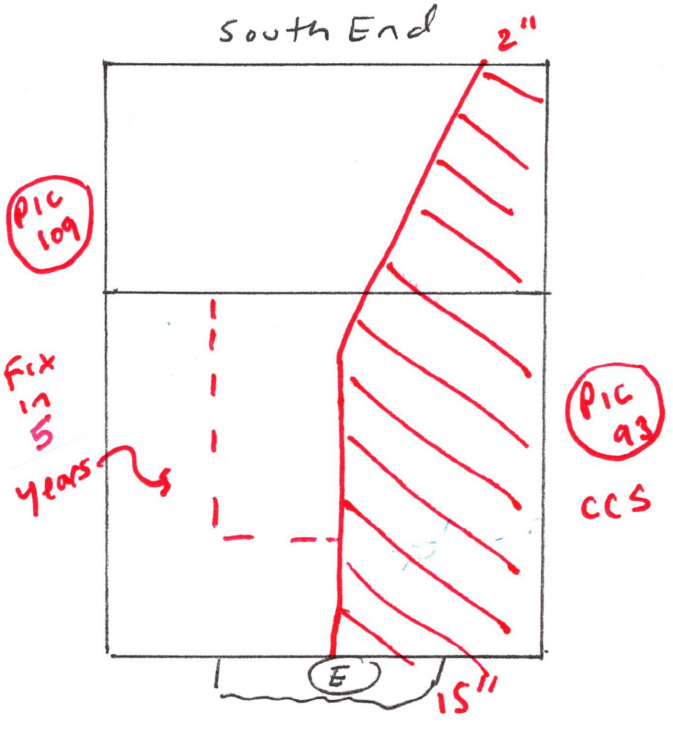
10/31/2024

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Hermosa Beach Pier - 2024

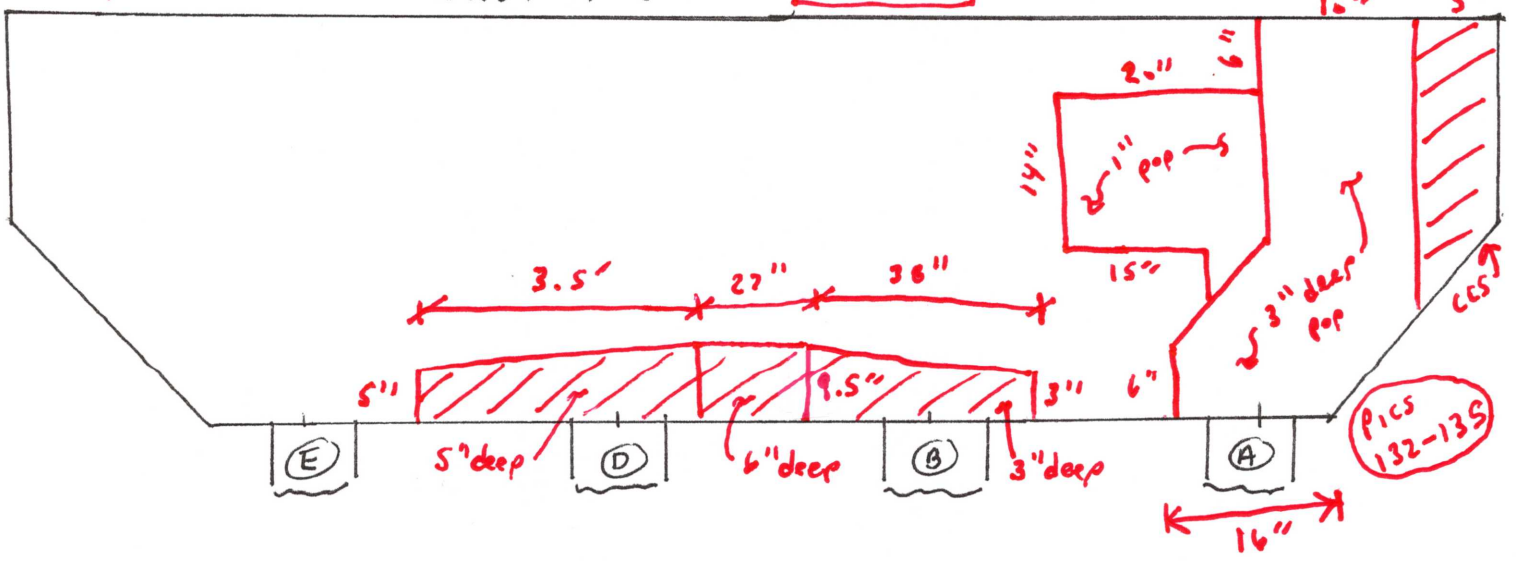
Pile Cap – 4 Pile Bent

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10/31/2024

East Face

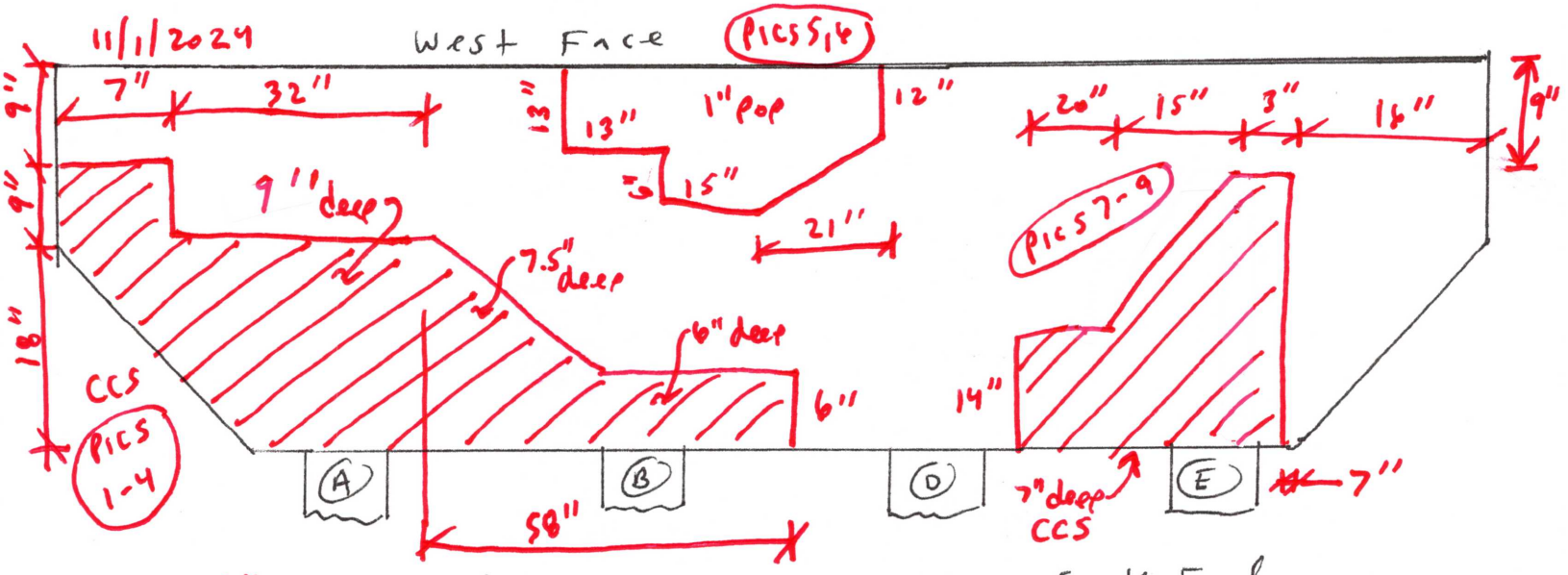
Bent 21



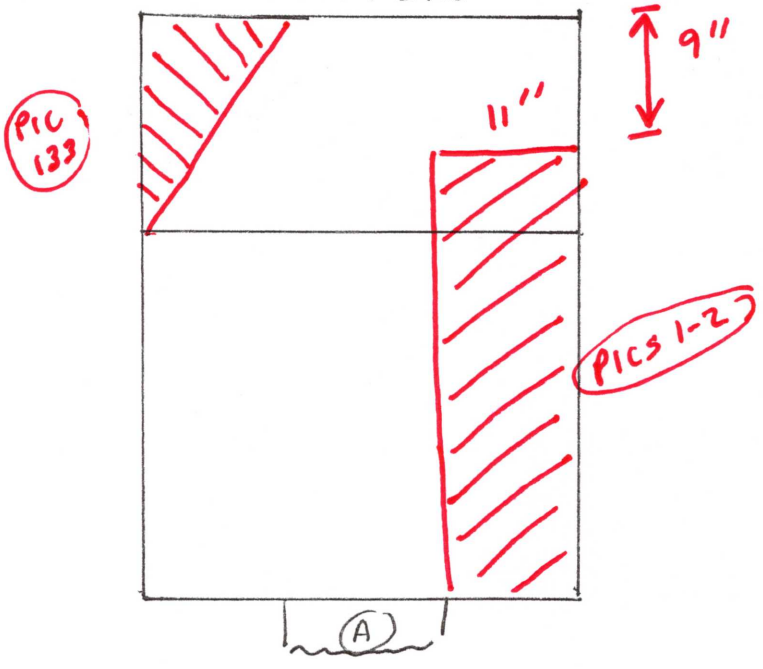
11/1/2024

West Face

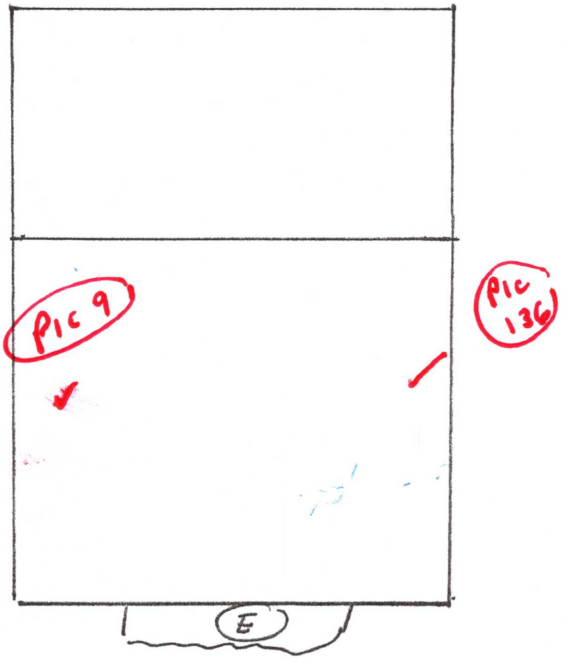
PICS 5, 6



6" North End



South End



Hermosa Beach Pier - 2024

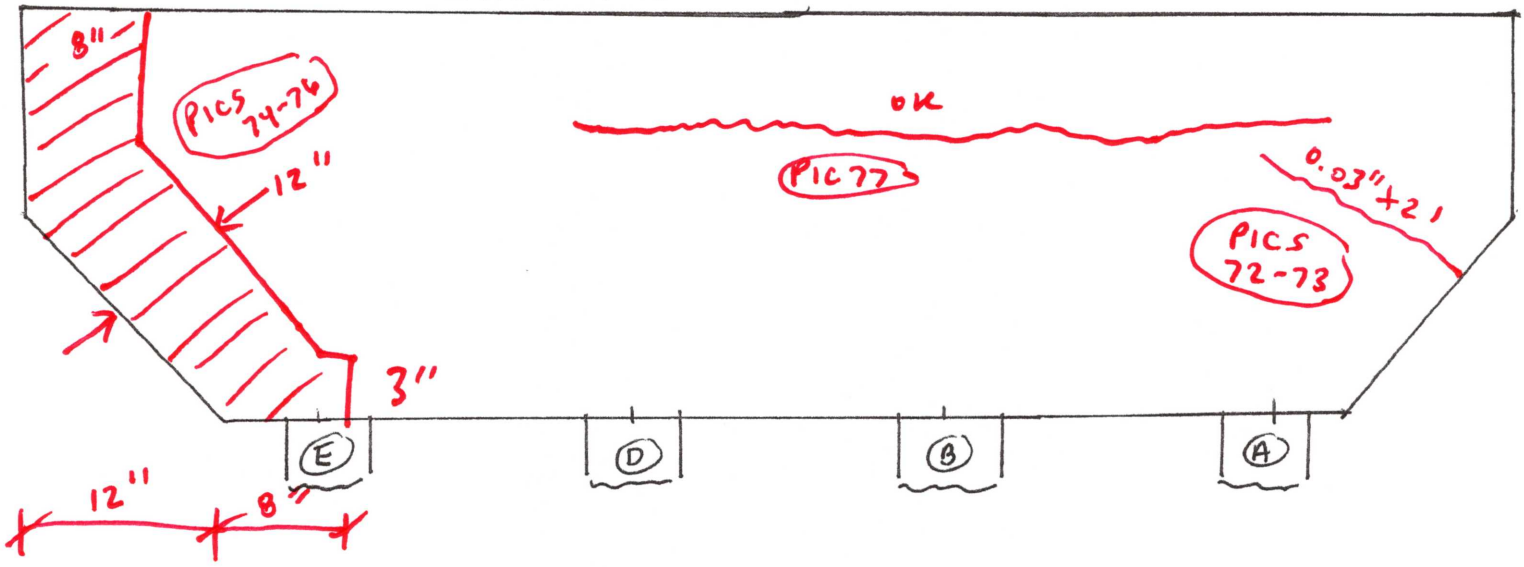
Pile Cap – 4 Pile Bent

11/1/2024

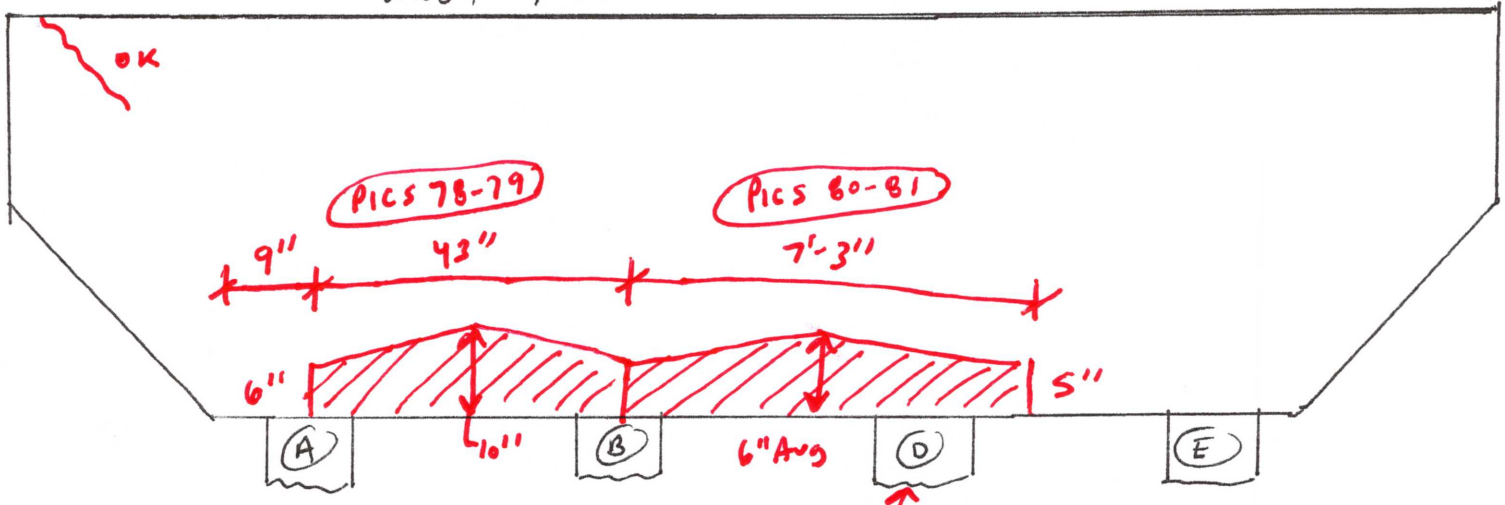
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Bent 22

East Face



West Face

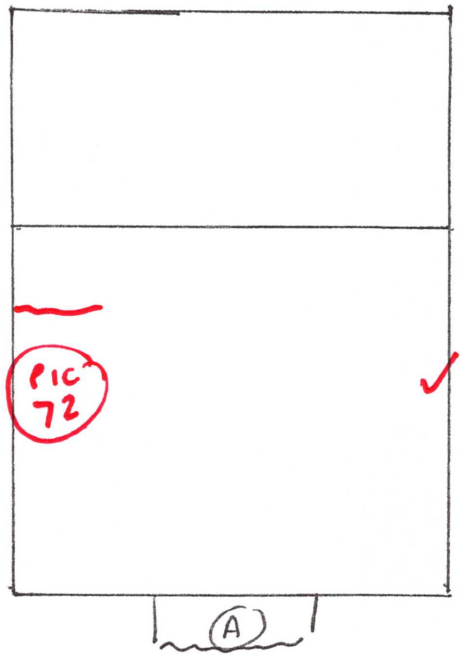


Pile 22 Dout

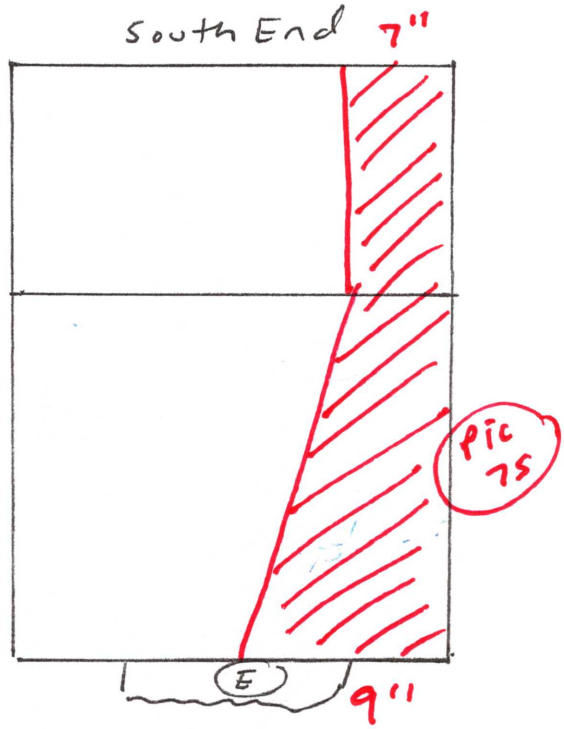
CCS @ Top 4'

Pics 82-84

North End



South End



Hermosa Beach Pier - 2024

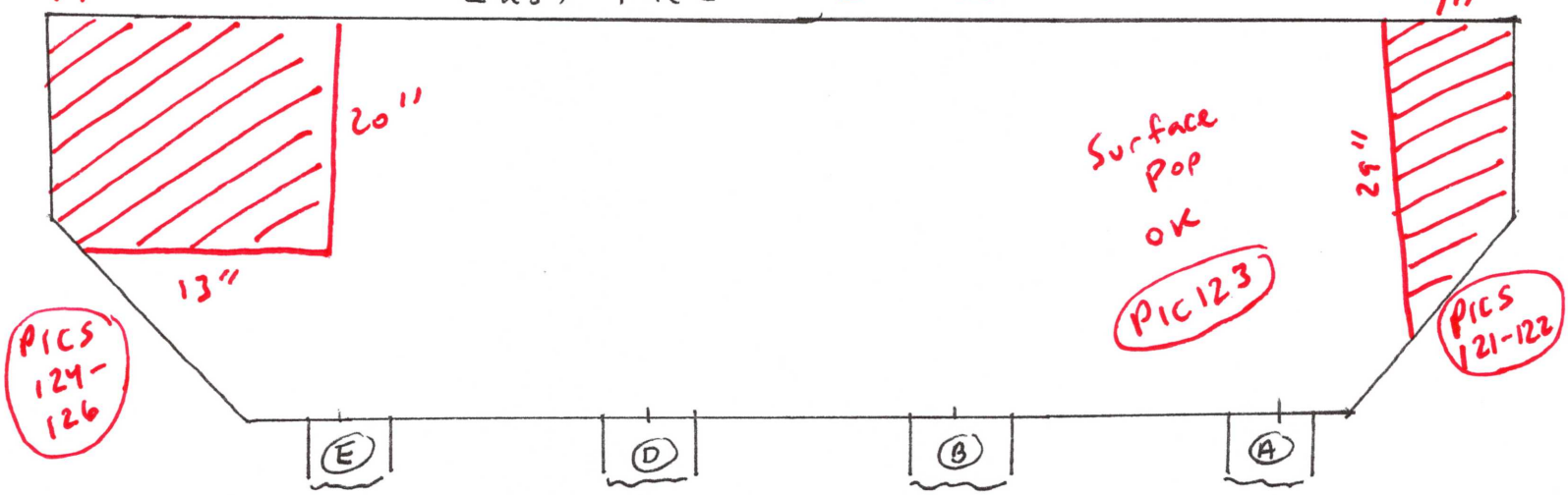
Pile Cap – 4 Pile Bent

11/1/2024

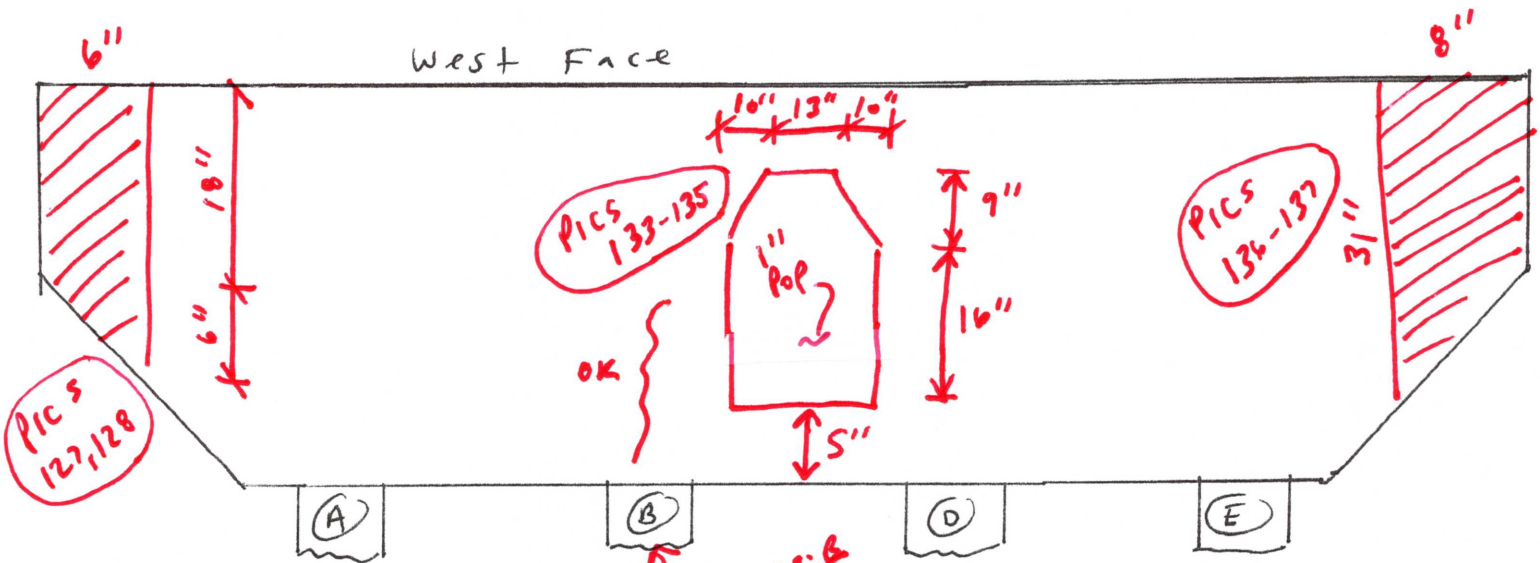
ESN Engineering, PLLC

Bent 23

East Face

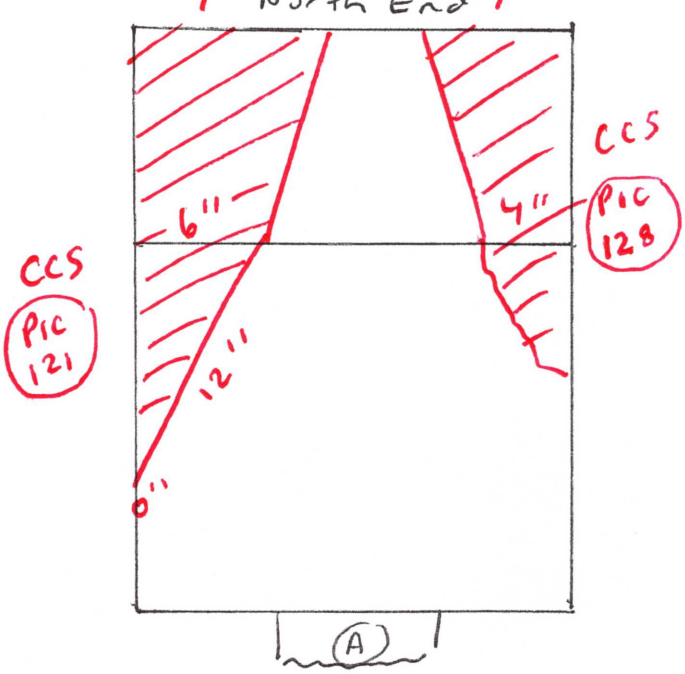


West Face



Pile 23:B out

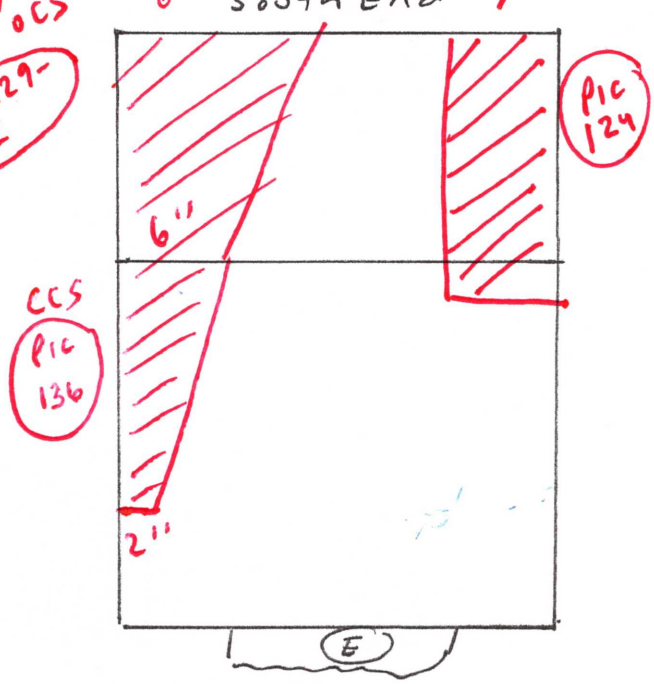
7" North End 7"



Top 4' OCS

PICS 129-132

8" South End 7"



Hermosa Beach Pier - 2024

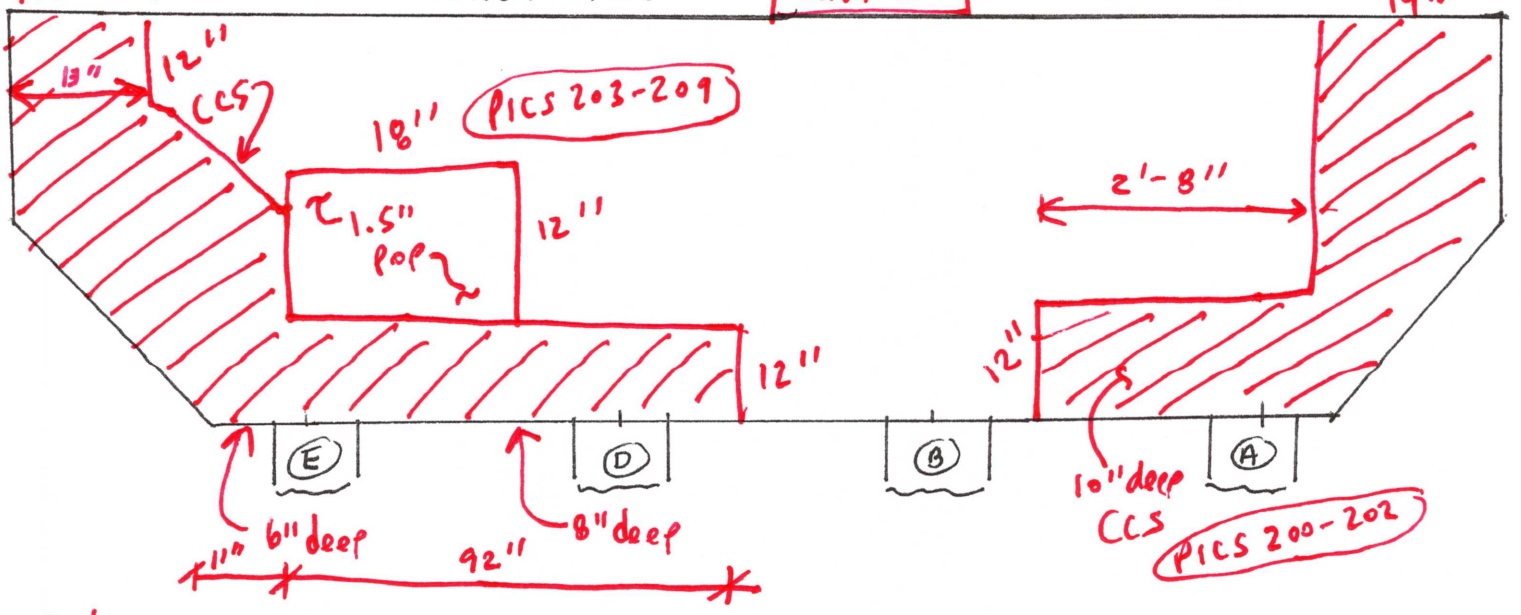
Pile Cap – 4 Pile Bent

ESN Engineering, PLLC

11/1/2024

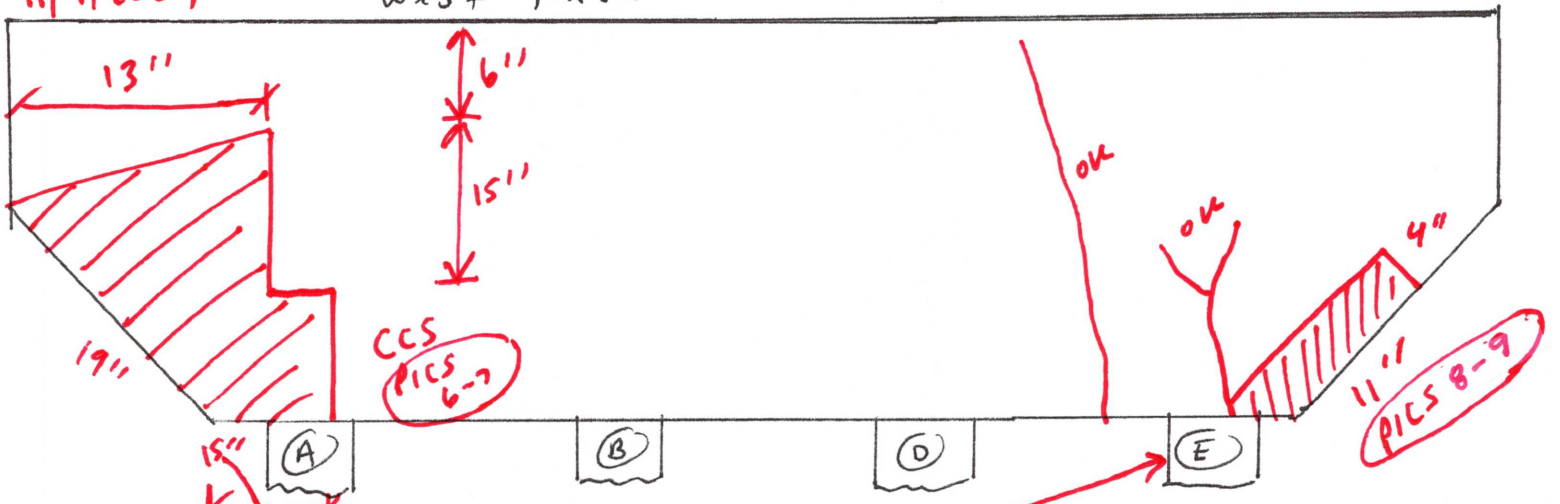
East Face

Bent 24

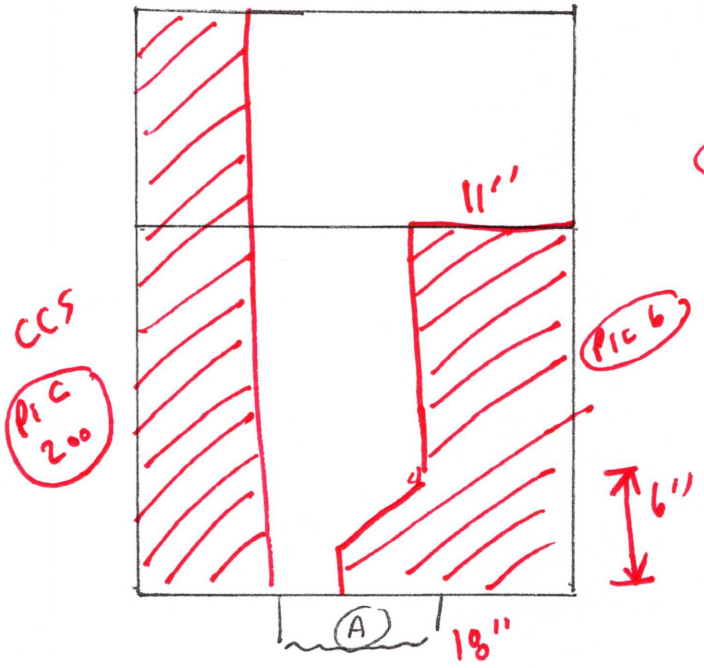


11/4/2024

West Face



North End

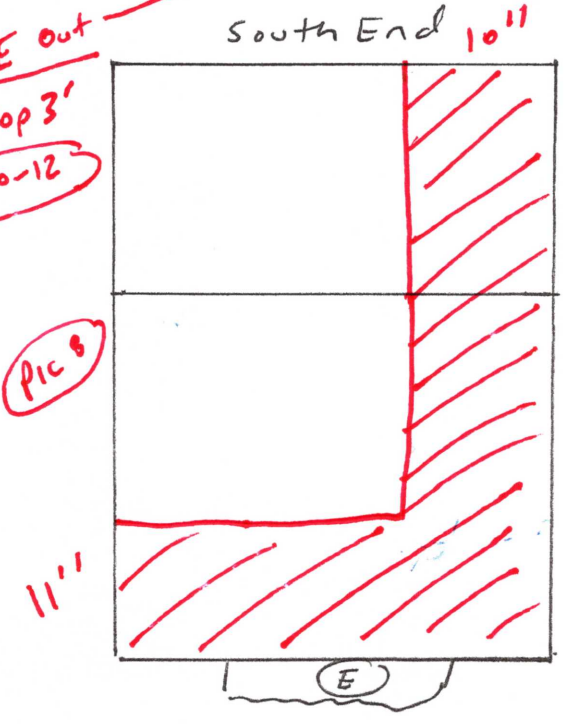


Pile 24E out

CCS Top 3'

PICS 10-12

South End

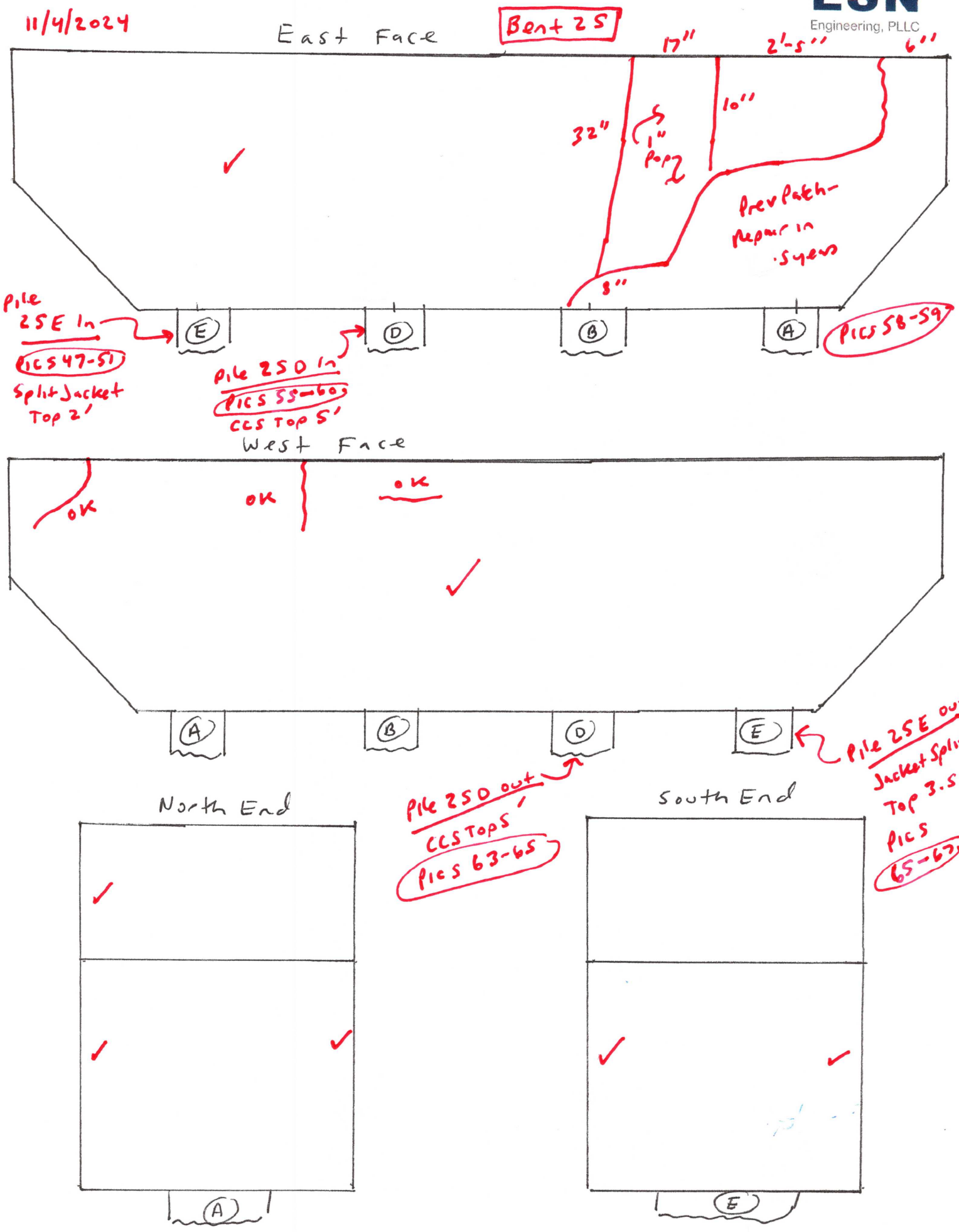


Hermosa Beach Pier - 2024

Pile Cap – 4 Pile Bent

11/4/2024

ESN Engineering, PLLC

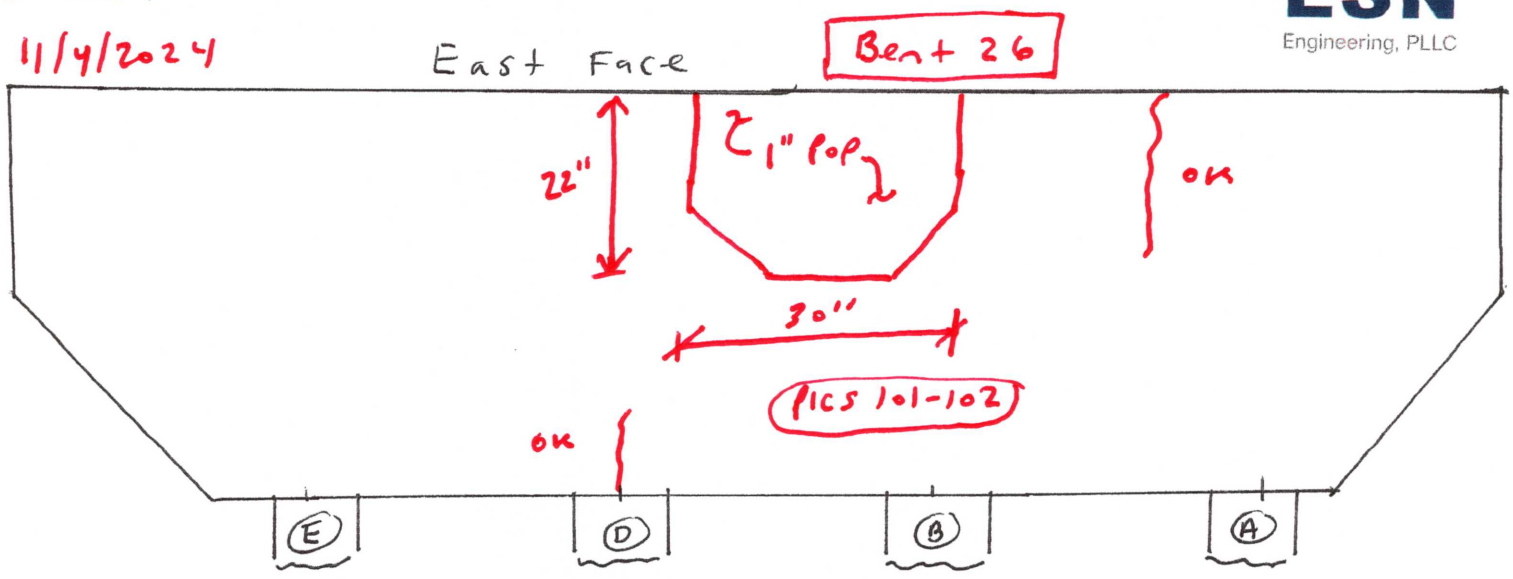


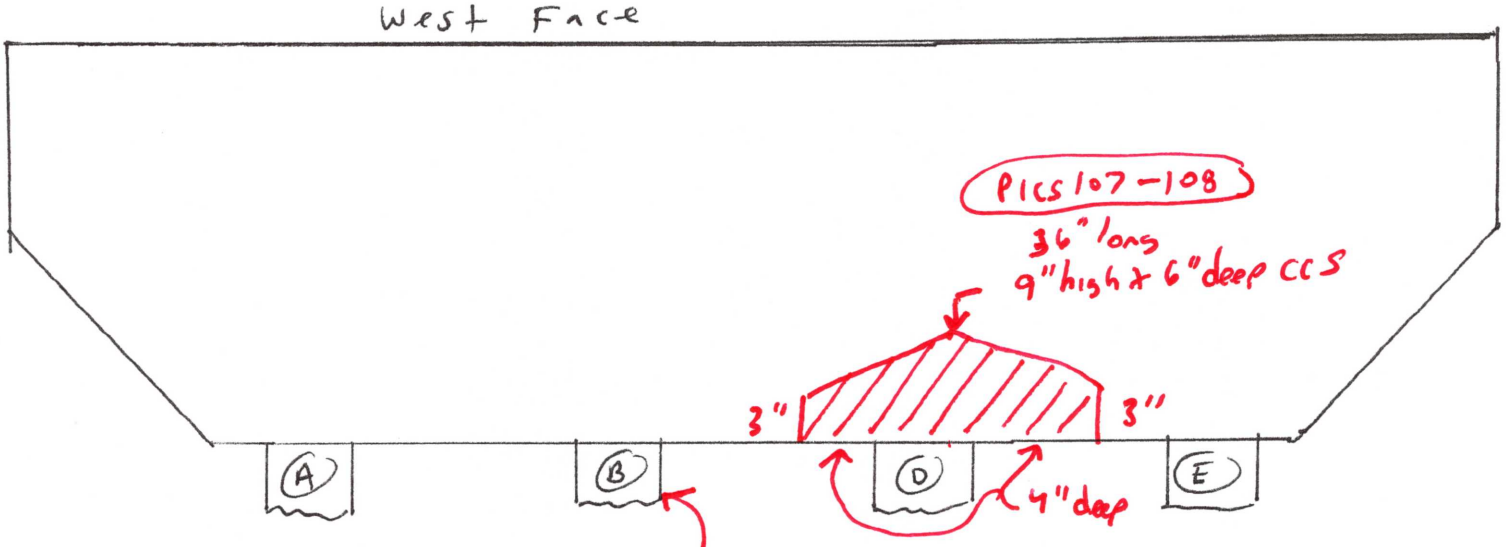
Hermosa Beach Pier - 2024

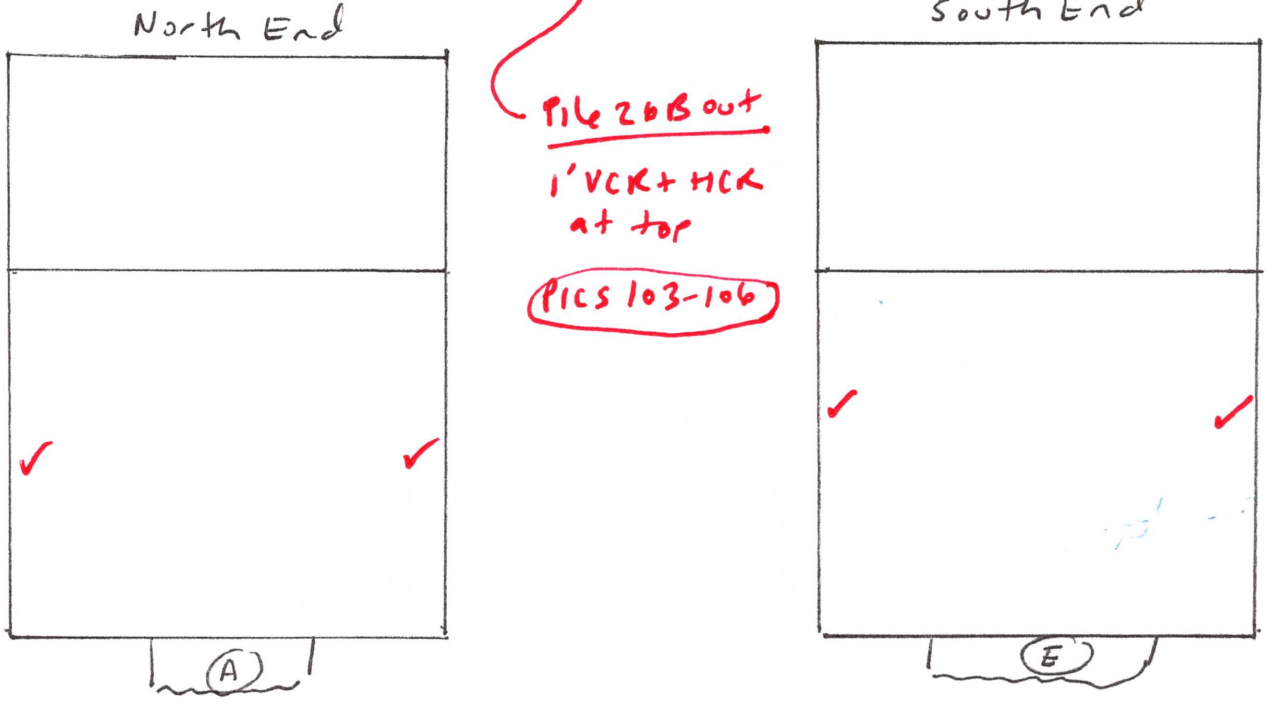
Pile Cap – 4 Pile Bent

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11/4/2024







Hermosa Beach Pier - 2024

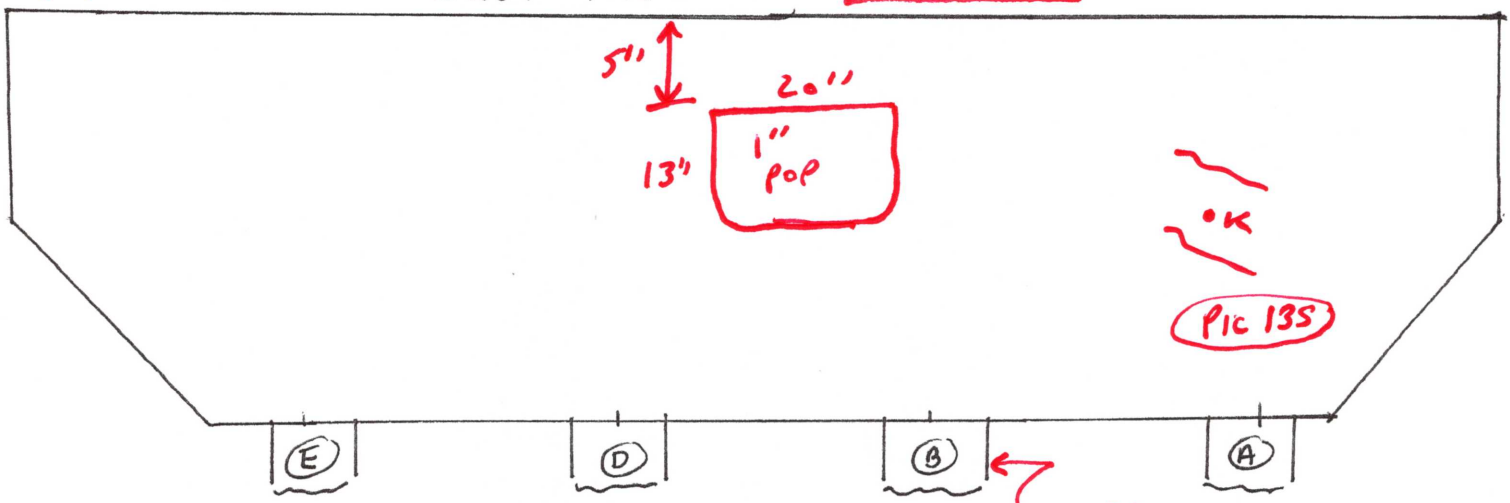
Pile Cap – 4 Pile Bent

11/4/2024

ESN Engineering, PLLC

Bent 27

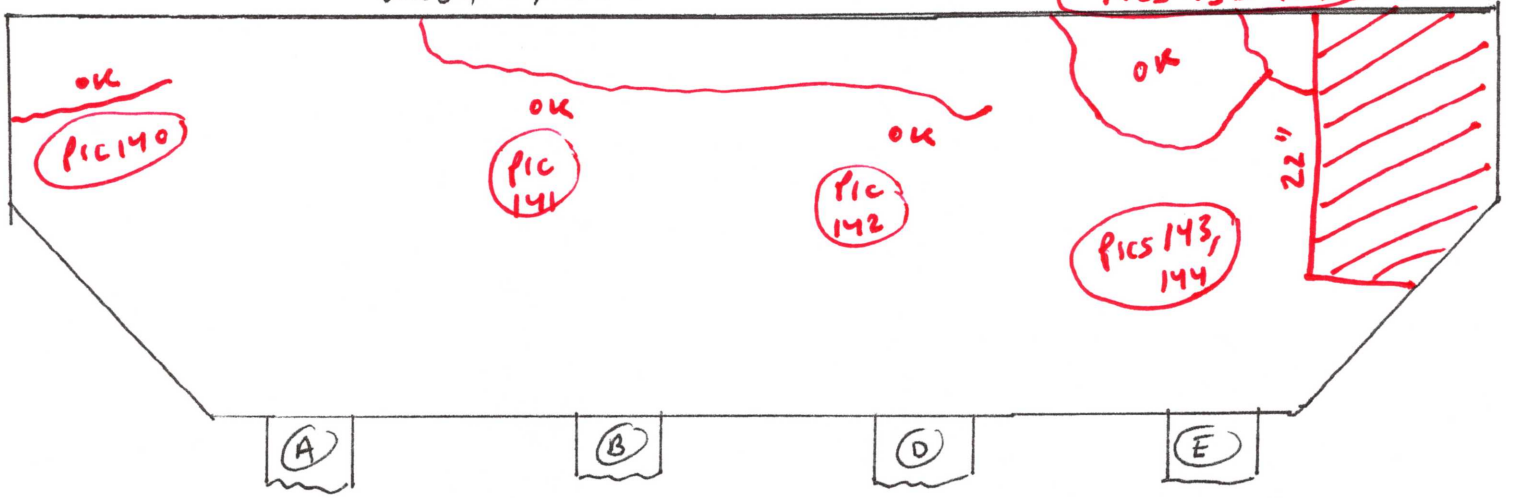
East Face



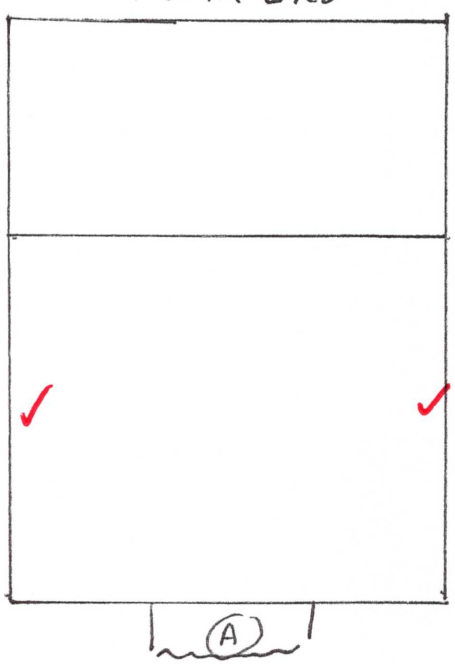
VCR Top 3'

Pics 136-139

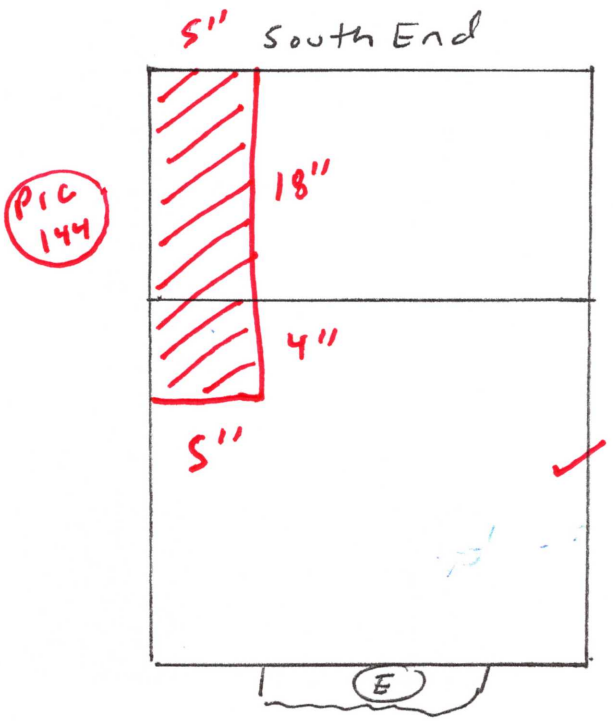
West Face



North End



5" South End



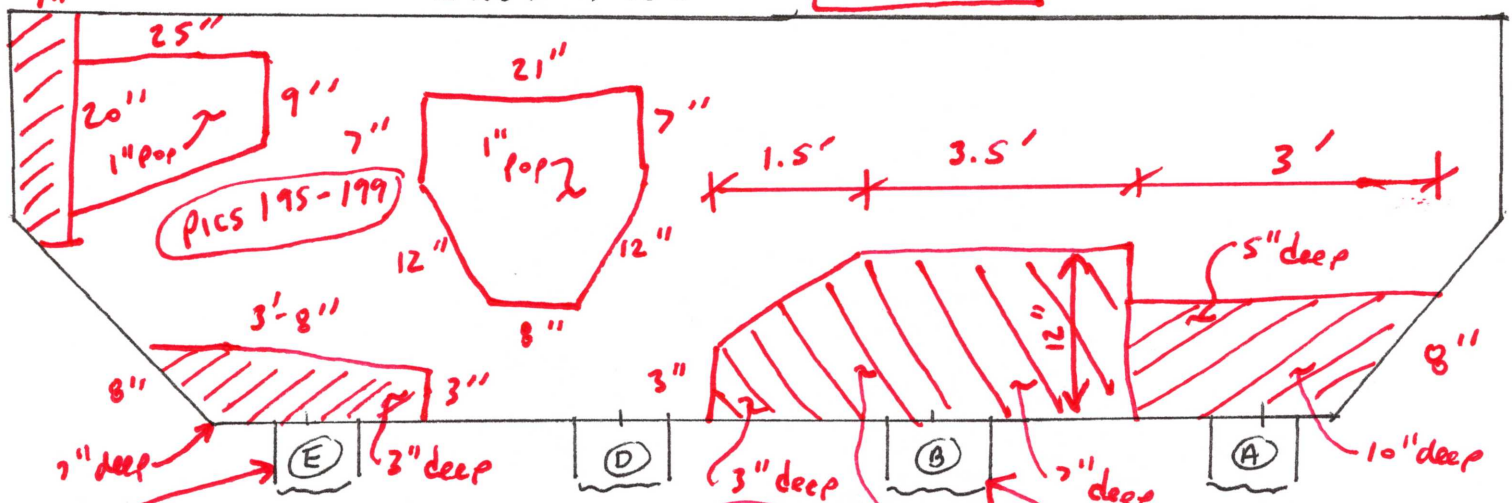
Hermosa Beach Pile Cap – 4 Pile Bent
Pier - 2024

ESN Engineering, PLLC

11/4/2024

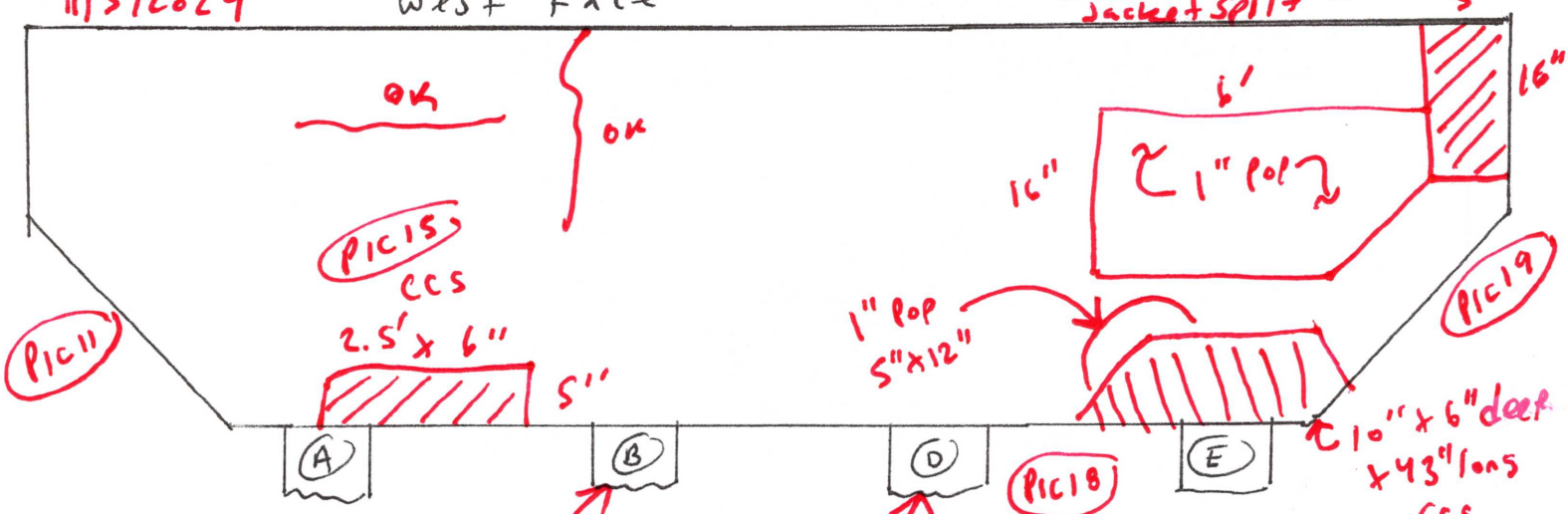
East Face

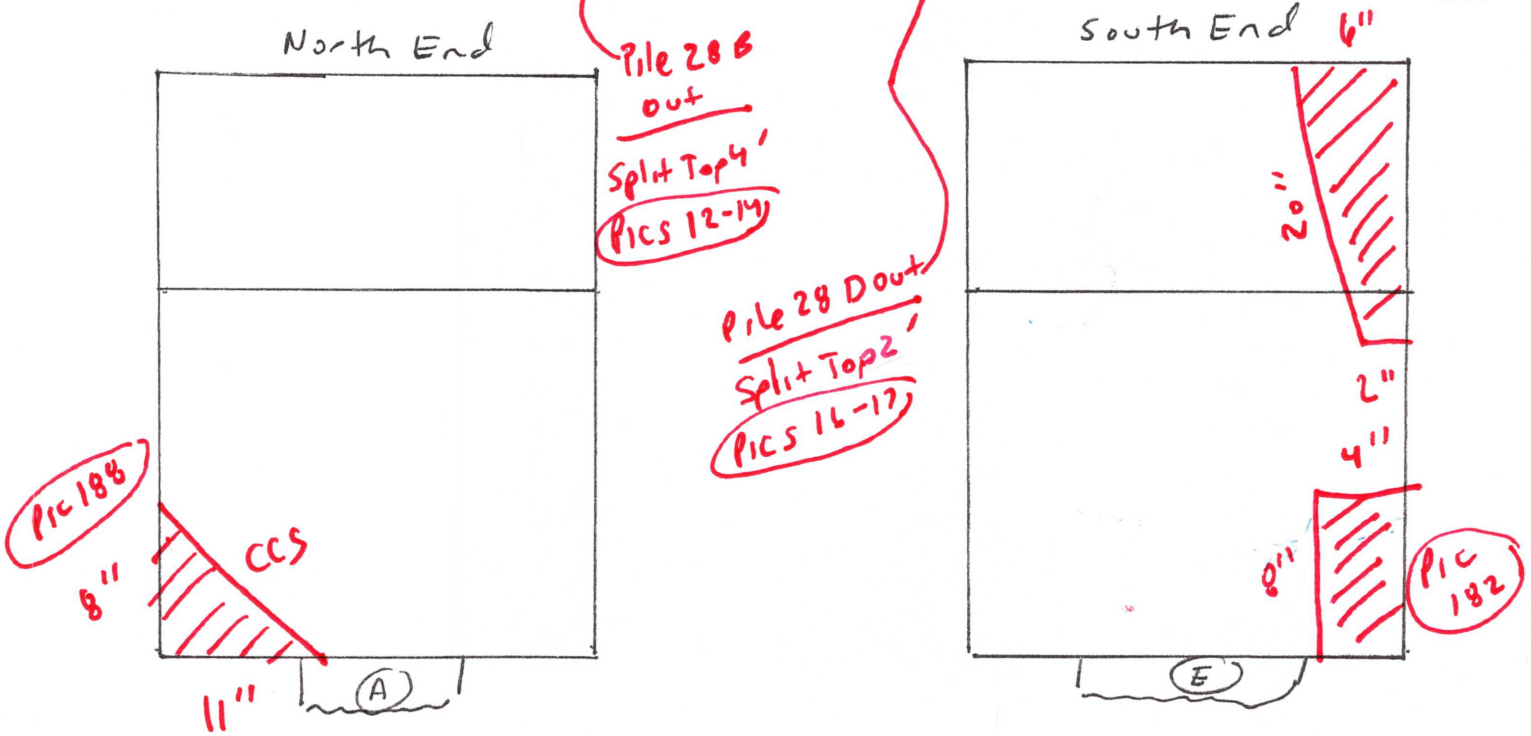
Bent 2 B



11/5/2024

West Face



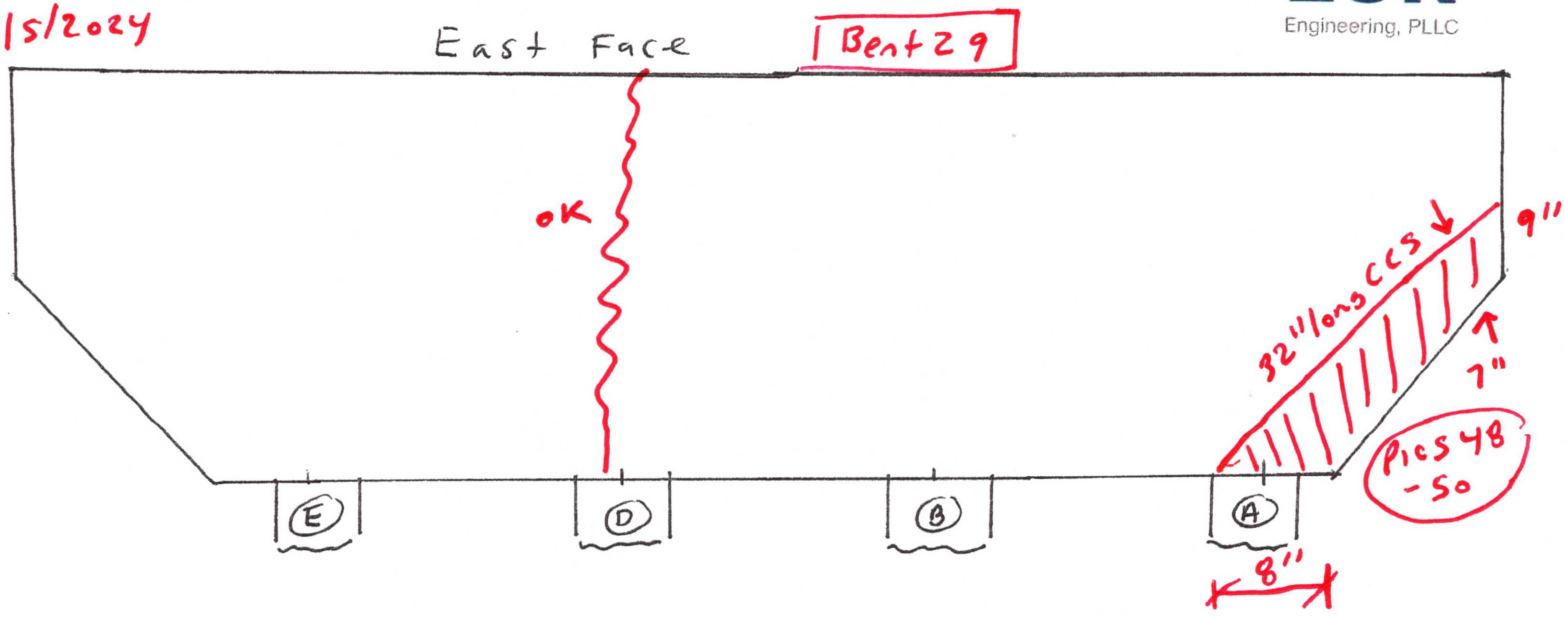


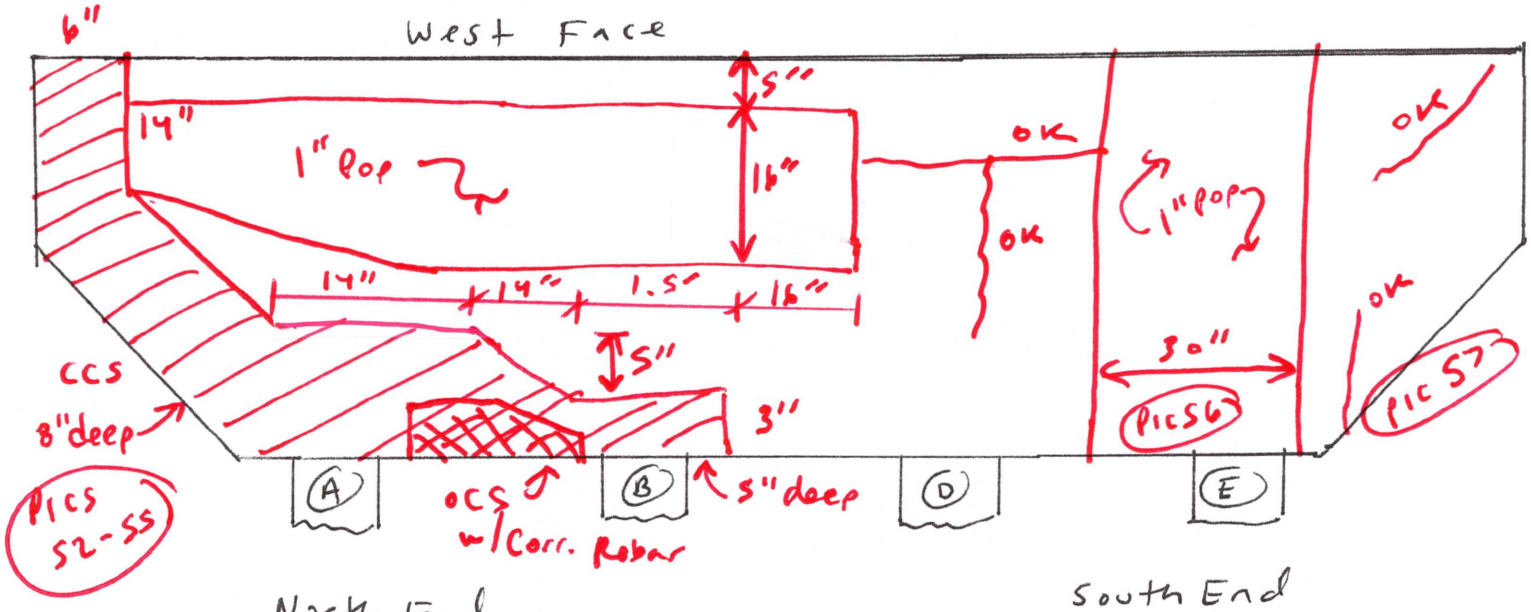
Hermosa Beach Pier - 2024

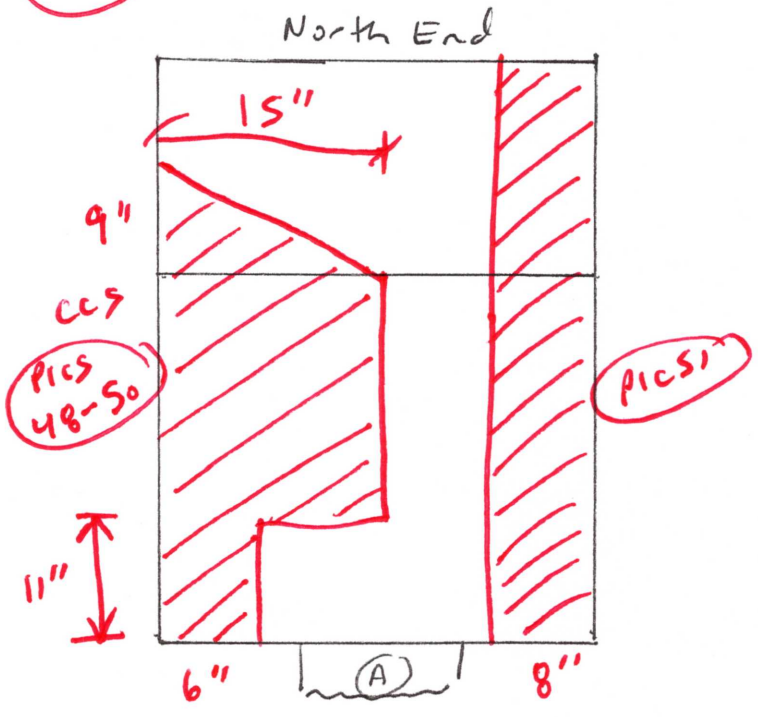
Pile Cap – 4 Pile Bent

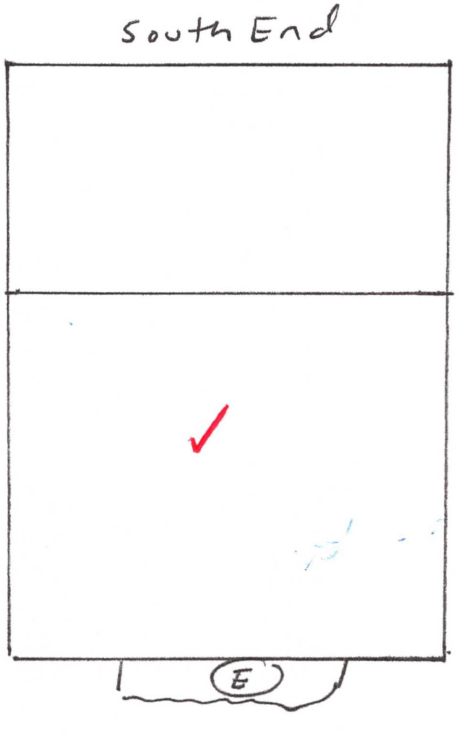
11/5/2024

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Hermosa Beach Pier - 2024

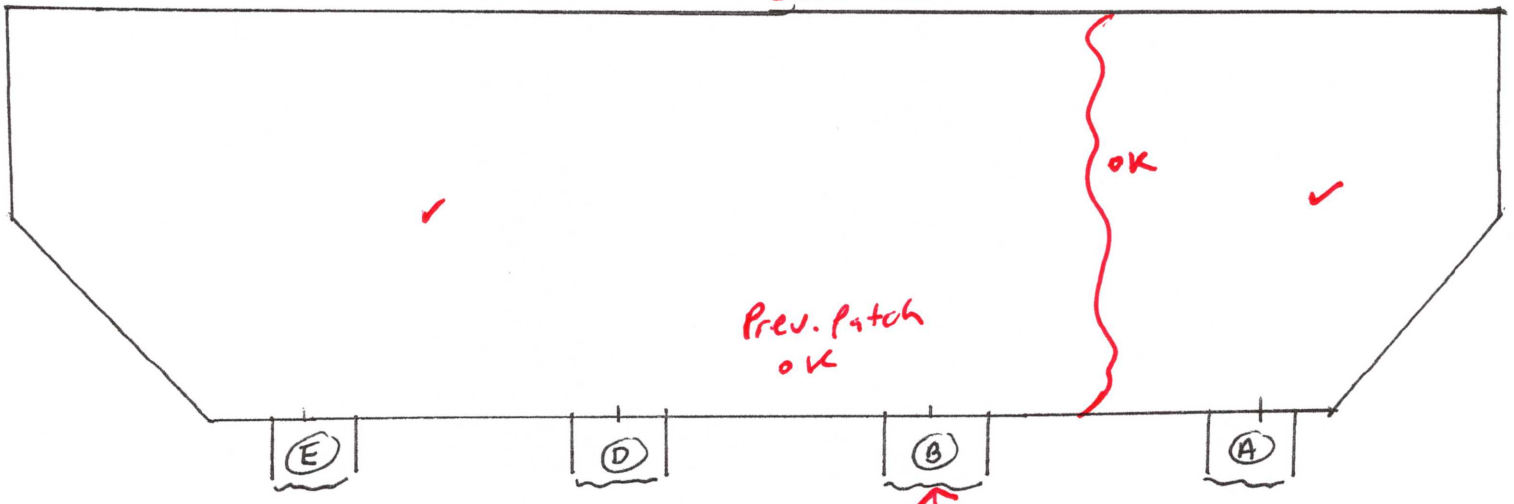
11/5/2024

Pile Cap – 4 Pile Bent

ESN Engineering, PLLC

East Face

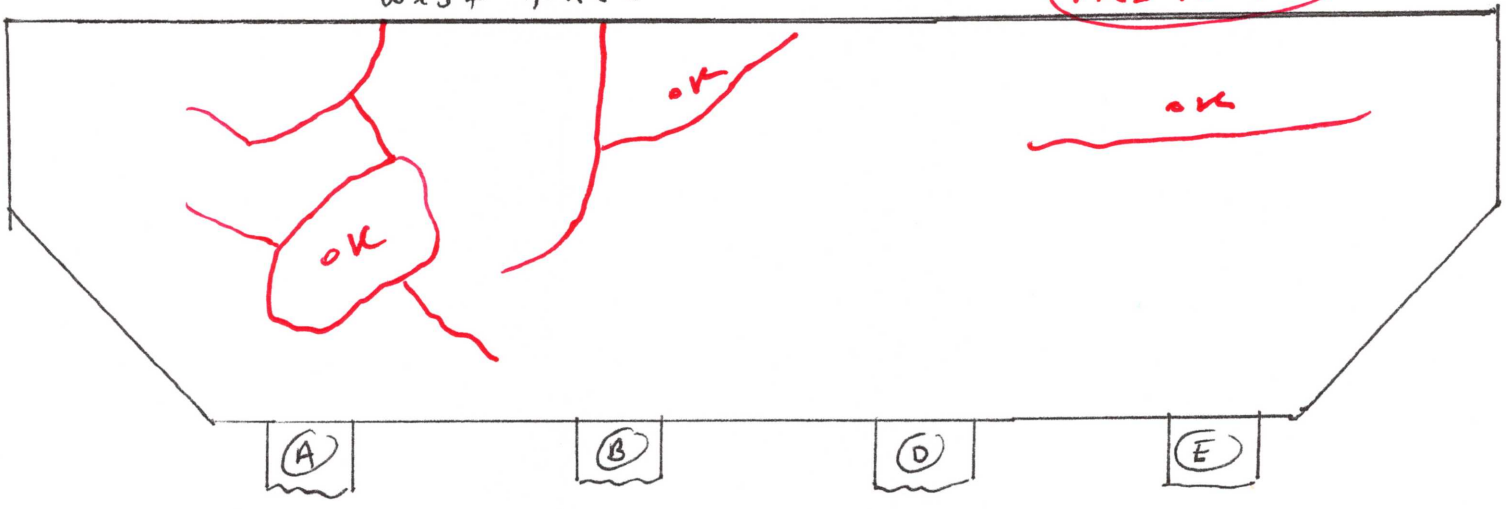
Bent 30



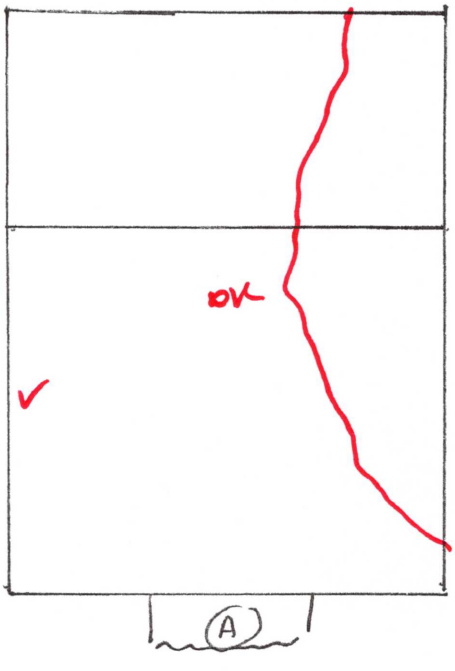
Pile 30B In CCS Top 3.5'

Pics 76-98

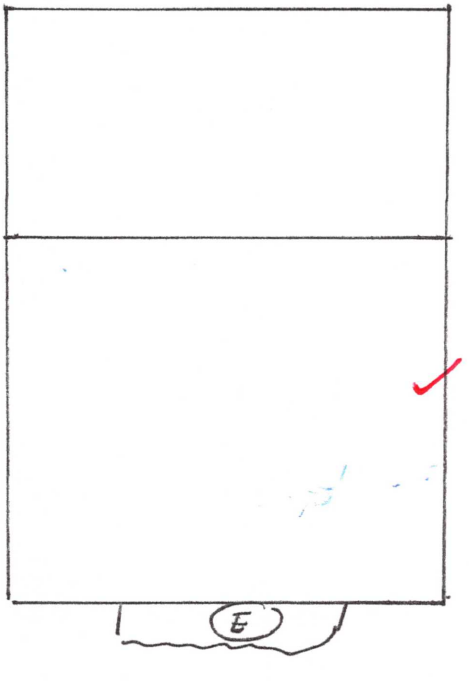
West Face



North End



South End



Hermosa Beach Pier - 2024

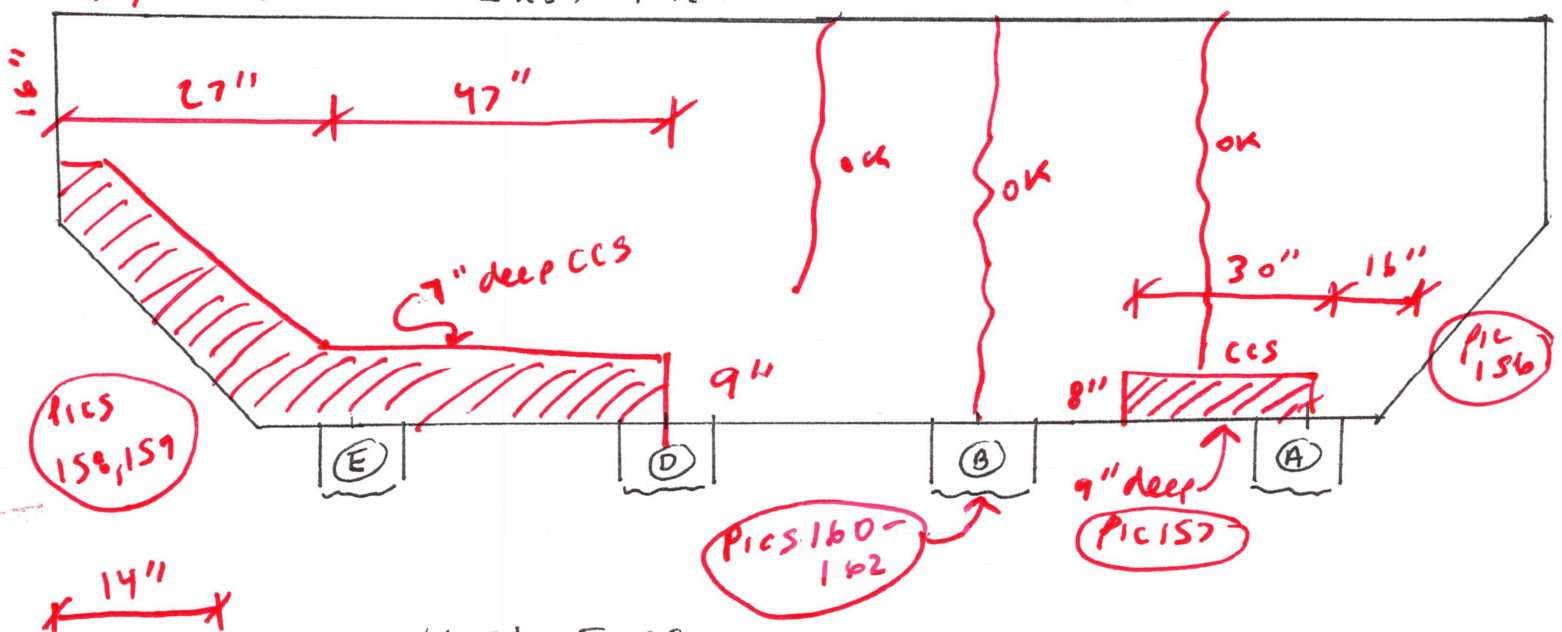
Pile Cap – 4 Pile Bent

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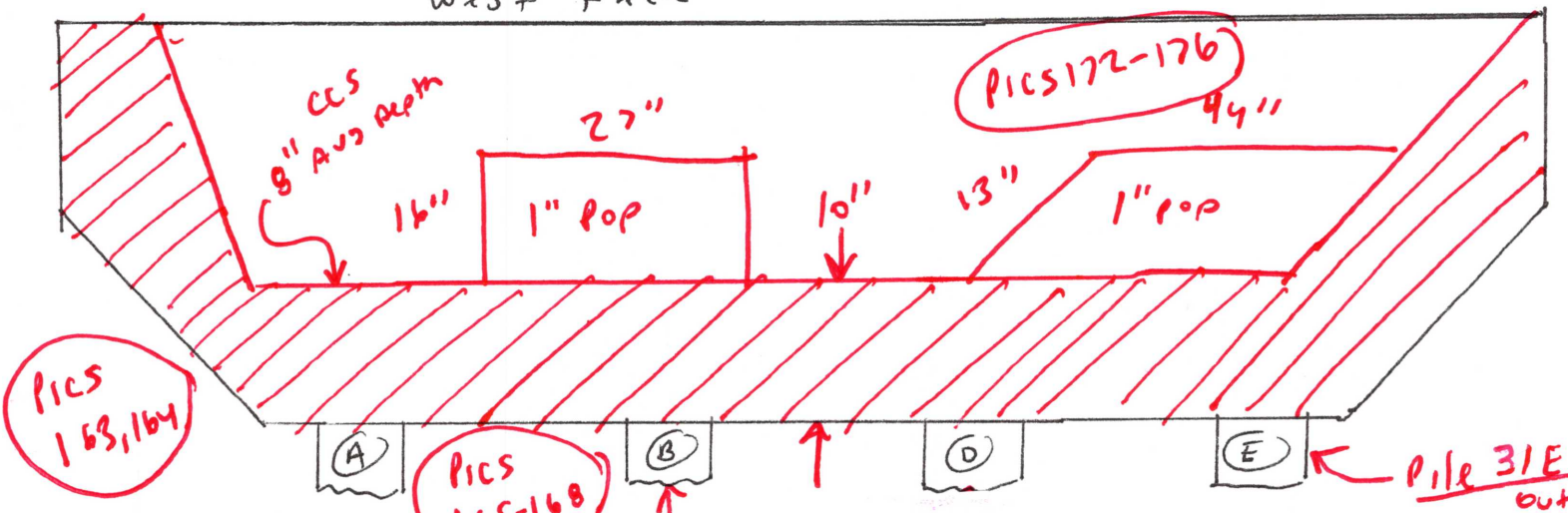
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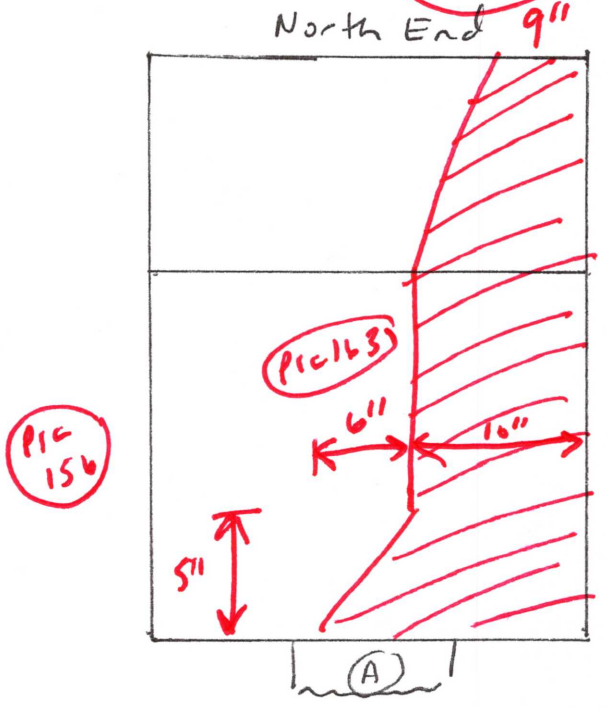
Bent 31

East Face



West Face

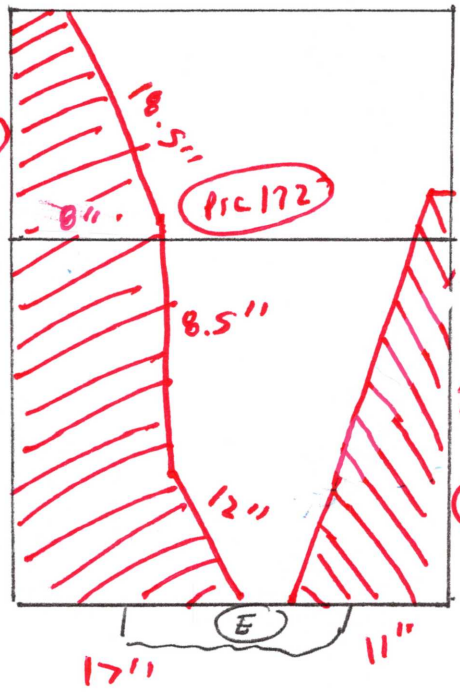




31B Out

Top 21 Jacket Split

Pics 183-185



Hermosa Beach Pier - 2024

Pile Cap – 4 Pile Bent

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11/5/2024

East Face

Bent 32



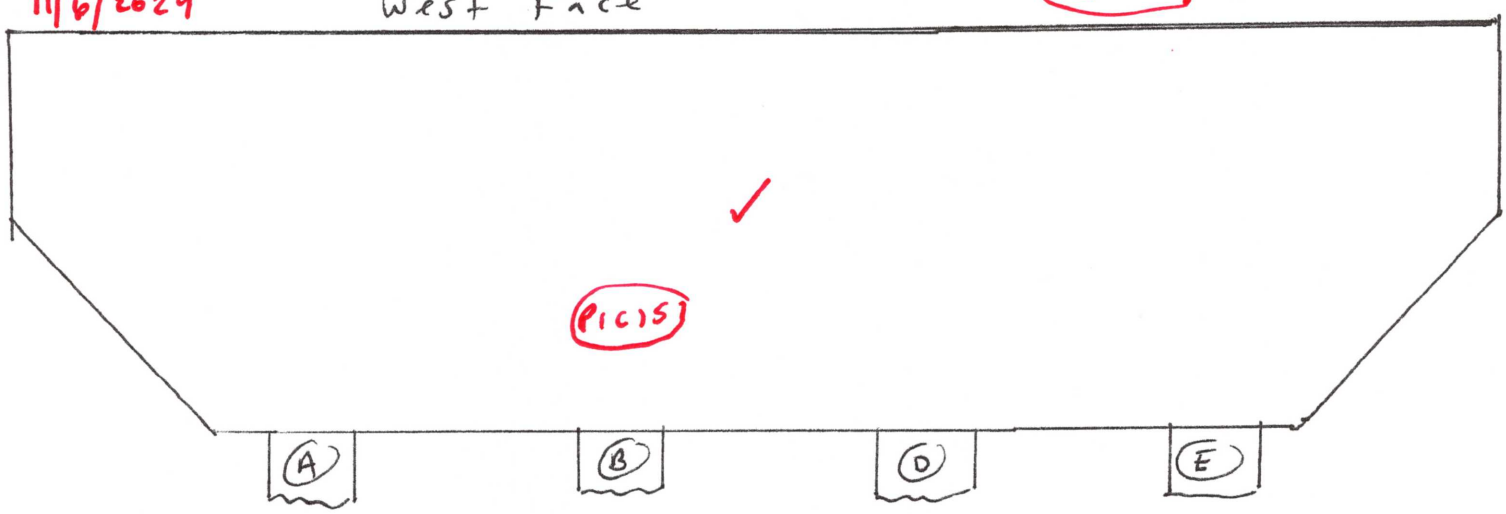
Pile 32 B R, I

Split in Top of Jacket (octagonal)

Pic 231

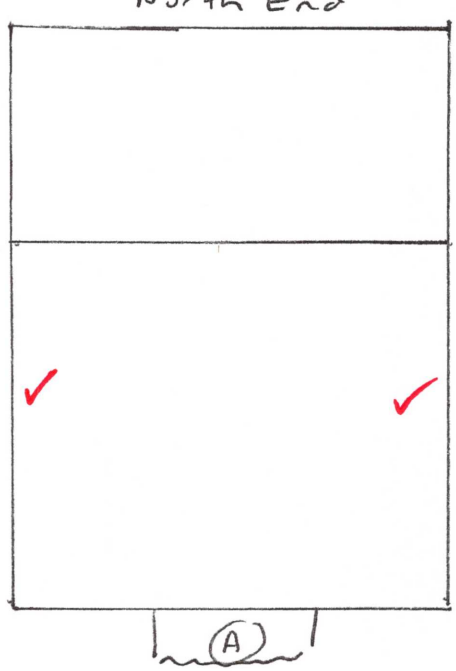
11/6/2024

West Face

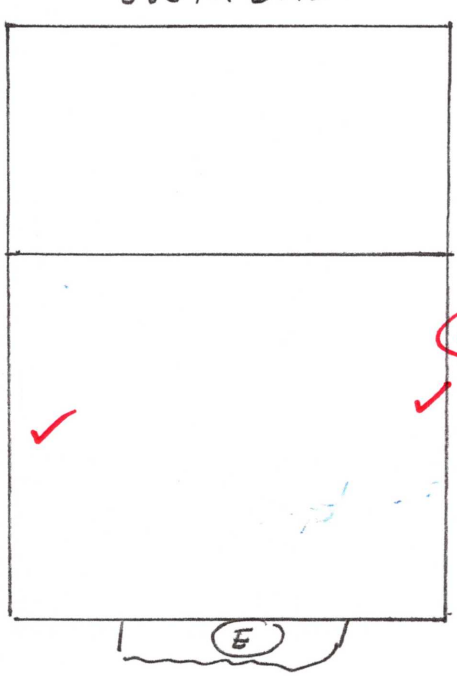


Pic 15

North End



South End



Pic 230

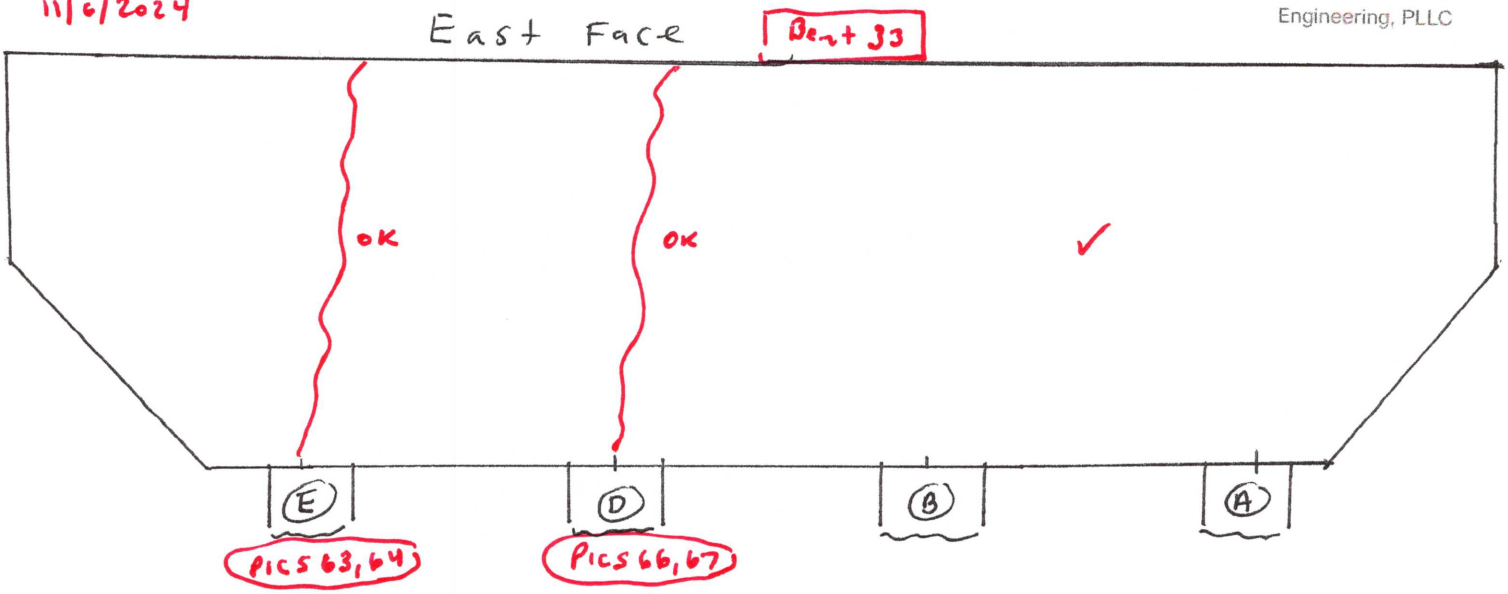
Hermosa Beach Pier - 2024

Pile Cap – 4 Pile Bent

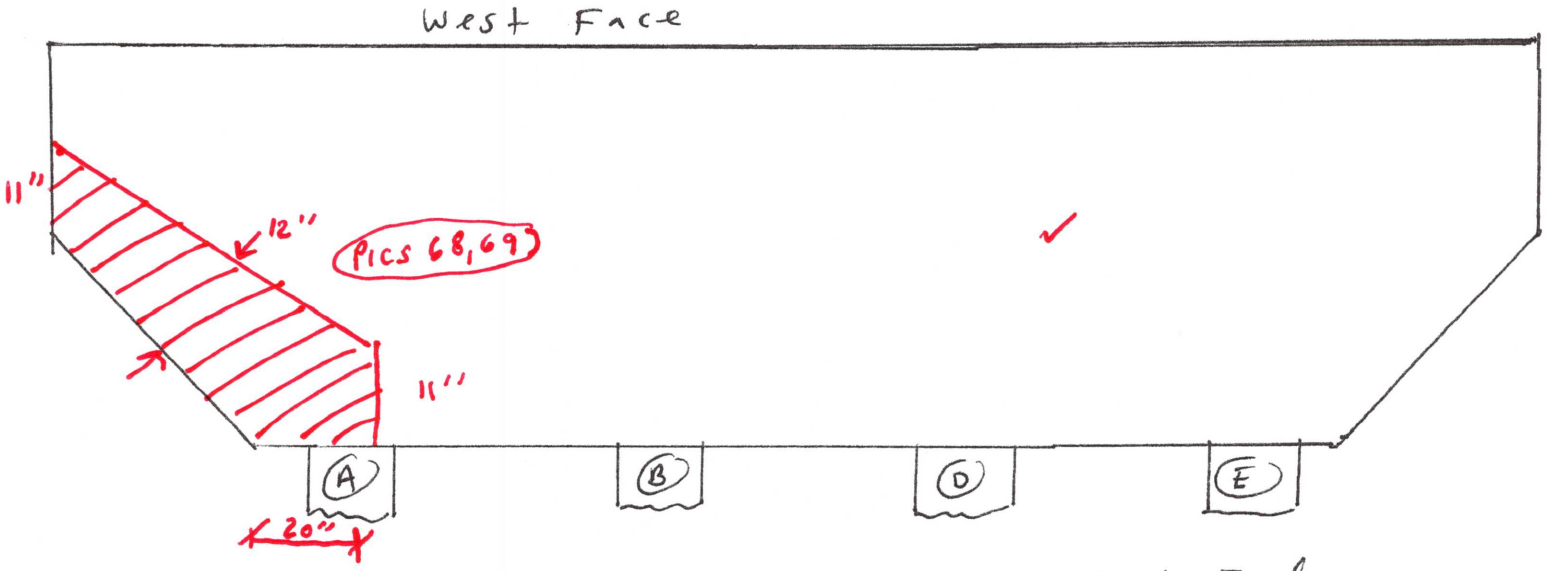
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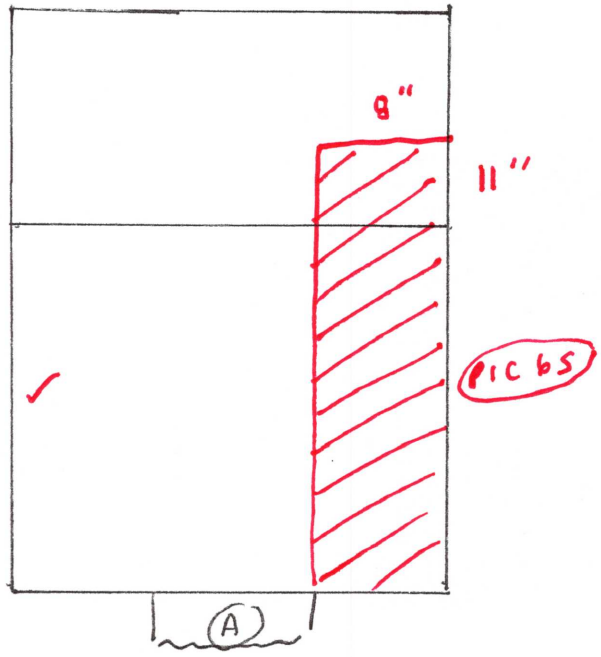
East Face



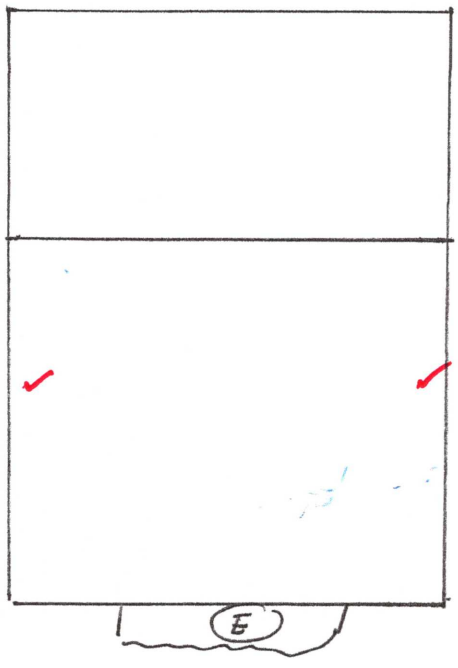
West Face



North End



South End



Hermosa Beach Pier 2024

Pile Cap – 7 Pile Bent – North

Bent 34

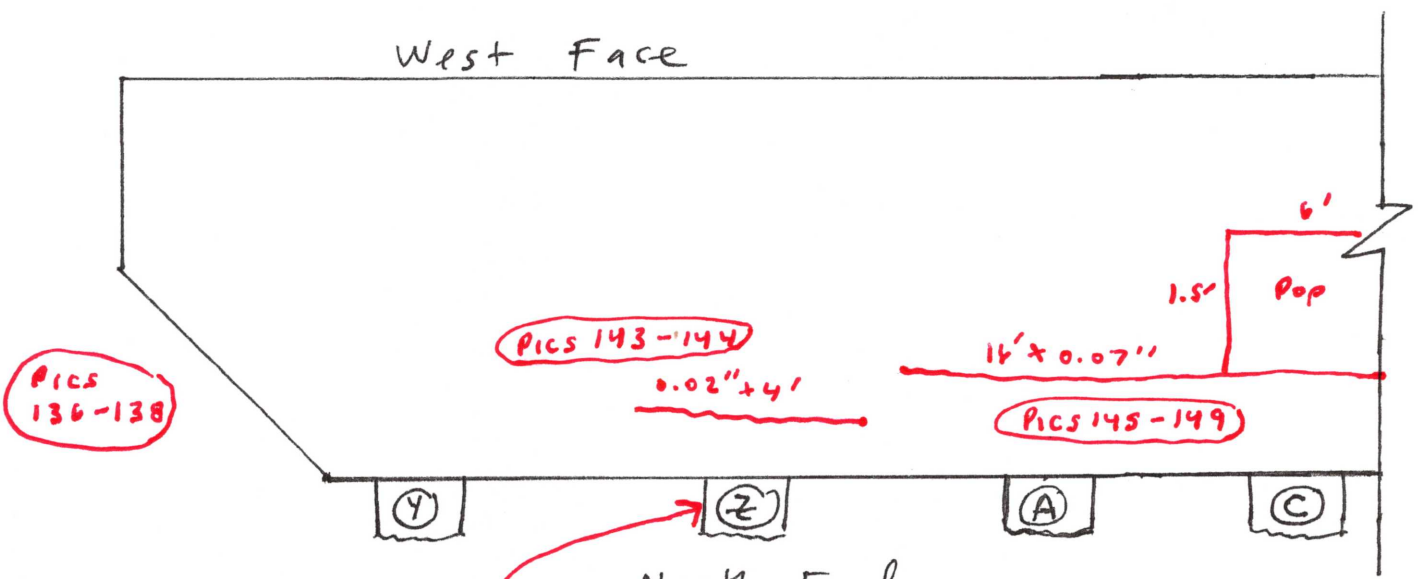
ESN Engineering, PLLC

East Face

11/6/2024



West Face

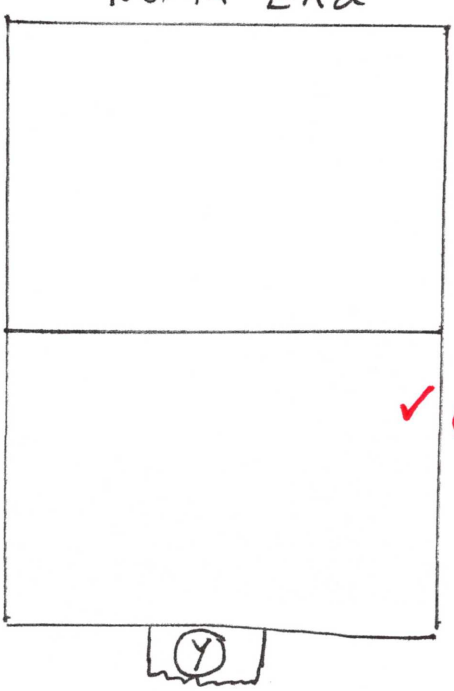


North End

Pile 34 Z out

CCS Top 3'

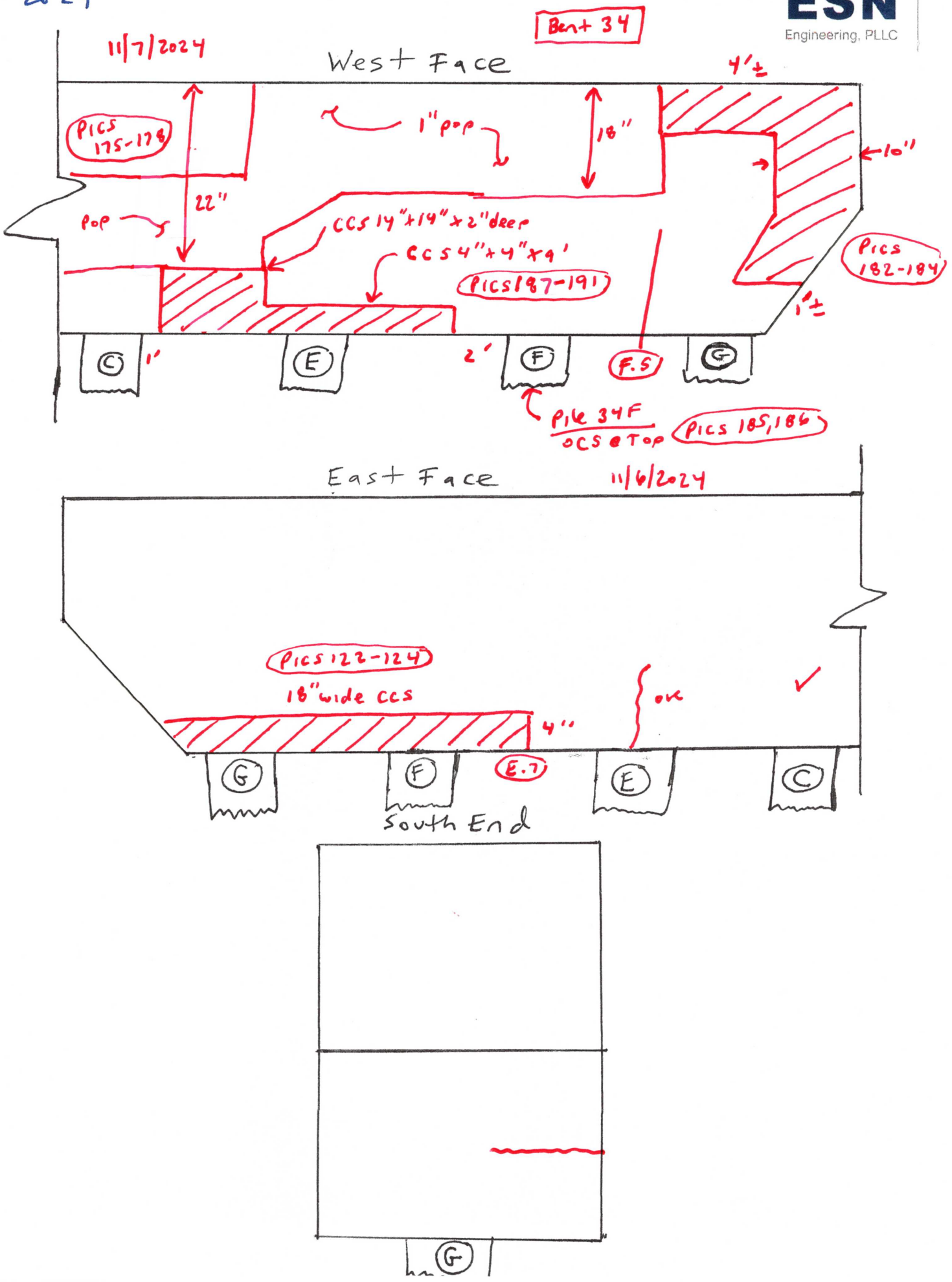
Pics 139-142, 150-153



Hermosa Beach Pier 2024

Pile Cap – 7 Pile Bent – South

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Hermosa Beach Pier 2024

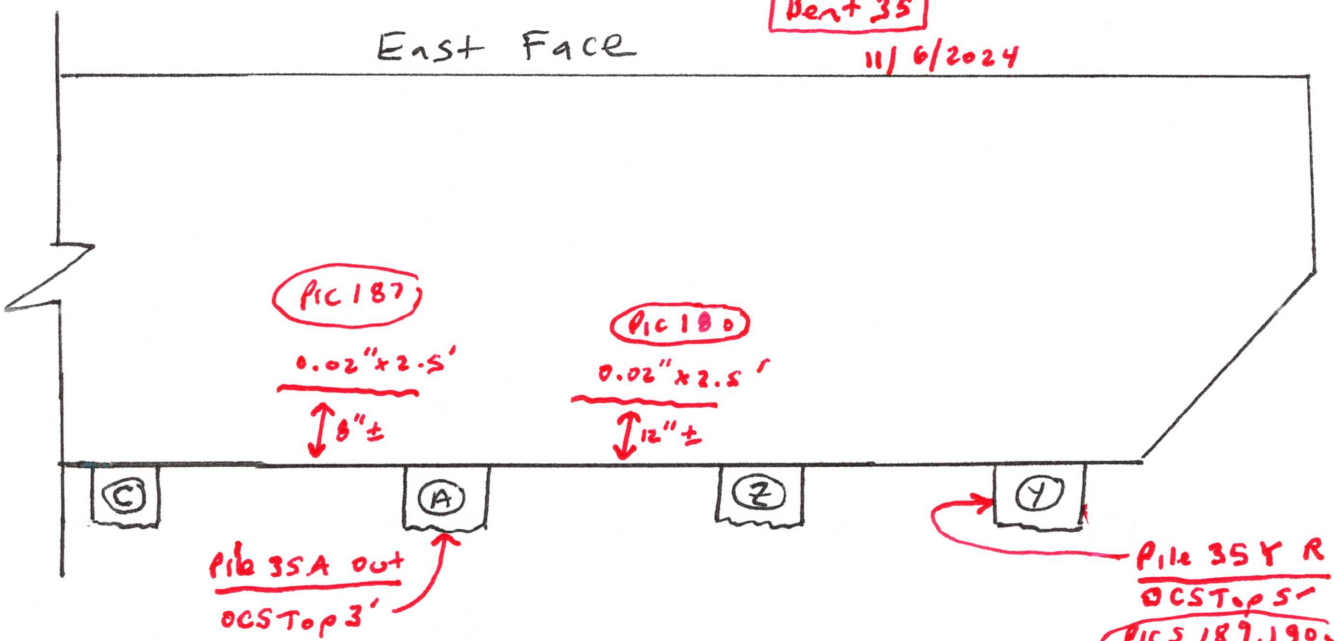
Pile Cap – 7 Pile Bent – North

ESN Engineering, PLLC

Bent 35

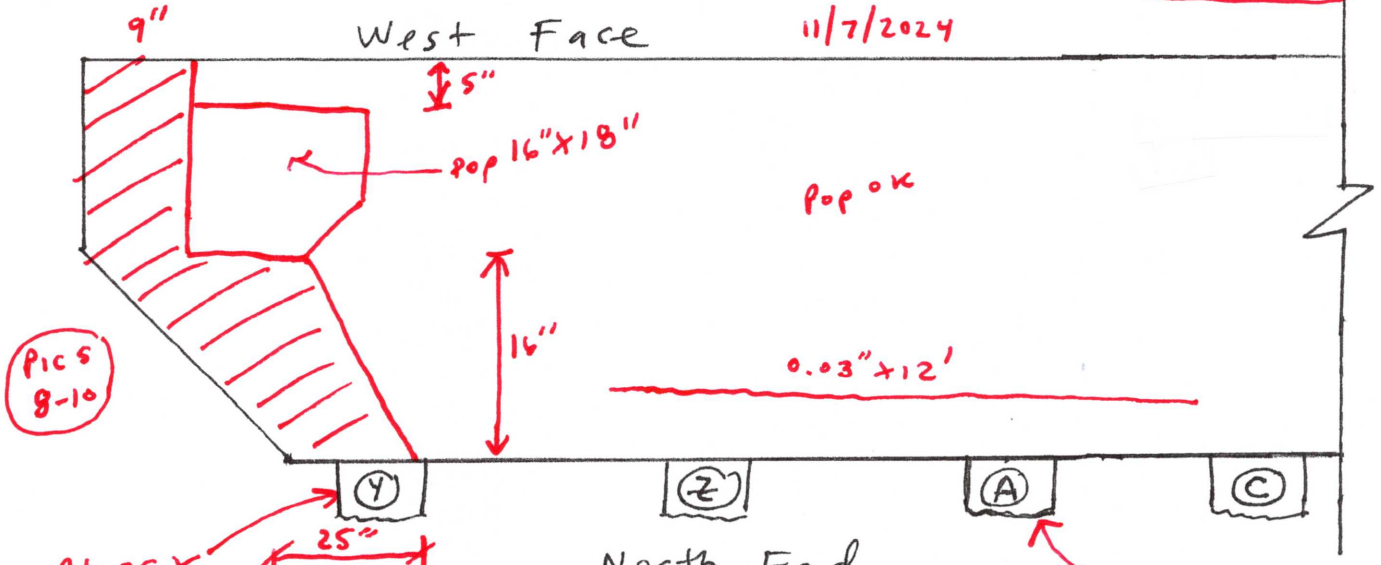
11/6/2024

East Face

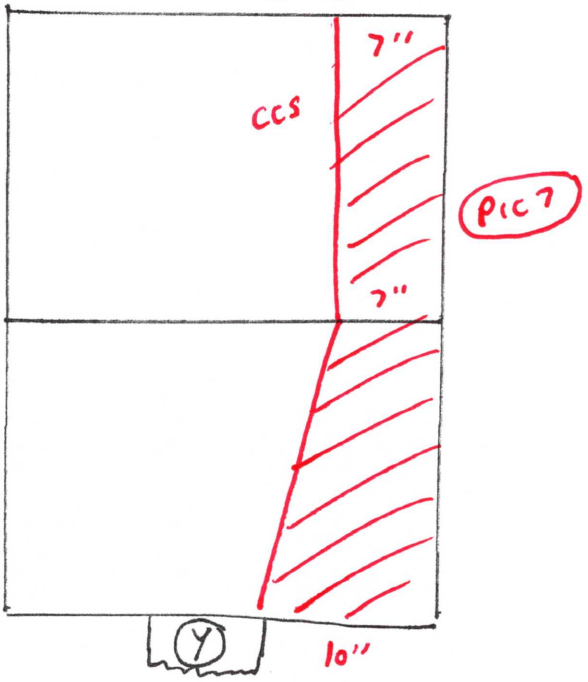


West Face

11/7/2024



North End

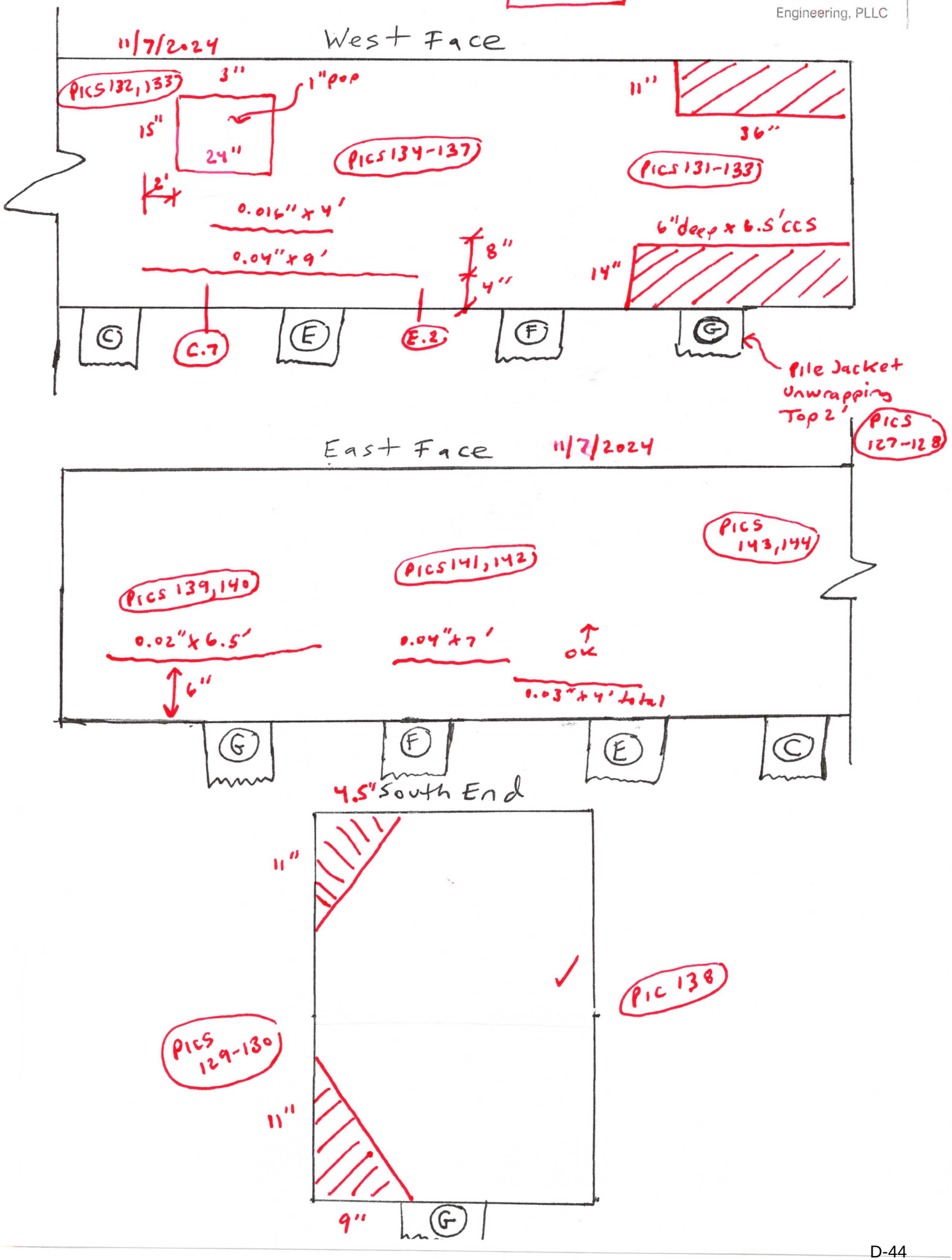


Hermosa Beach
Pier 2024

Pile Cap – 7 Pile Bent – South

Bent 35

ESN
Engineering, PLLC



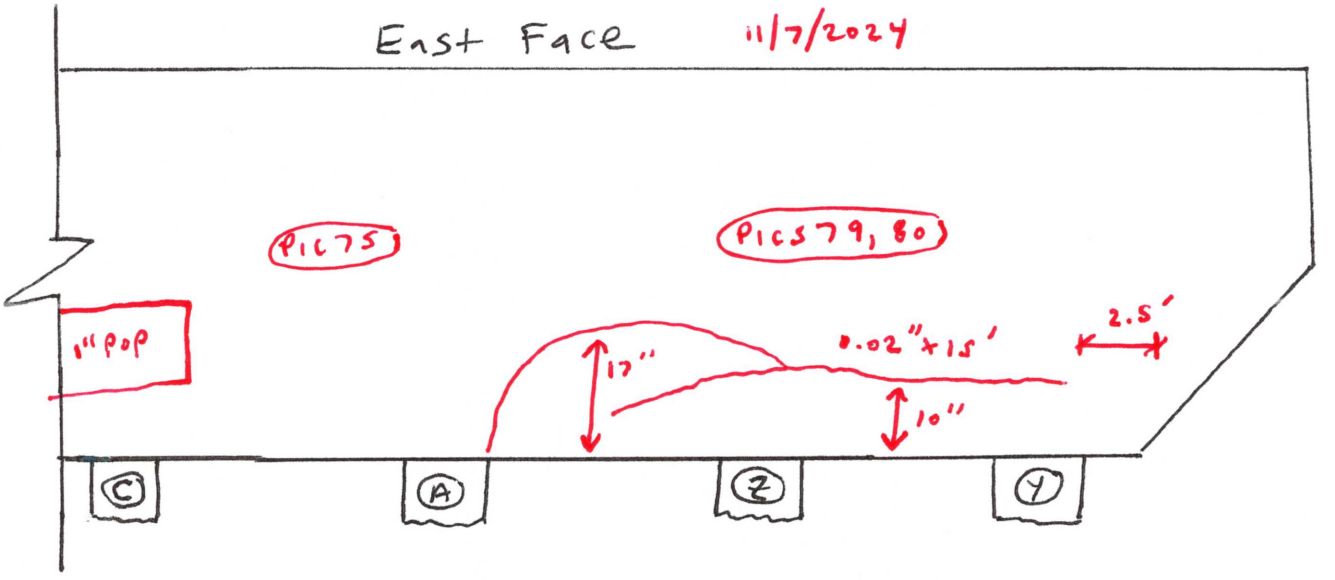
Hermosa Beach Pier 2024

Pile Cap – 7 Pile Bent – North

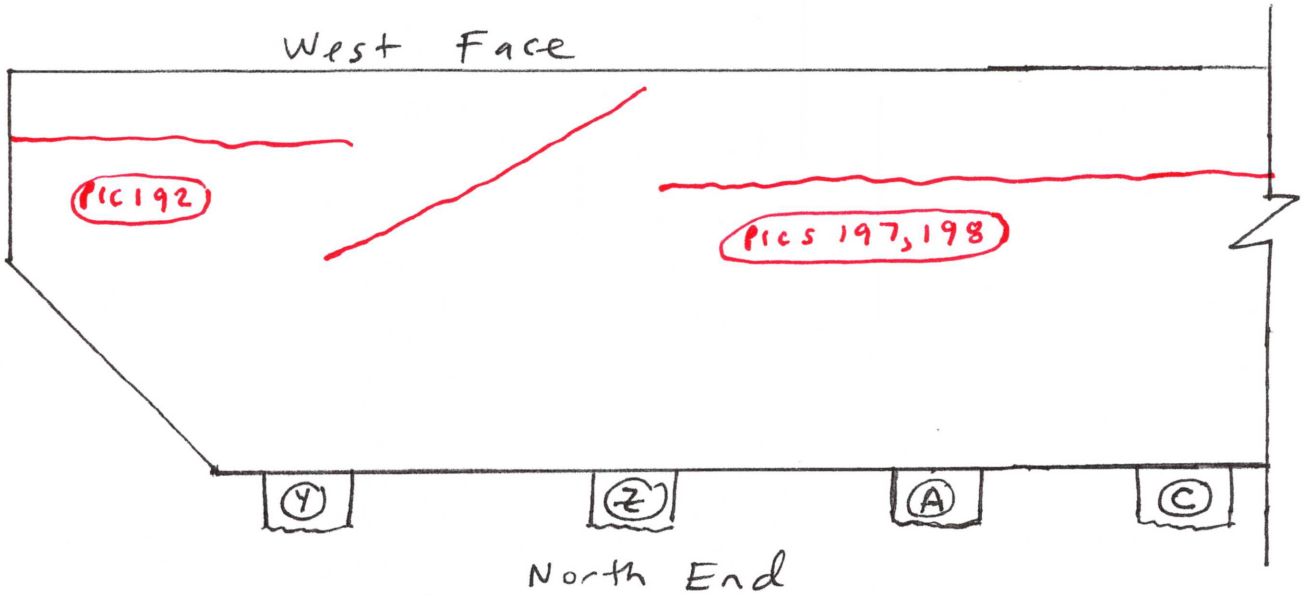
Bent 36

ESN Engineering, PLLC

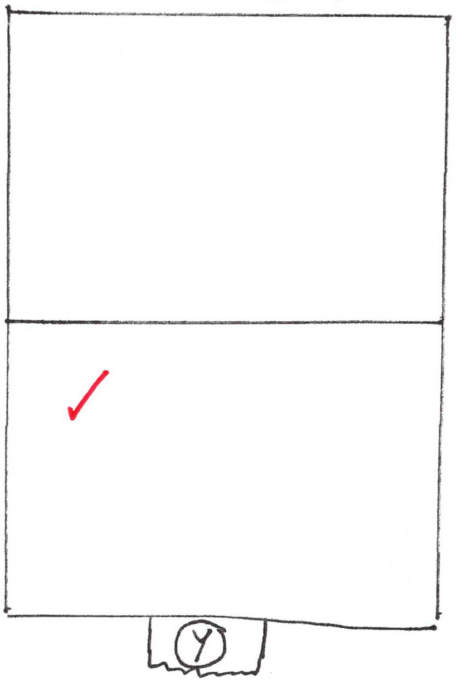
East Face 11/7/2024



West Face



North End



Hermosa Beach Pier 2024

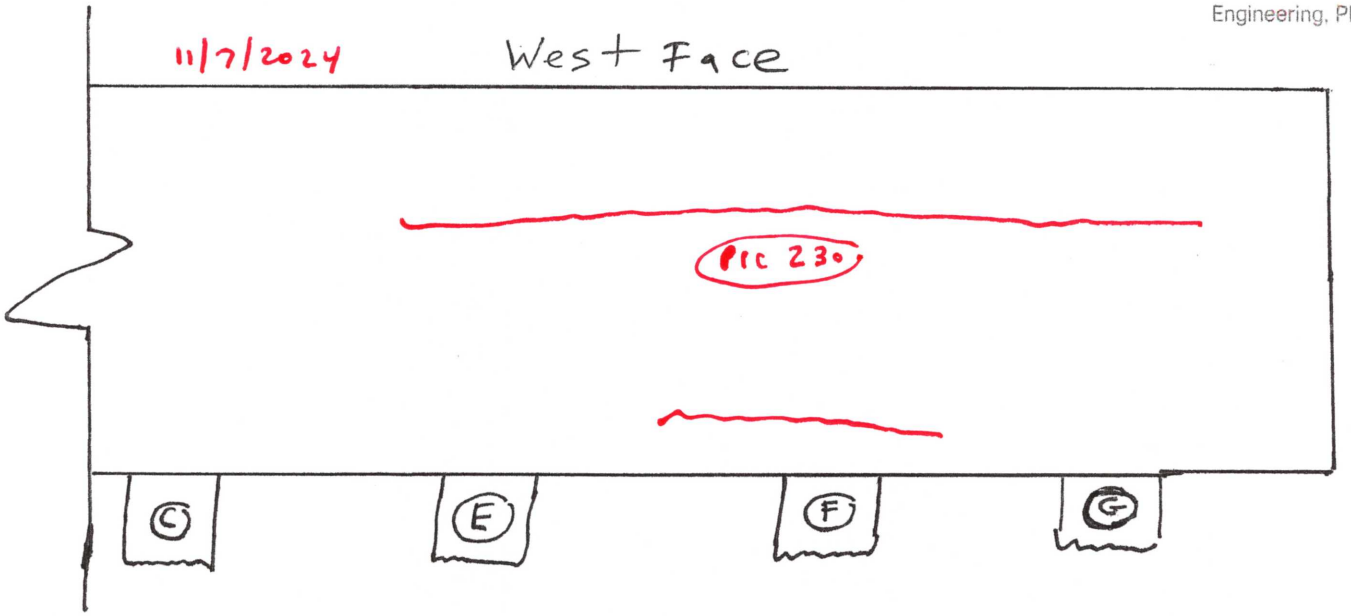
Pile Cap – 7 Pile Bent – South

Bent 36

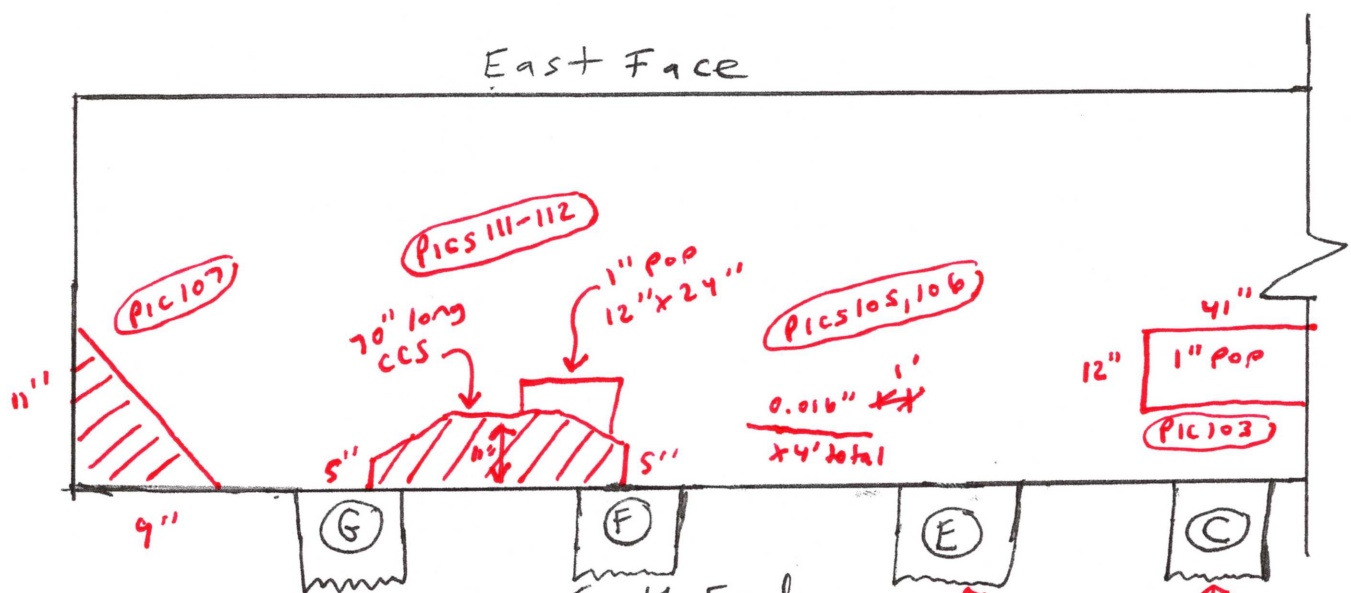
ESN Engineering, PLLC

11/7/2024

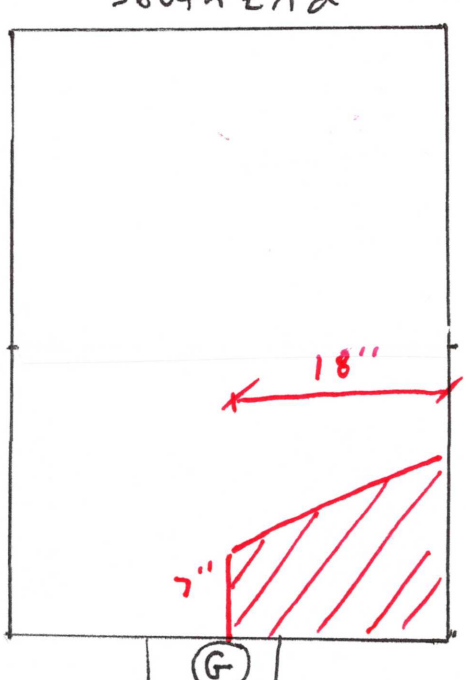
West Face



East Face



South End



Pile 36 C, I
CCS Top 4'
Pics 73, 74

Pile 36 E, O
CCS Top 4'
Pics 91-93

Pics 107-110

Hermosa Beach Pier - 2024 Condition Assessment

Pile Cap Repair Recommendations

ESN Engineering, PLLC

Bent	Approx. Spall Repair Volume (CF) Repairs within 5 years				Notes	Observed Defect: Repairs Beyond 5 years
	East	West	North	South		
1						
2						
3		1.36			CCS	
4			0.93		CCS	
5		4.93	0.47	0.52	CCS	
6		1.88			CCS	
7	5.03				CCS	
8	3.06	3.59			CCS	
9	1.22	3.37			CCS	
10	0.63	4.12	1.31		CCS + OCS w/ exposed reinforcing	West: Surface Spall
11	1.53	2.05			CCS	West: Surface Spall
12						
13	4.92	5.86	0.63	0.97	CCS + OCS	
14	0.66	10.67			CCS	
15	9.81	1.11		0.44	CCS	
16	1.75	4.28			CCS	
17	1.14	1.36	0.88		CCS	West: Soffit Spall Repair in 5 years
18	2.10				CCS	
19	4.80	9.21	0.44		CCS	
20	12.99	5.97	1.69	2.16	CCS	South: Spall Repair in 5 years
21	2.14	9.75	1.02		CCS	East & West: Surface Spalls
22	2.67	2.51			CCS East: DCR 0.03" x 2'	
23	1.64	1.13			CCS	
24	8.17	1.66	2.35	9.43	CCS	
25						East: Repair Previous Patch in 5 years
26		0.75			CCS	
27		1.02			CCS	
28	4.61	2.01		0.32	CCS	
29		1.25	1.03	1.00	CCS + OCS	
30						
31	4.09	10.00	1.25	1.90	CCS	
32						

Bent	Approx. Spall Repair Volume (CF) Repairs within 5 years				Notes	Repairs Beyond 5 years
	East	West	North	South		
33		2.00			CCS	
34	11.00	3.14			CCS West: HCR 0.02" x 4', 0.07" x 16'	
35		6.38	1.50		CCS East: HCR 0.02"x 11.5', 0.03" x 4', 0.04" x 7' West: HCR 0.016" x 4', 0.03" x 12', 0.04" x 9'	
36	1.88		0.35	0.47	CCS East: HCR 0.016" x 4', 0.02" x 15' West: HCR estimated 40'	

Estimated Spall Repair Total Volume = 218 CF

Estimated Total Crack Injection Length = 129 LF

Pile Cap Repair Assumptions

1) Spall repair depth is assumed to be 5" unless measured as greater than 5".

Abbreviations

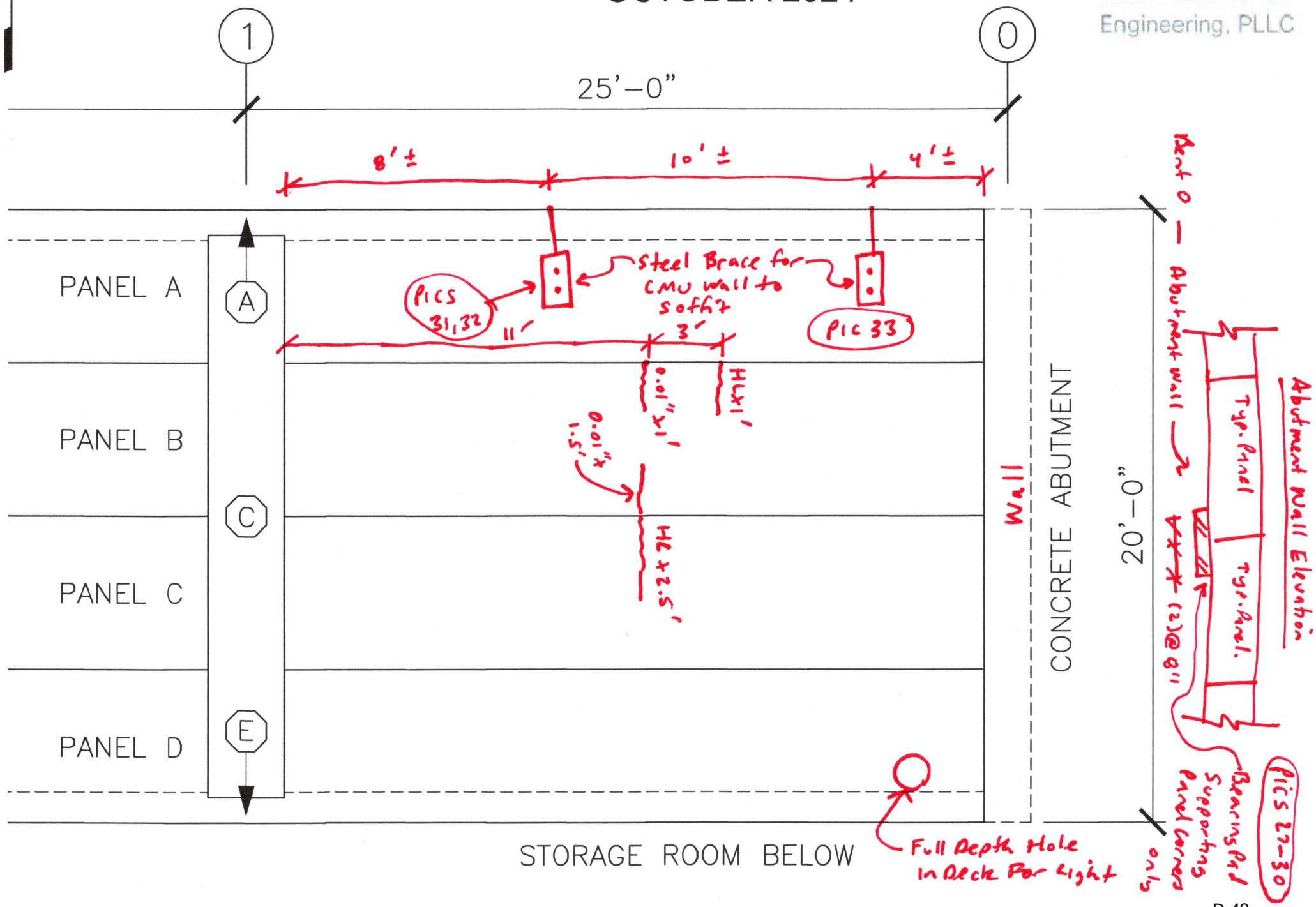
LF = Linear Feet
SF = Square Feet
CF = Cubic Feet
bot. = bottom
CCS = Closed Corrosion Spall
OCS = Open Corrosion Spall
VCR = Vertical Crack
DCR = Diagonal Crack
HCR = Horizontal Crack

10/17/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

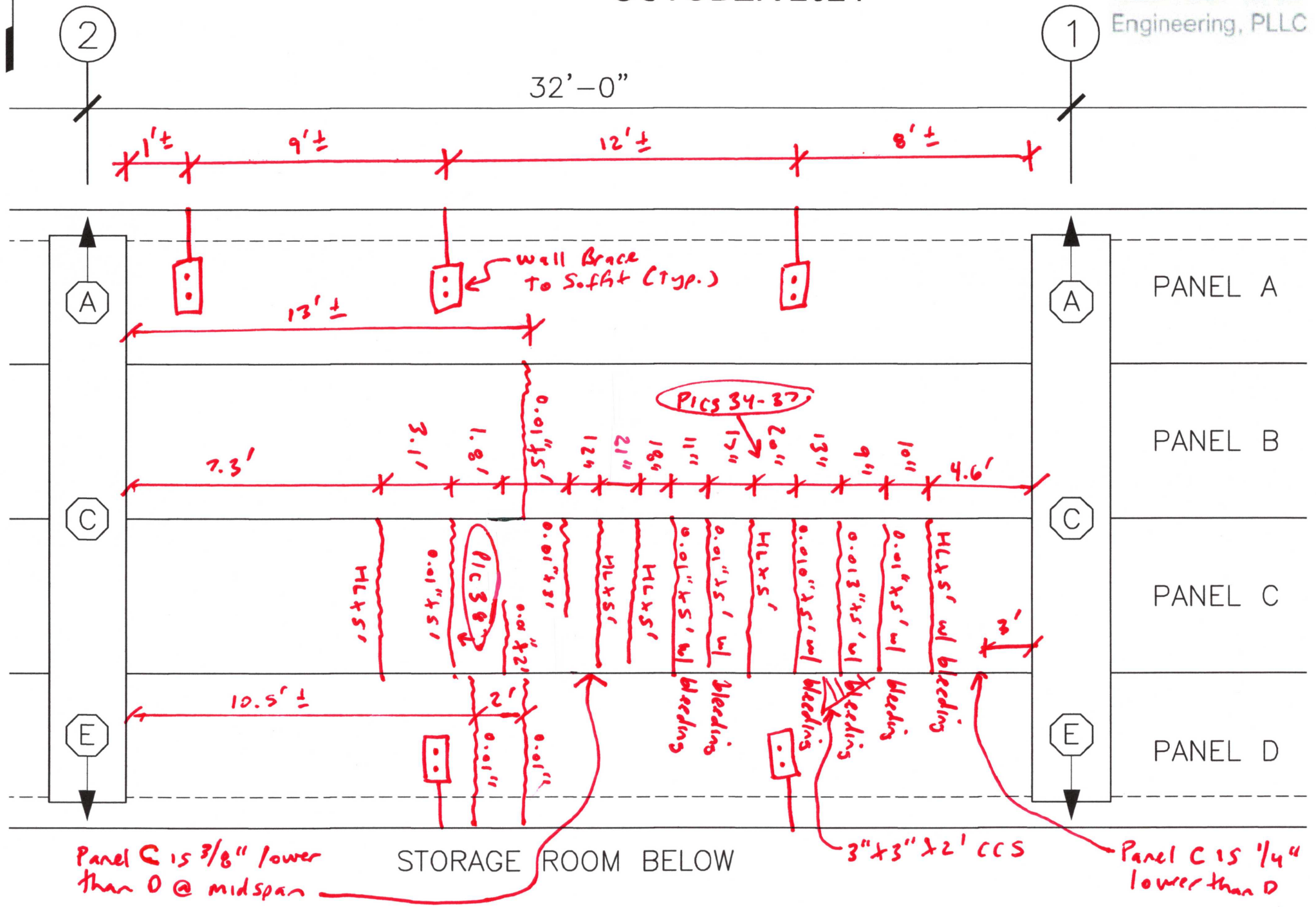


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HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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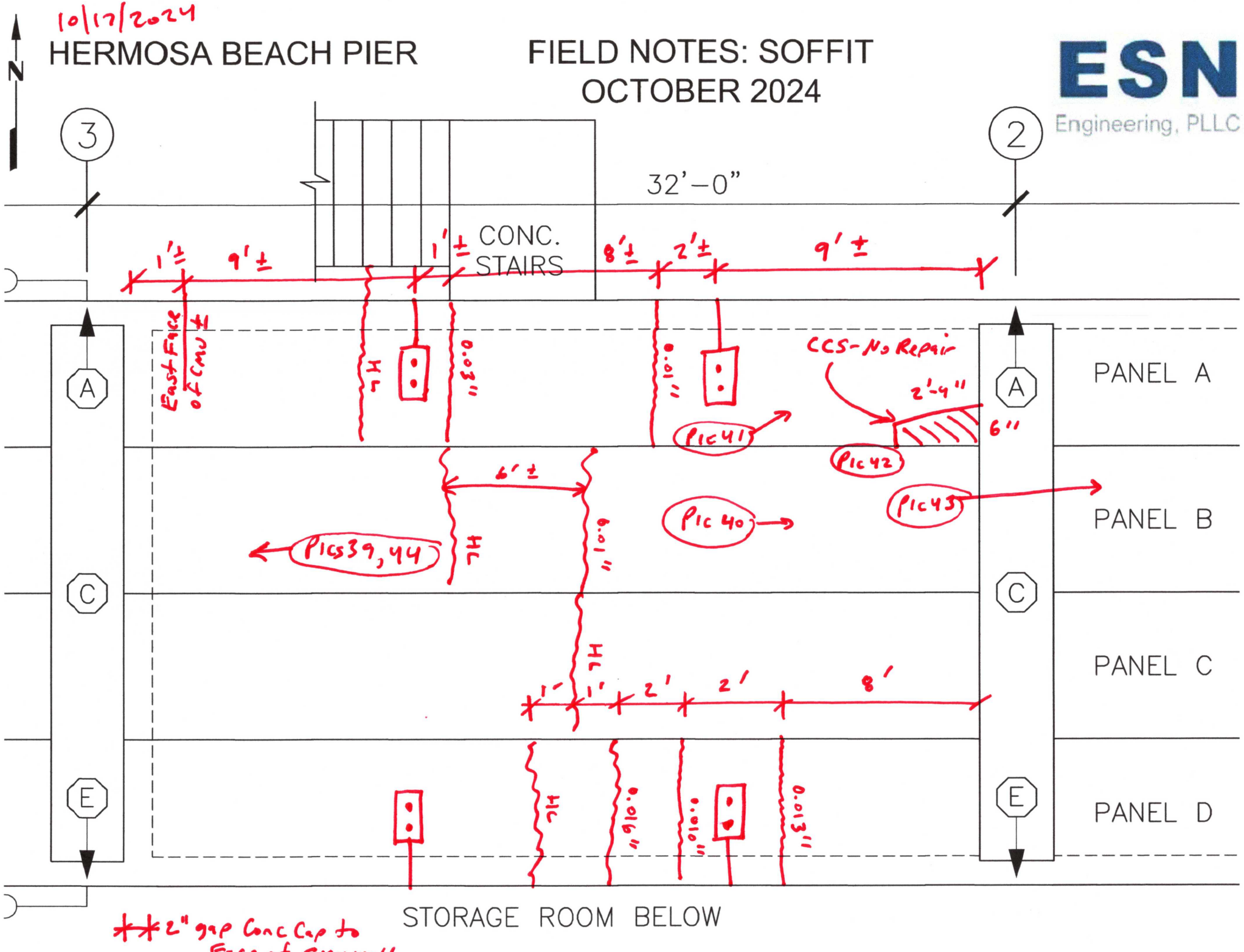


10/17/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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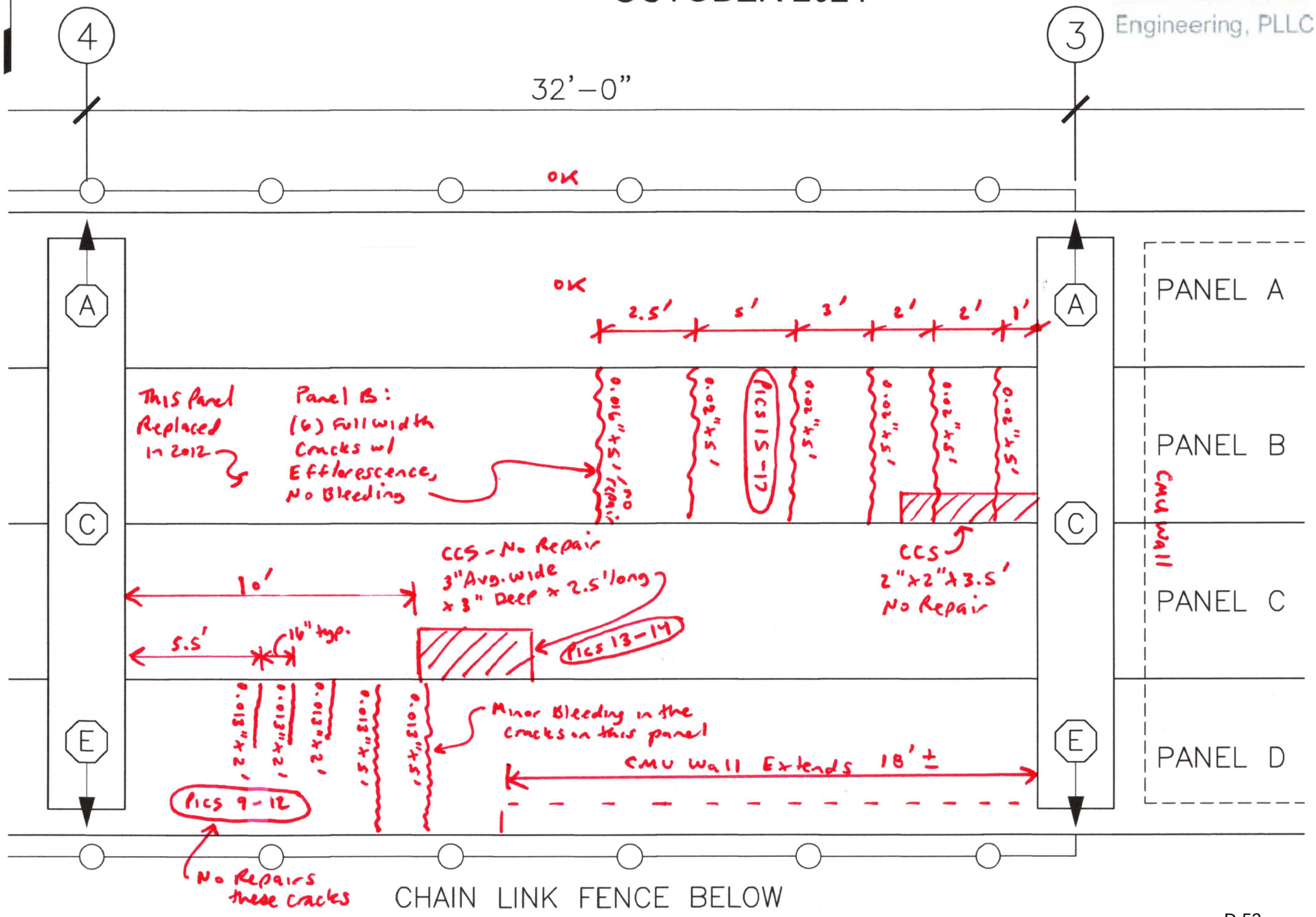
** 2" gap Conc Cap to Face of CMU wall

10/15/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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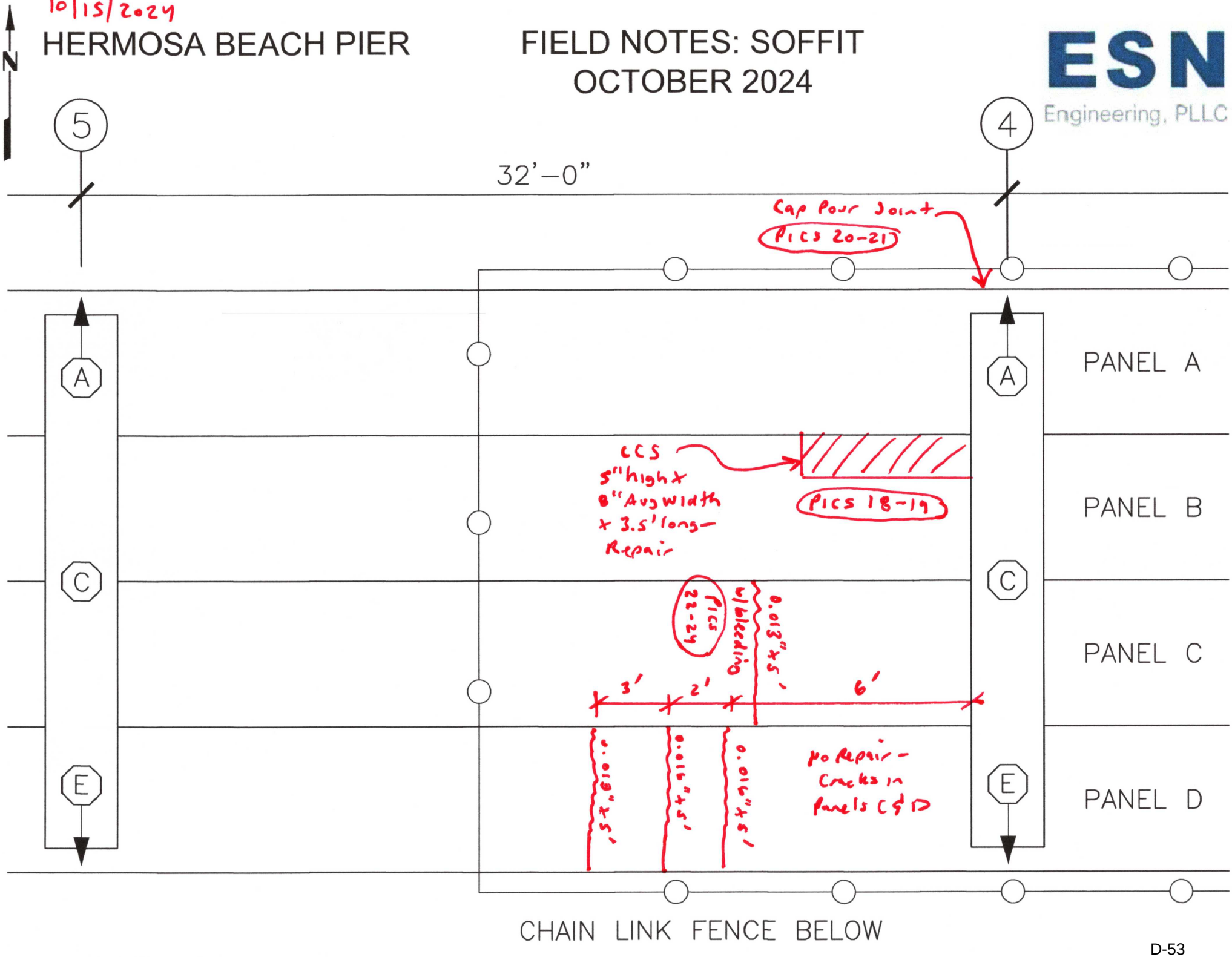


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HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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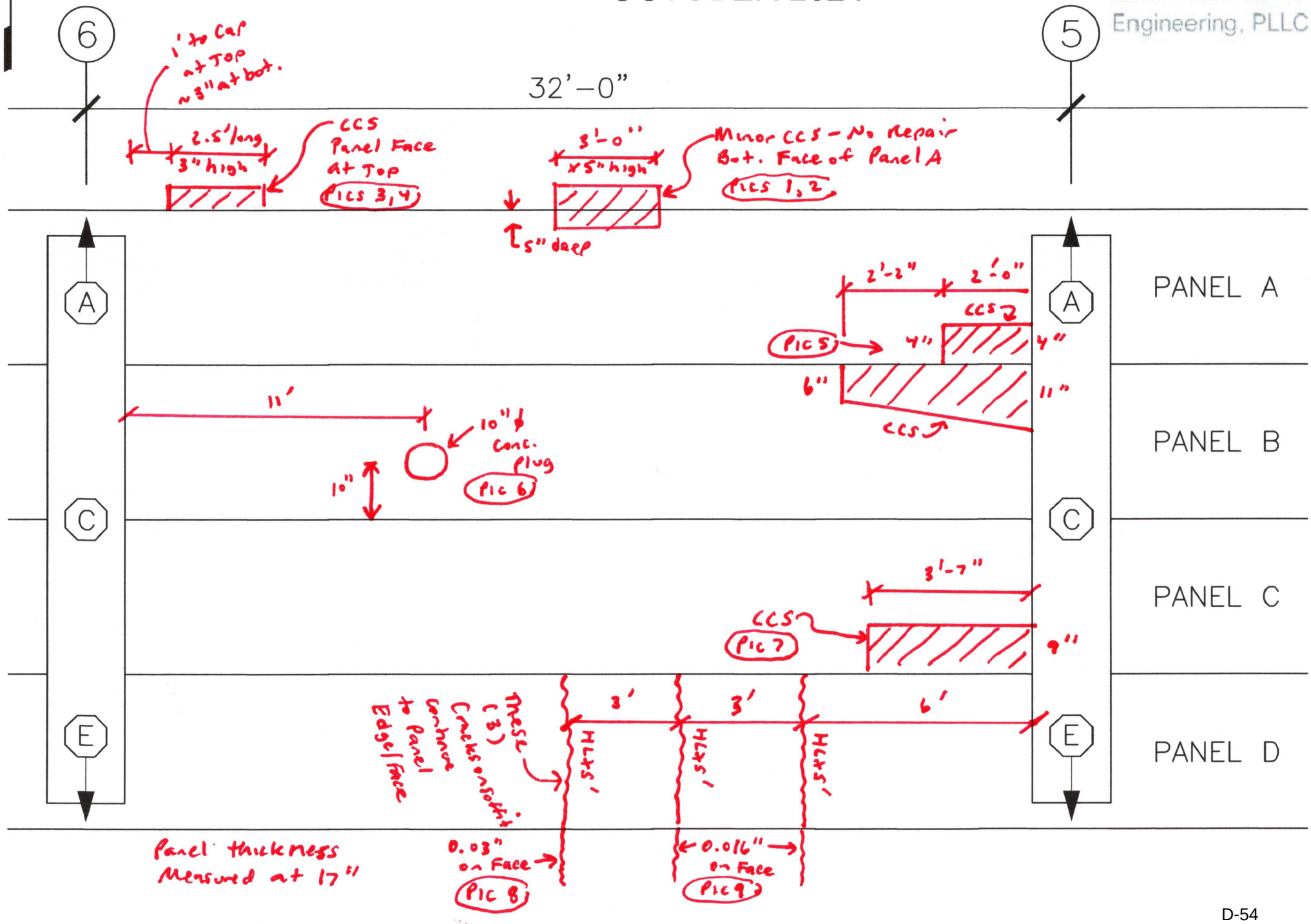


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HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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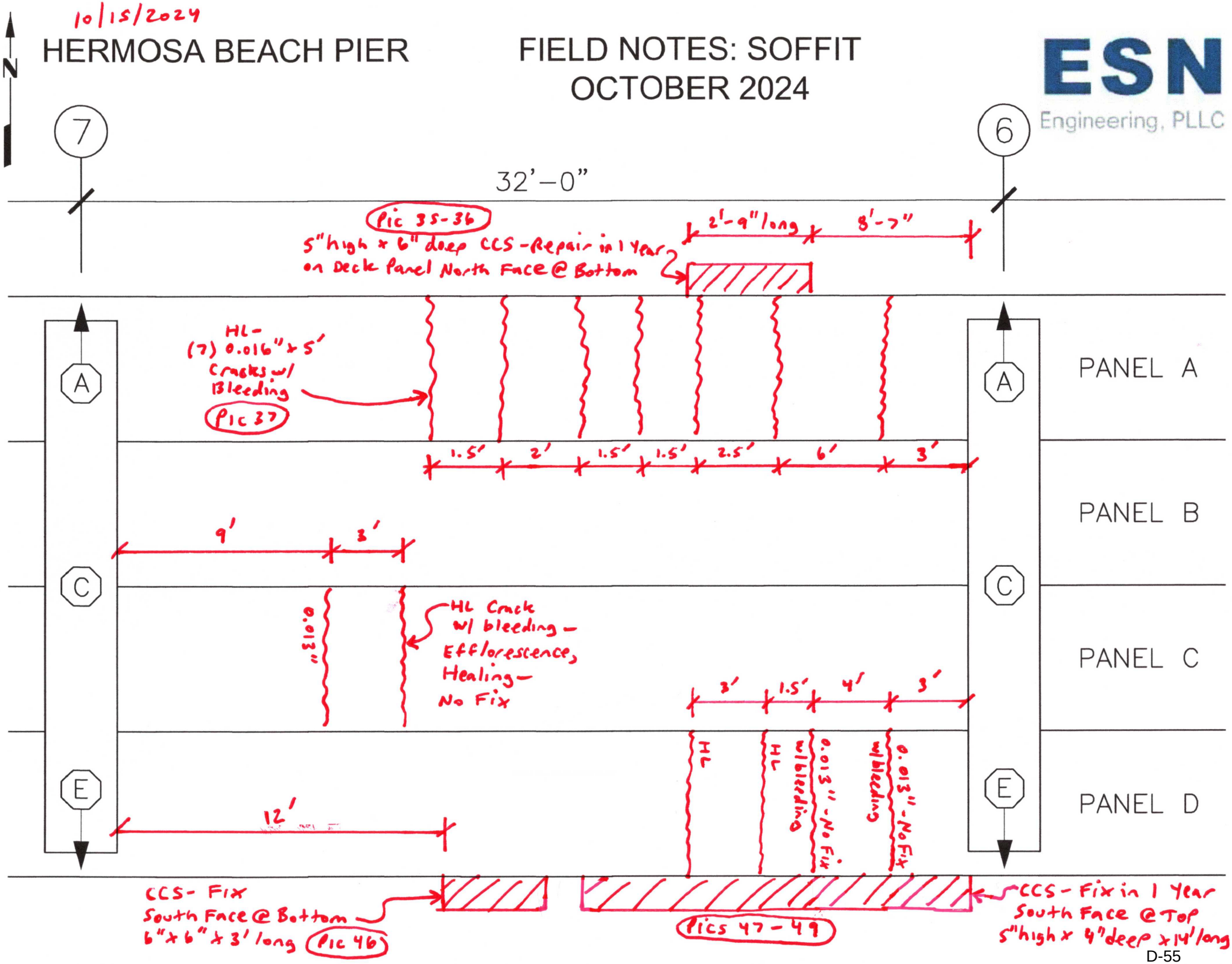


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HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

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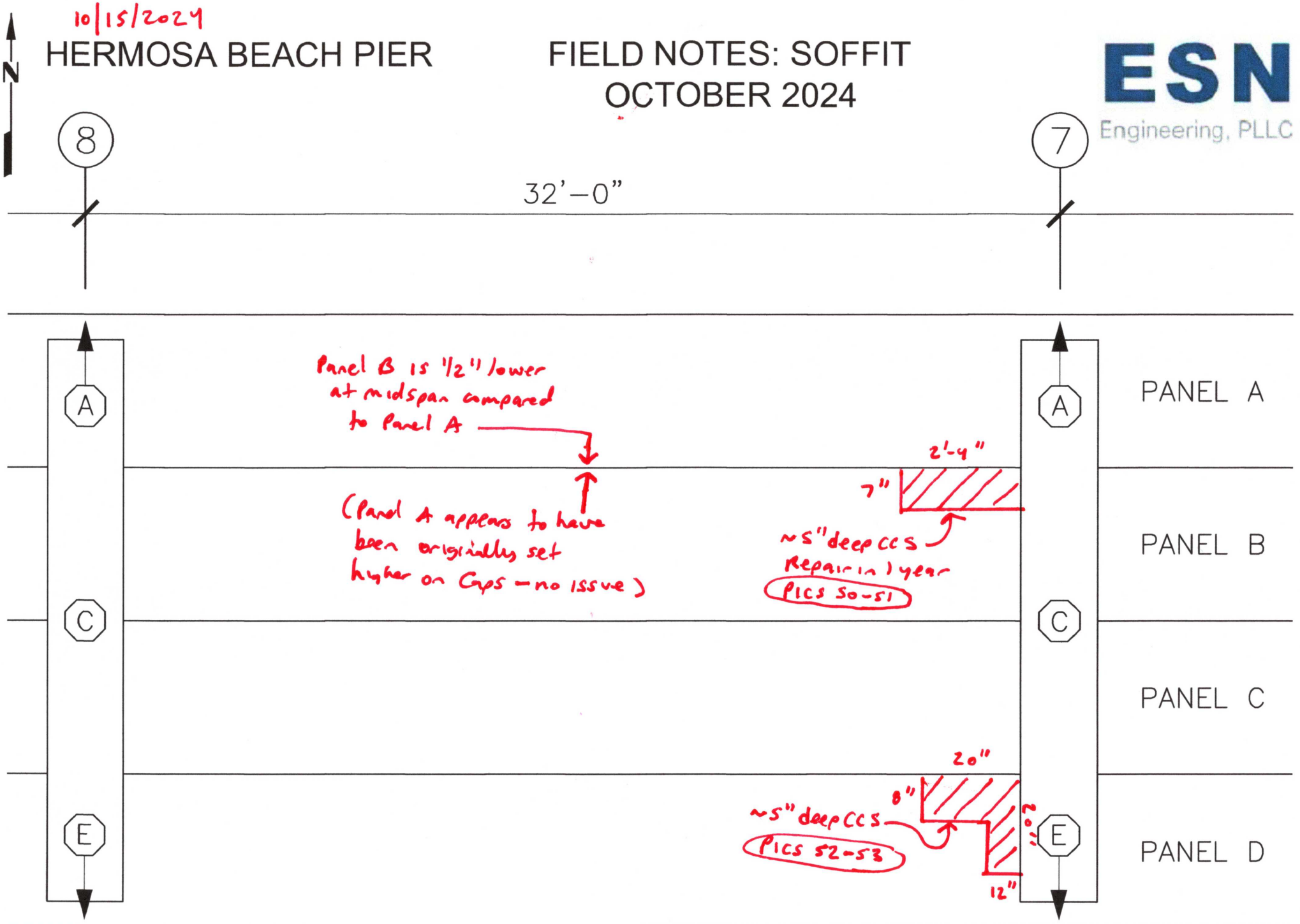


10/15/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

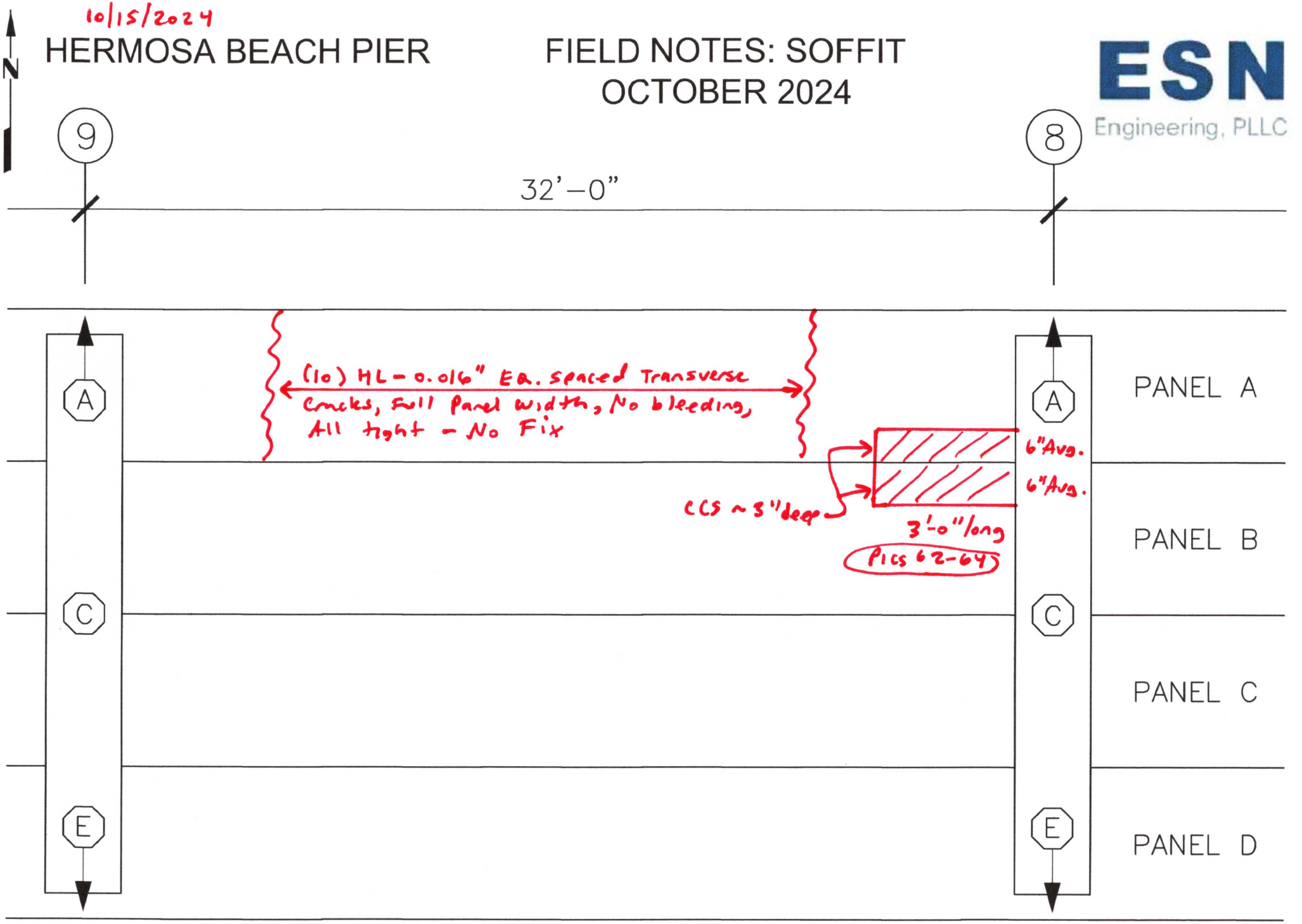


10/15/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

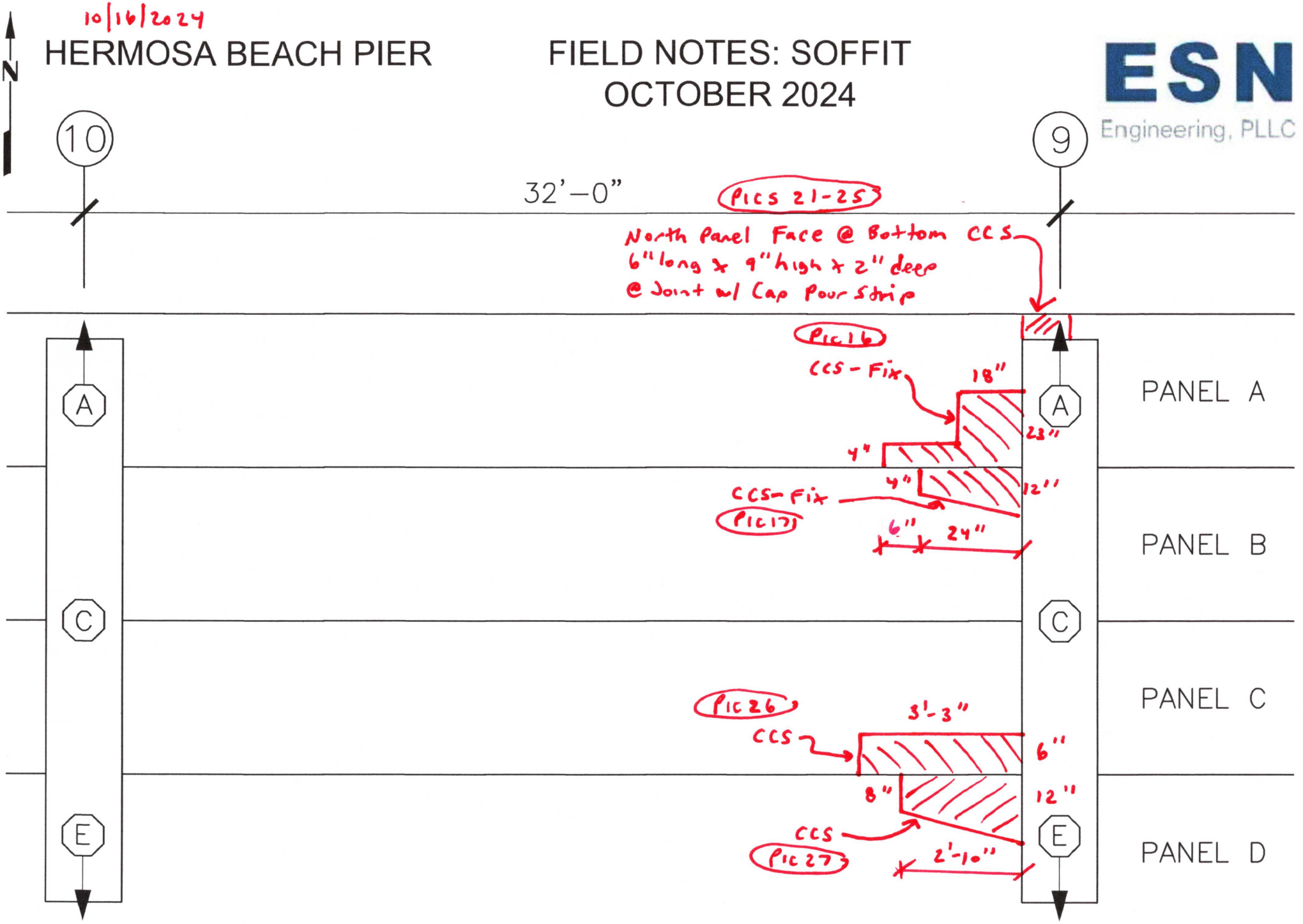


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

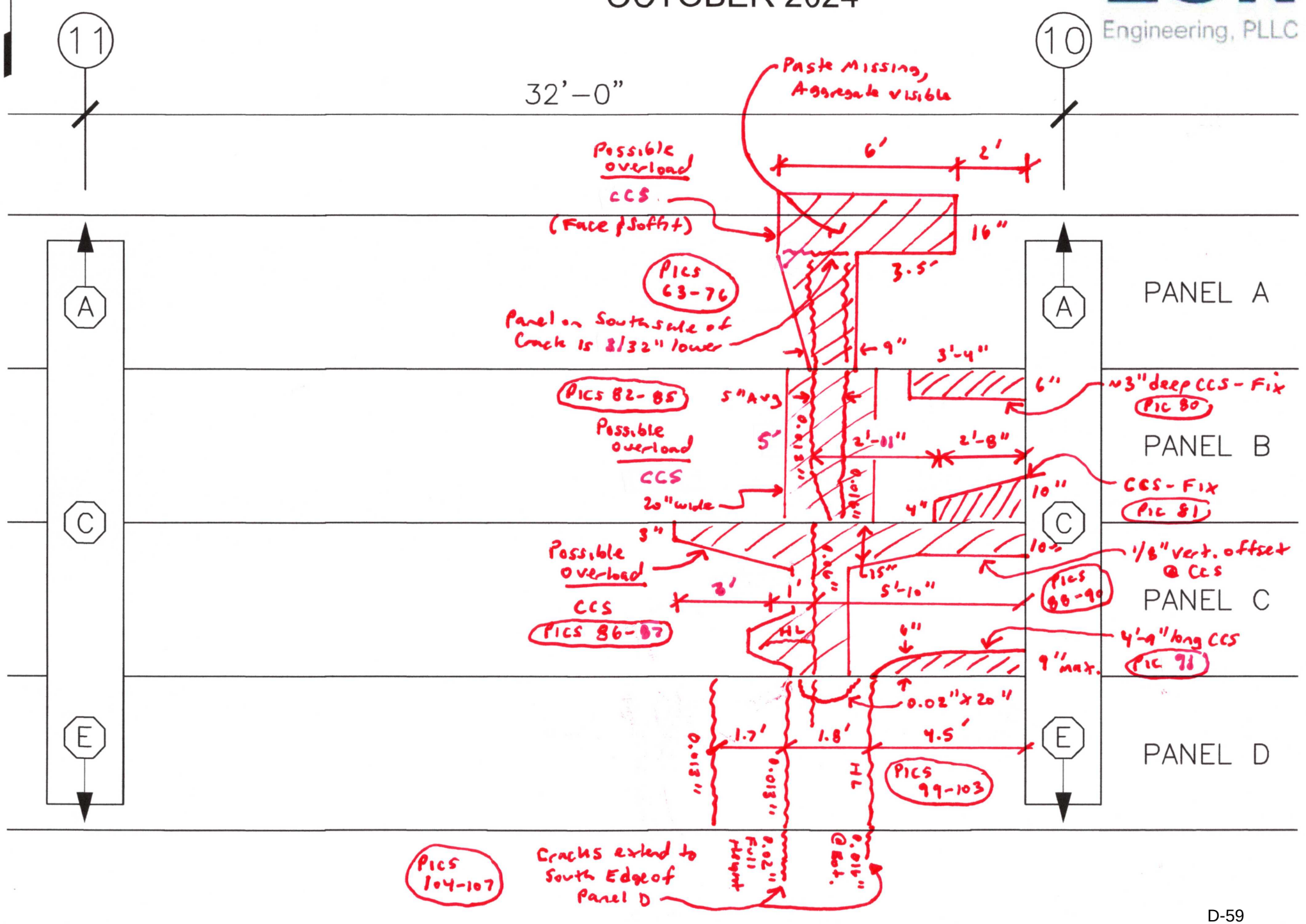


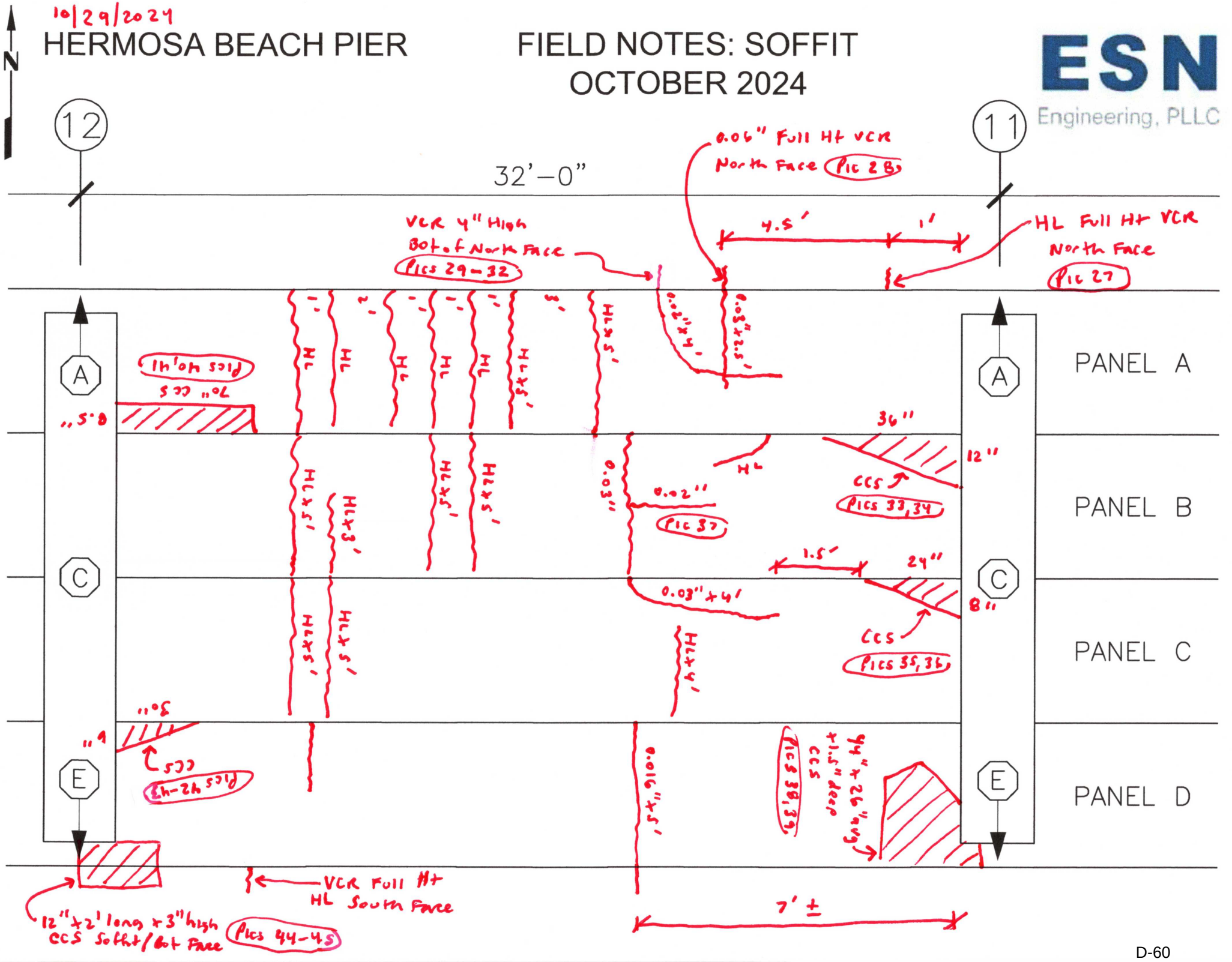
10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC



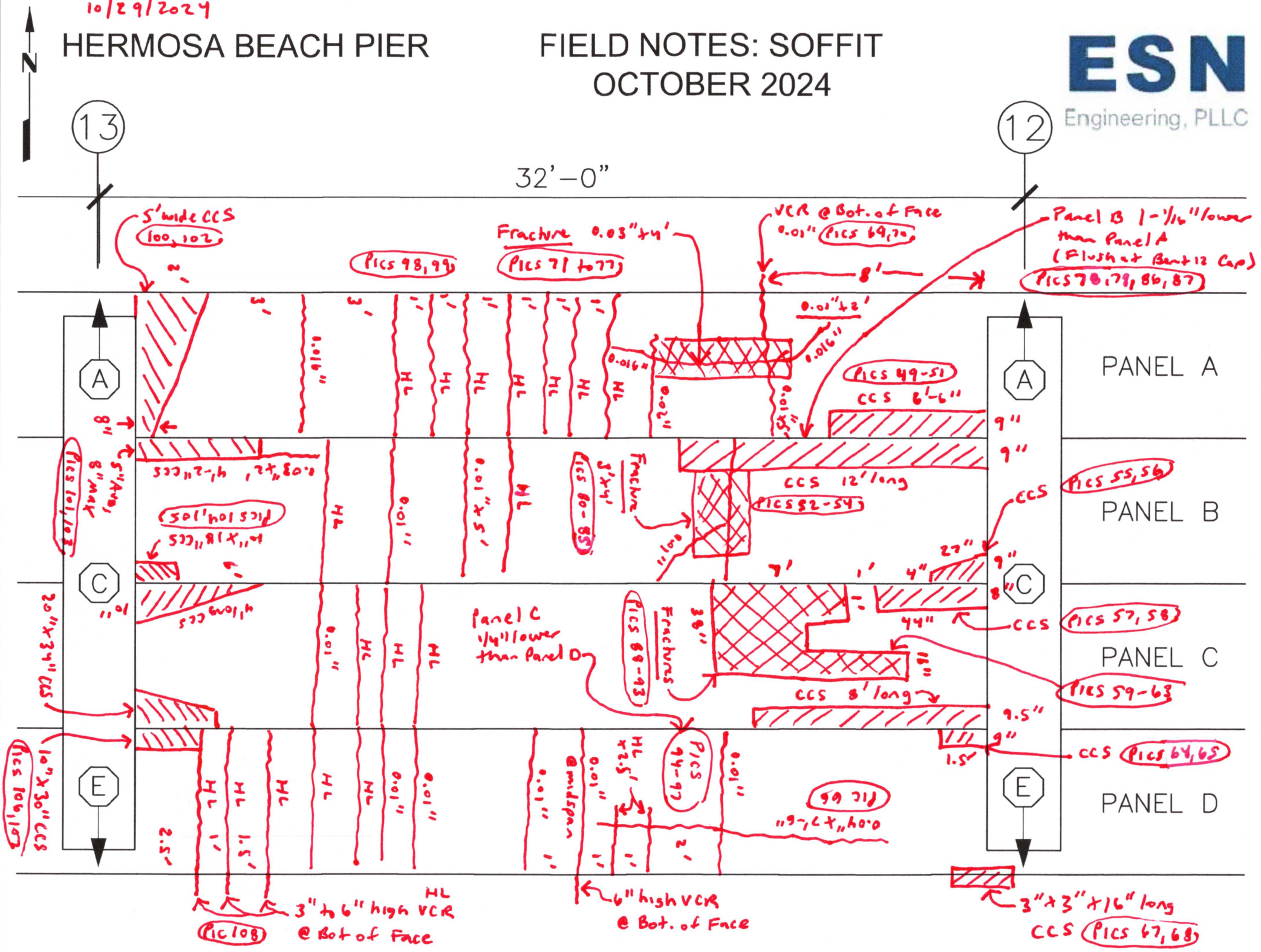

10/29/2024
HERMOSA BEACH PIER
FIELD NOTES: SOFFIT
OCTOBER 2024
ESN
Engineering, PLLC
N
12
11
32'-0"
0.06" Full Ht VCR
North Face
Pic 28
VCR 4" High
Bot of North Face
Pics 29-32
4.5'
1'
HL Full Ht VCR
North Face
Pic 27
A
C
E
PANEL A
PANEL B
PANEL C
PANEL D
HL
0.03"x2.5'
0.02"
Pic 37
36"
12"
CCS
Pics 33,34
1.5'
24"
8"
0.03"x4'
CCS
Pics 35,36
0.03"x10'
Pics 38,39
CCS
1.5" deep
4" x 26" long
VCR Full Ht
HL South Face
12" ±2' long x 3" high
CCS Soffit/Bot Face
Pics 44-45
7' ±

10/29/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

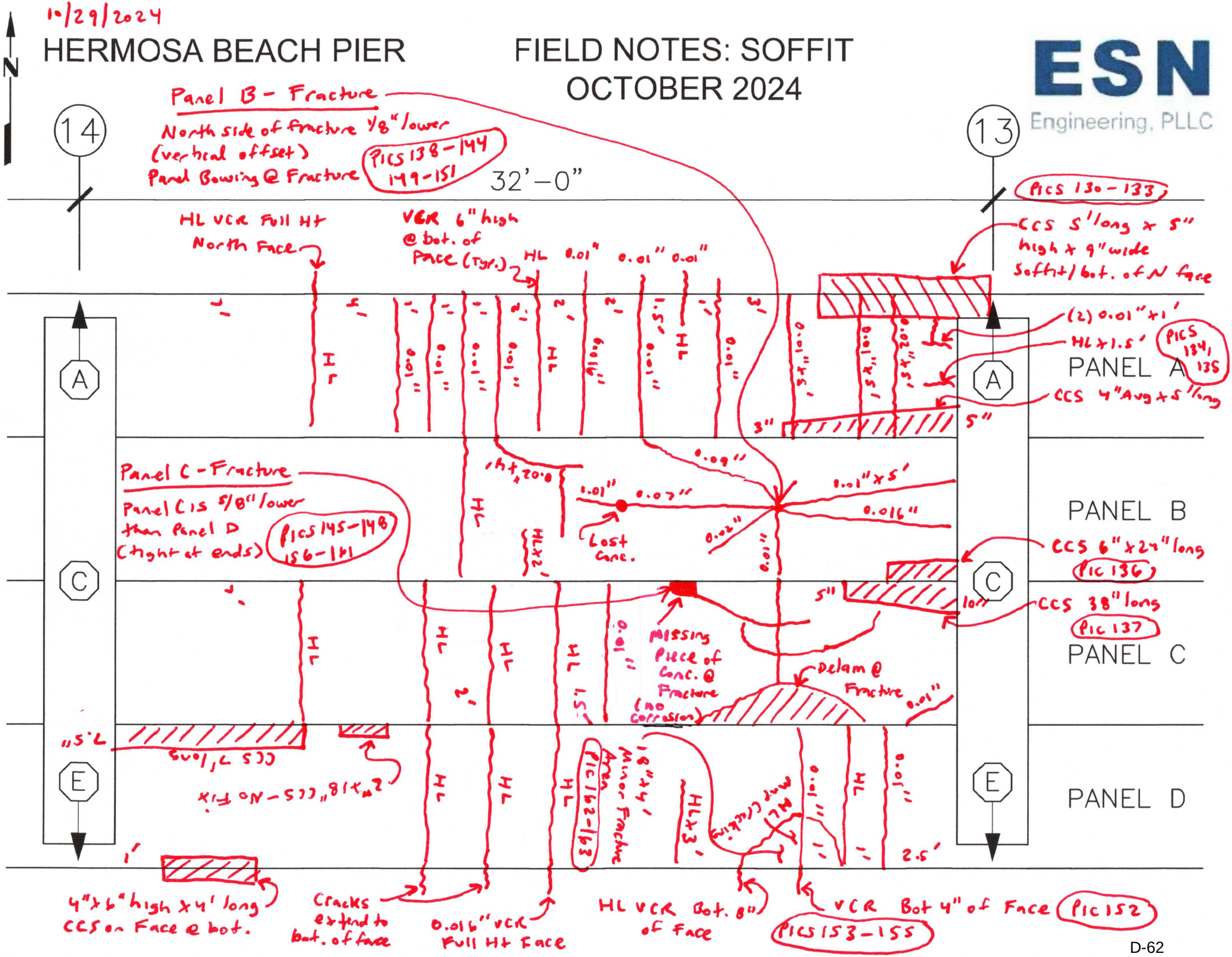


10/29/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

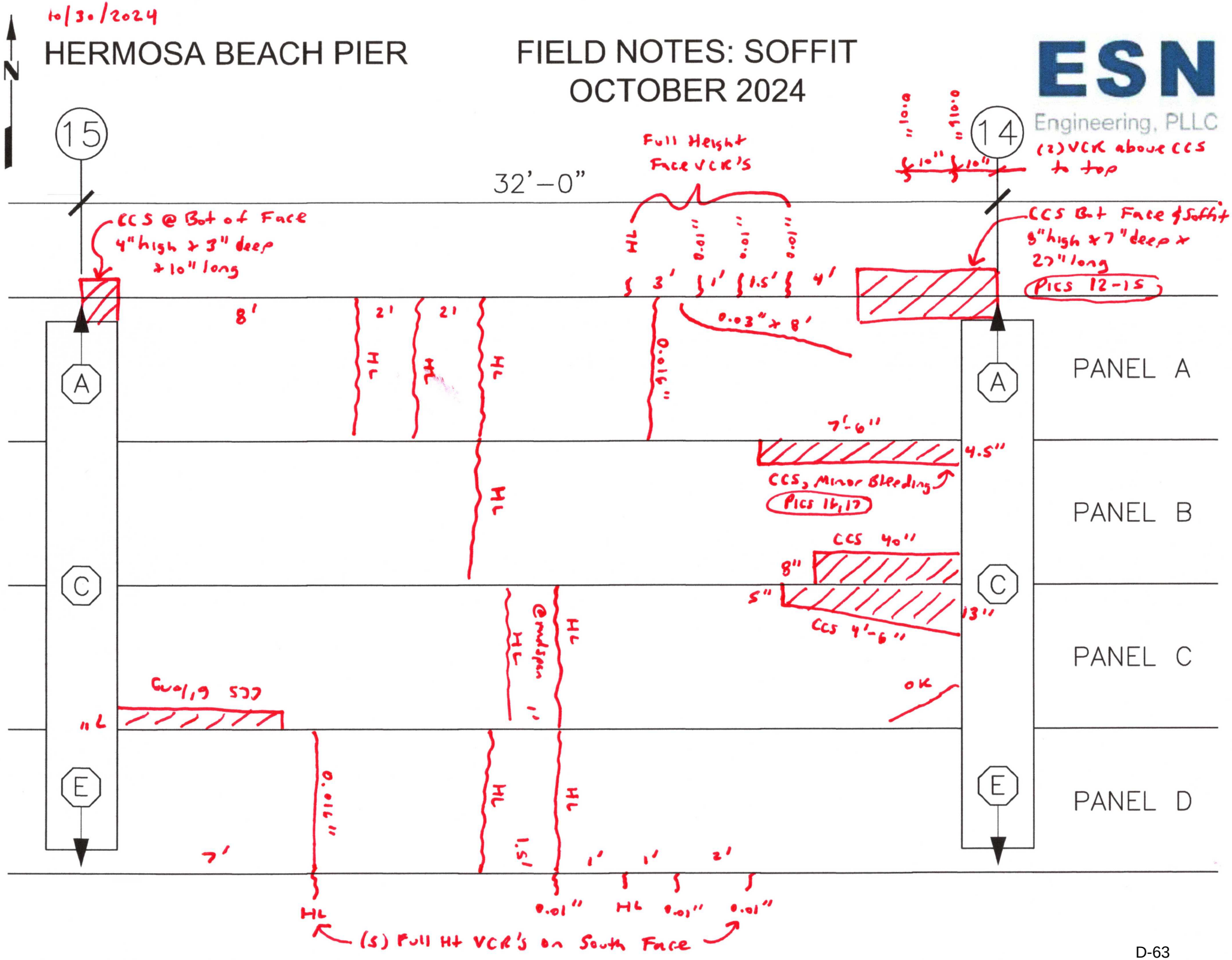


10/30/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

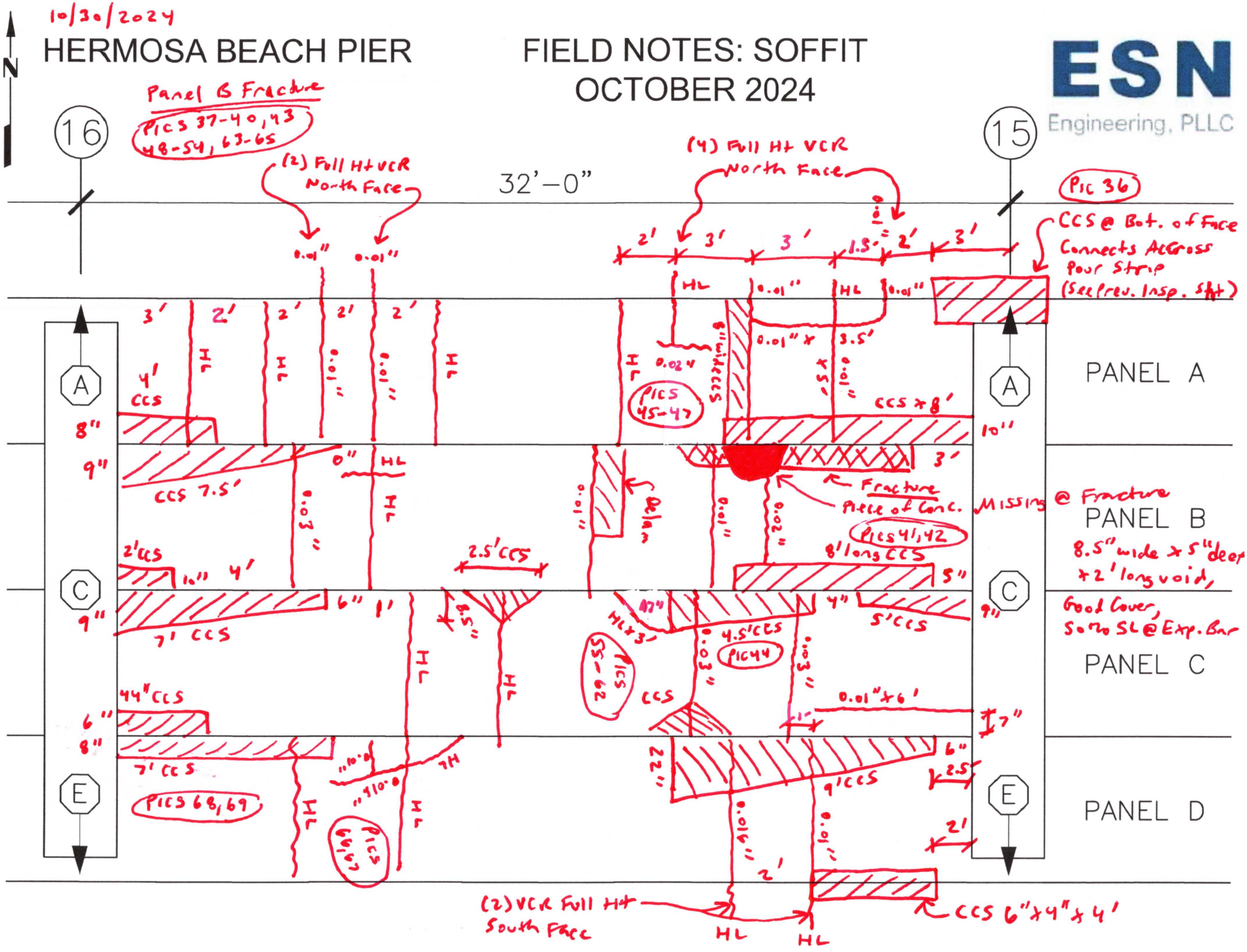


10/30/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

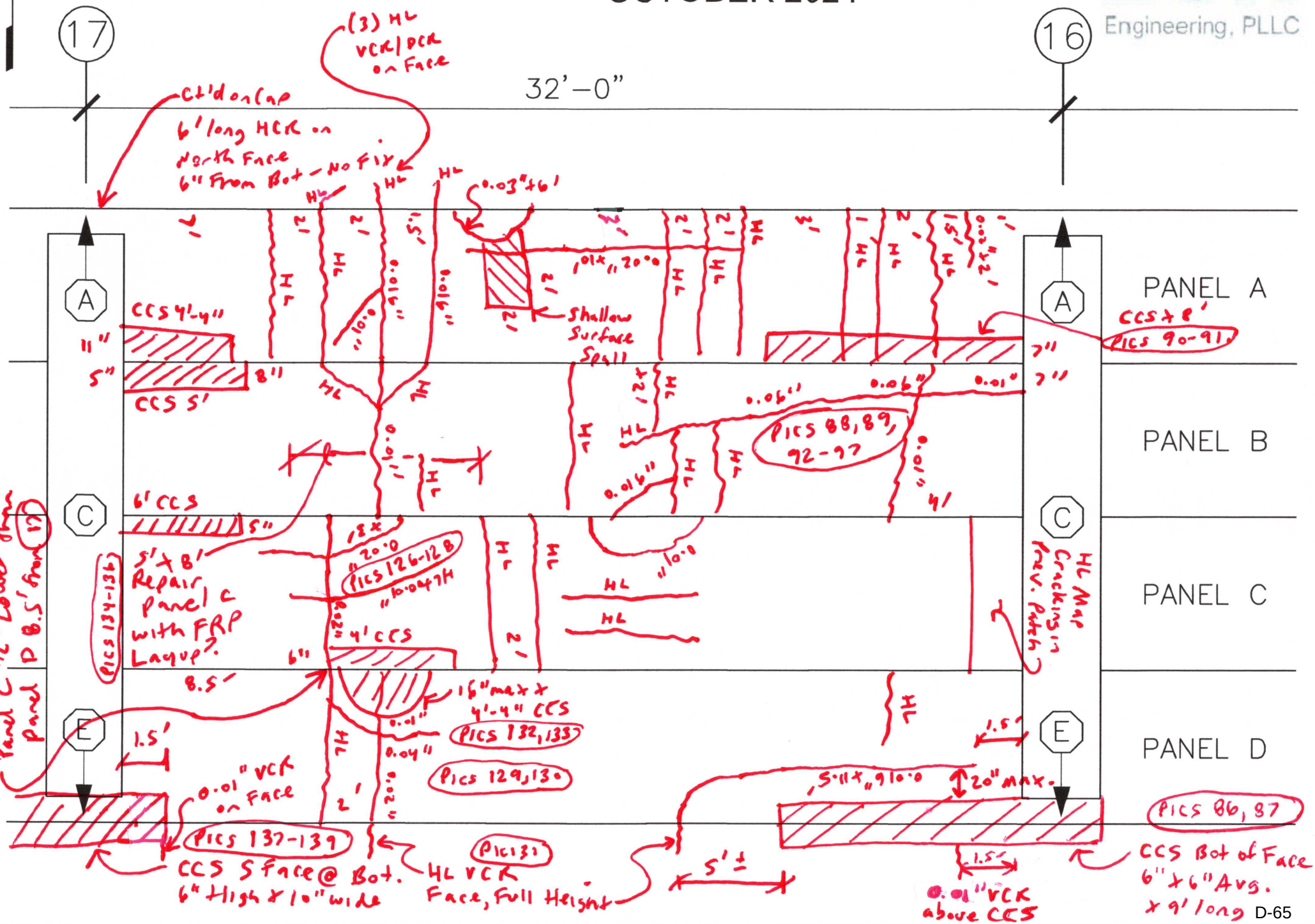


10/30/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

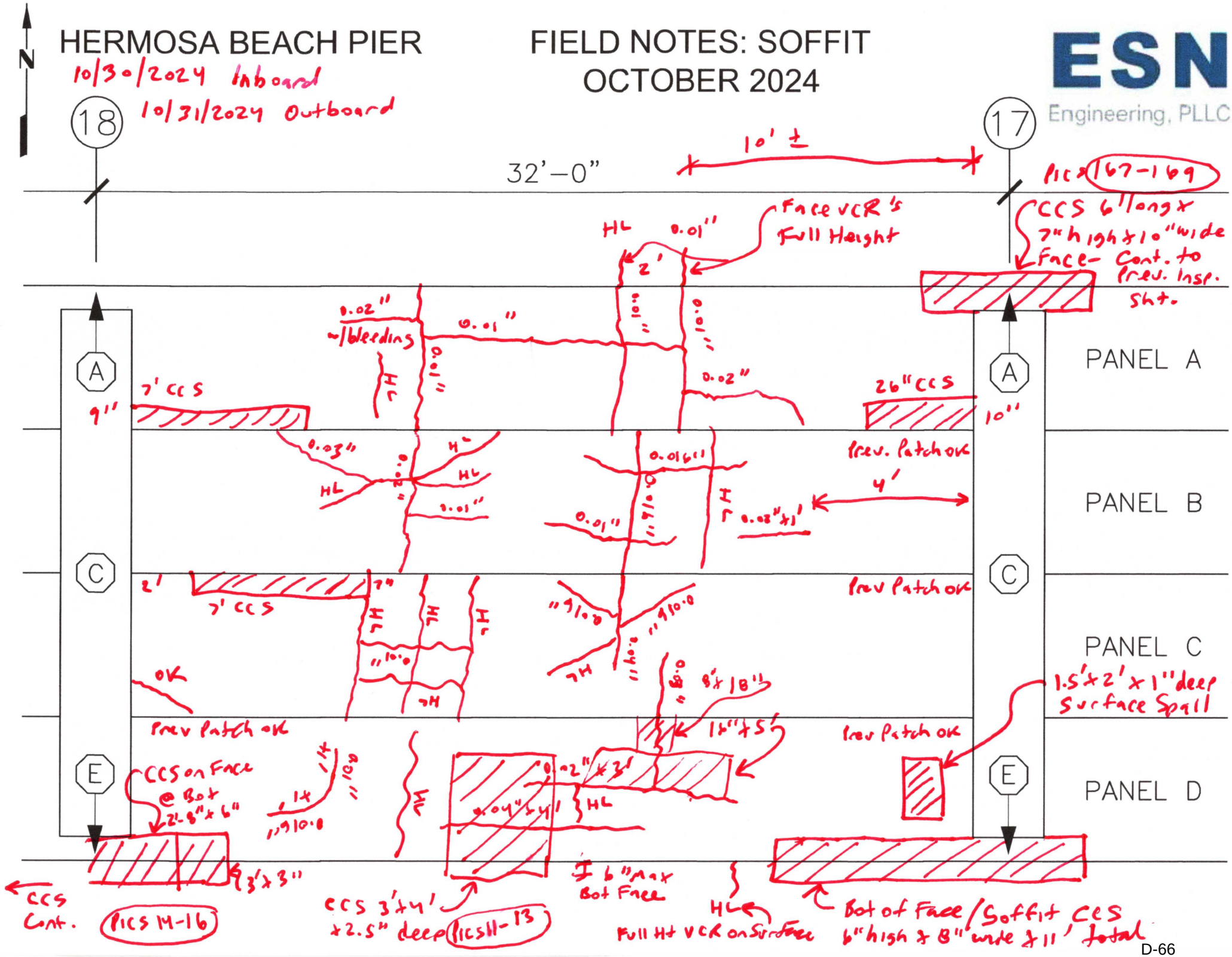


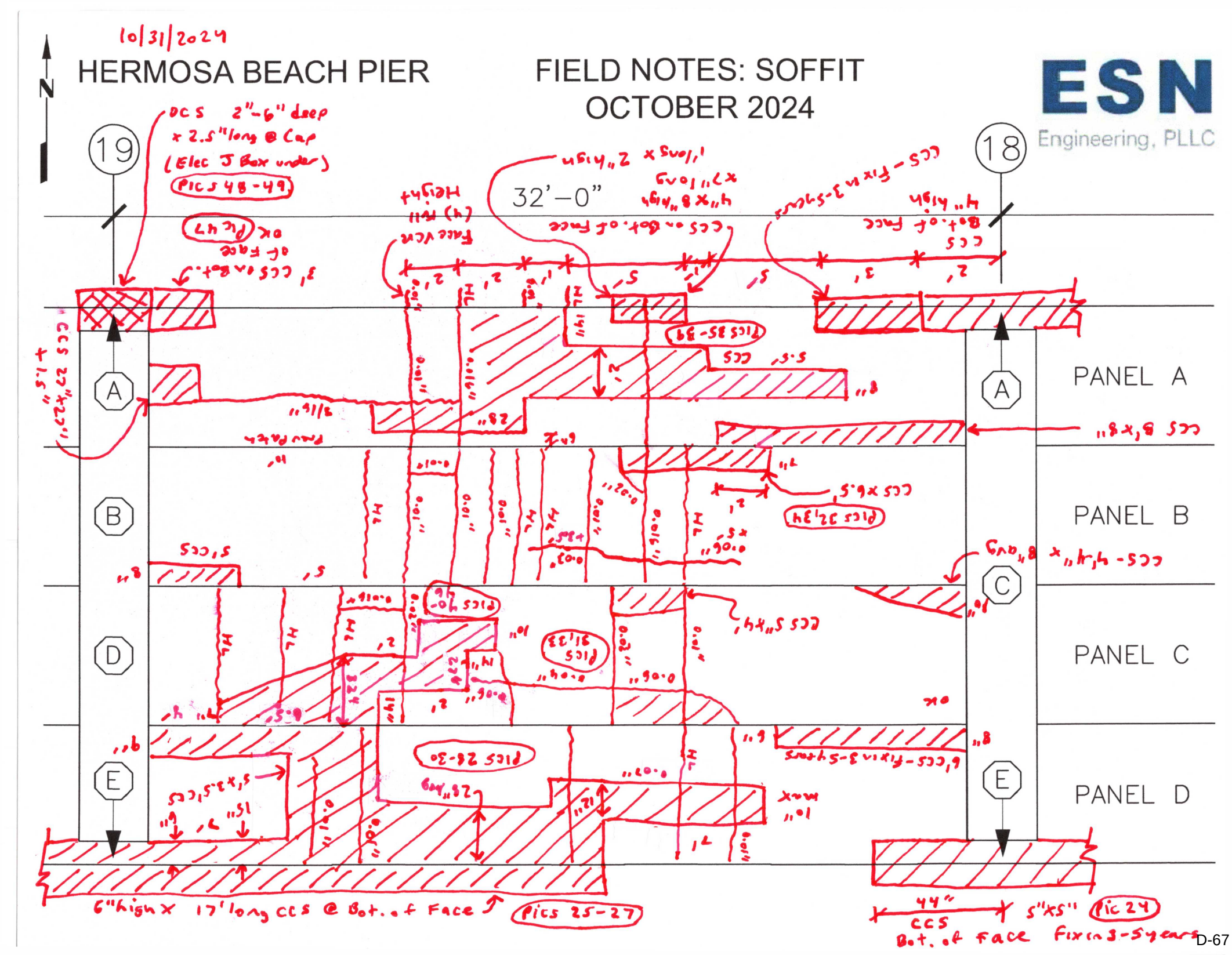
HERMOSA BEACH PIER

10/30/2024 Inboard
10/31/2024 Outboard

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC



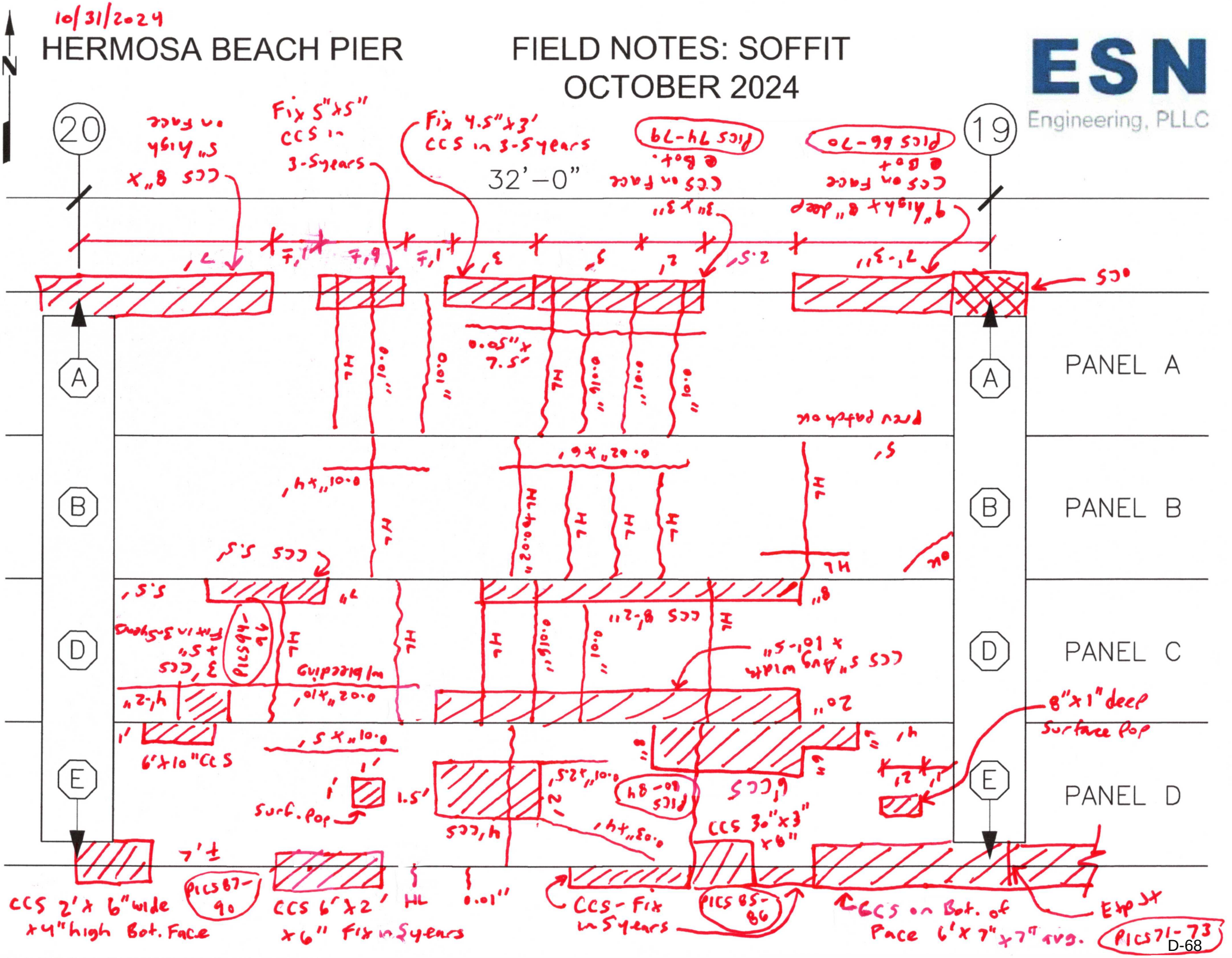

10/31/2024
HERMOSA BEACH PIER
FIELD NOTES: SOFFIT
OCTOBER 2024
ESN
Engineering, PLLC
N
19
18
32'-0"
A
B
C
D
E
PANEL A
PANEL B
PANEL C
PANEL D
CCS 2"-6" deep x 2.5" long @ Cap (Elec J Box under)
Pics 48-49
Pic 47
Pics 35-39
Pics 32, 33
Pics 30-31
Pics 31, 33
Pics 28-30
Pics 25-27
Pic 24
6" high x 17' long CCS @ Bot. of Face
44" CCS Bot. of Face
5"x5"
Fixing 3-5 years
D-67

10/31/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

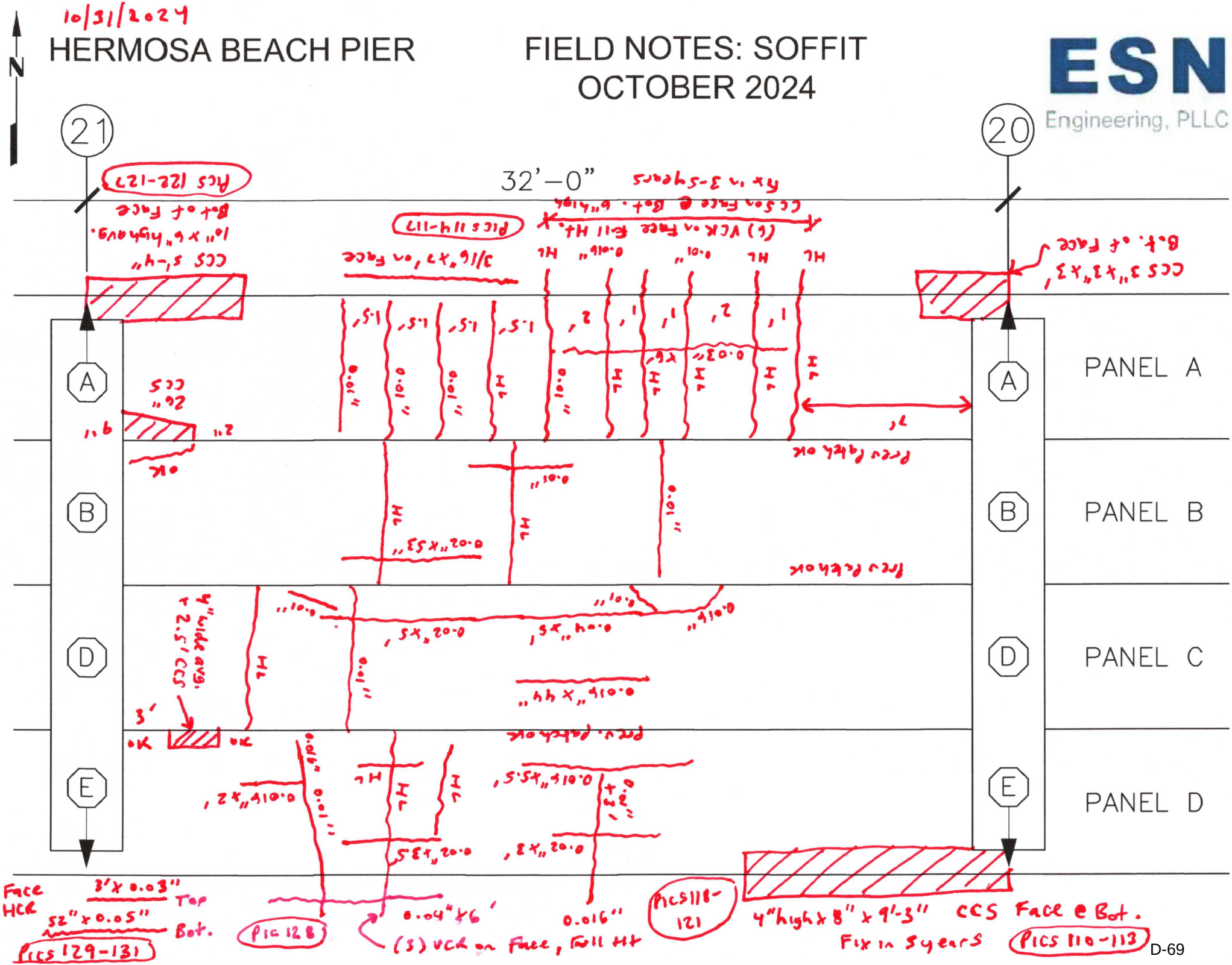


10/31/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

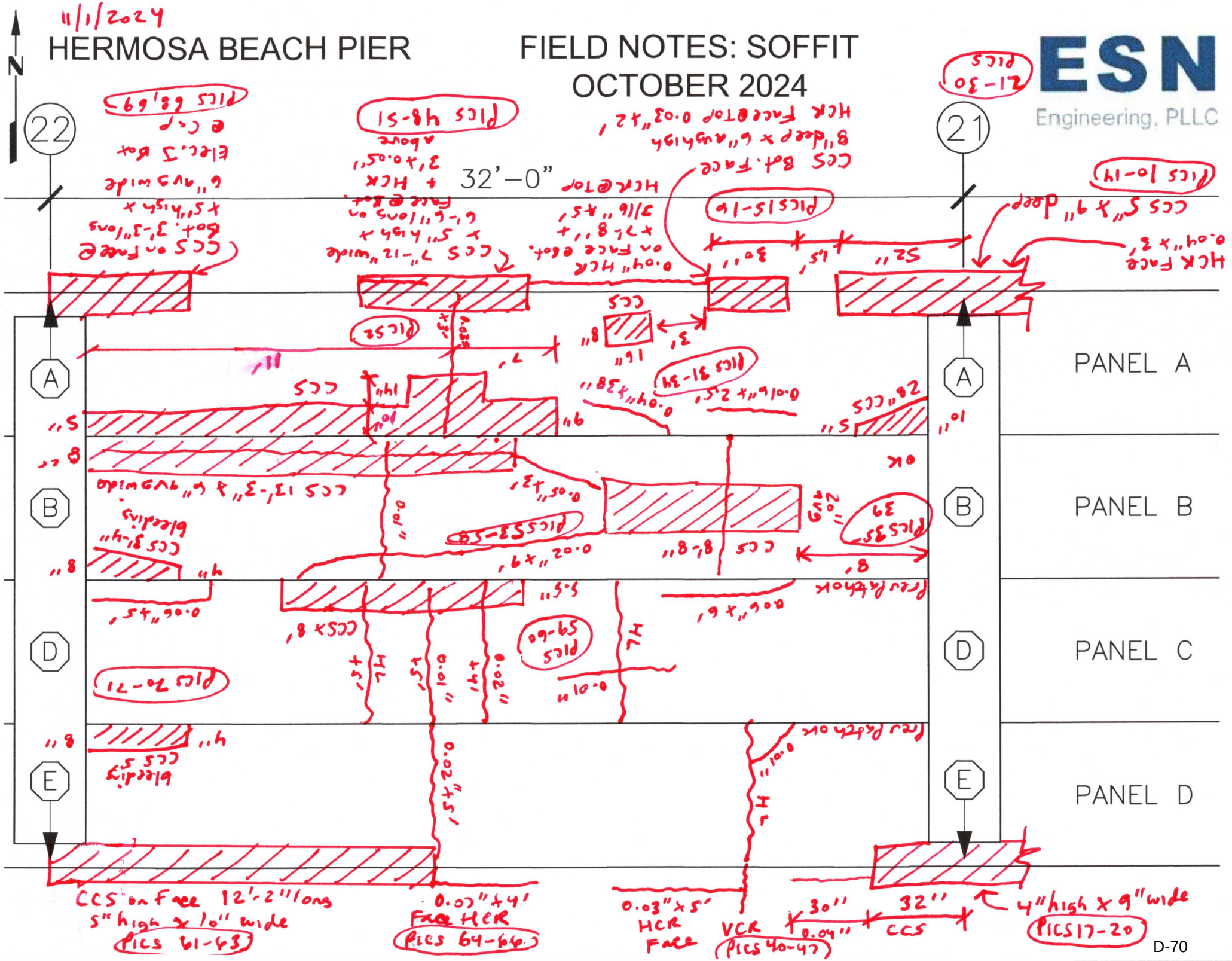


11/1/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

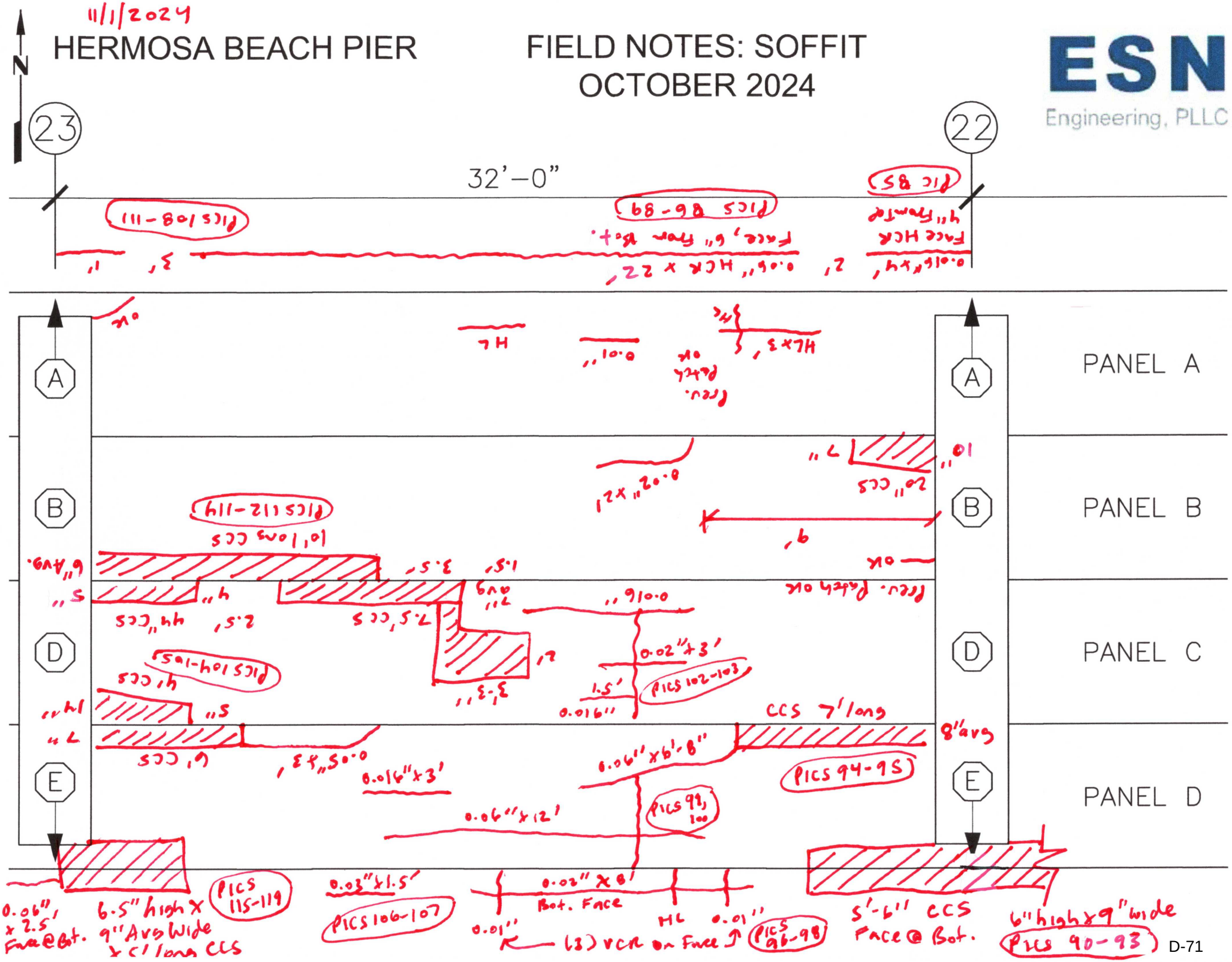


11/1/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

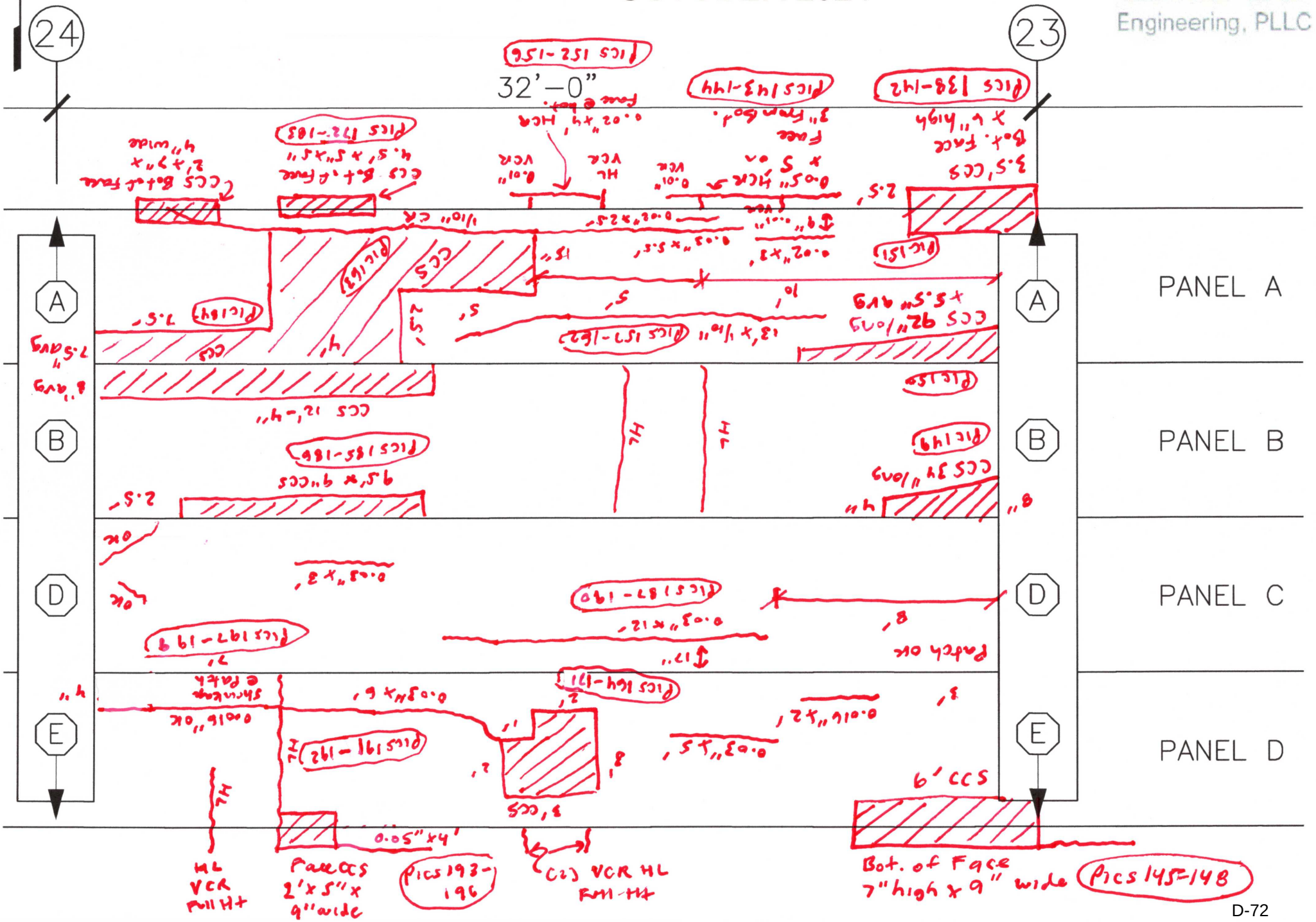


11/1/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

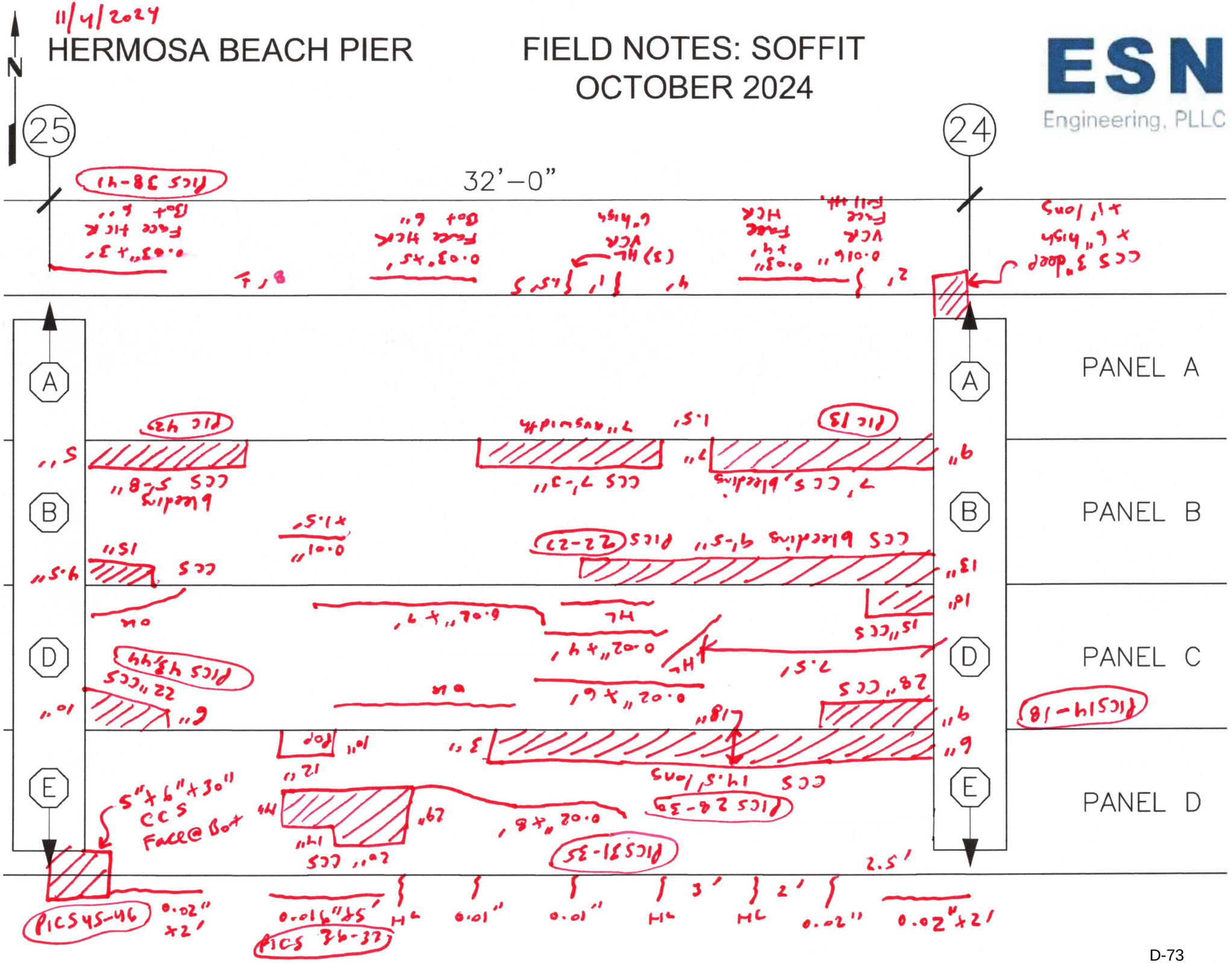


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

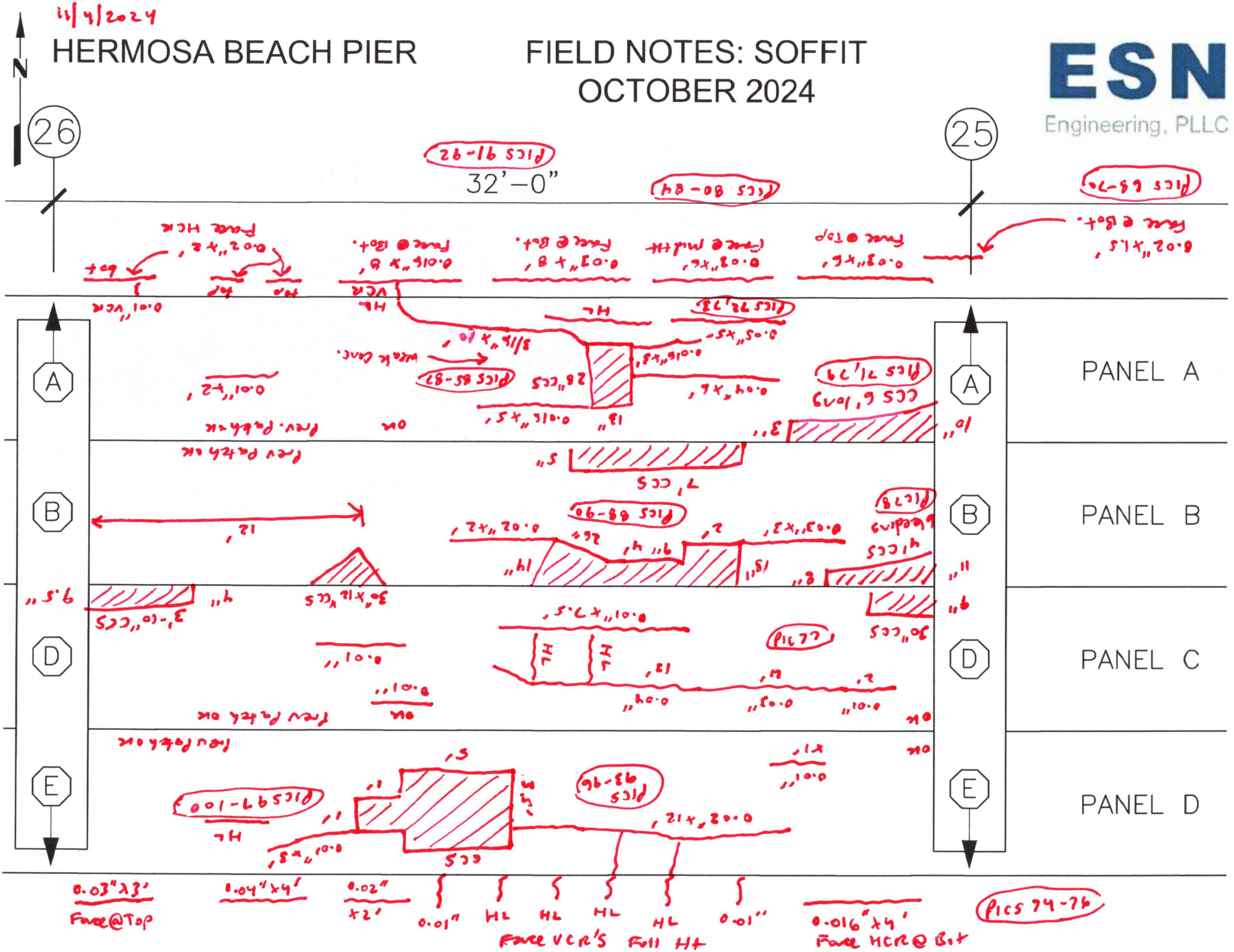


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

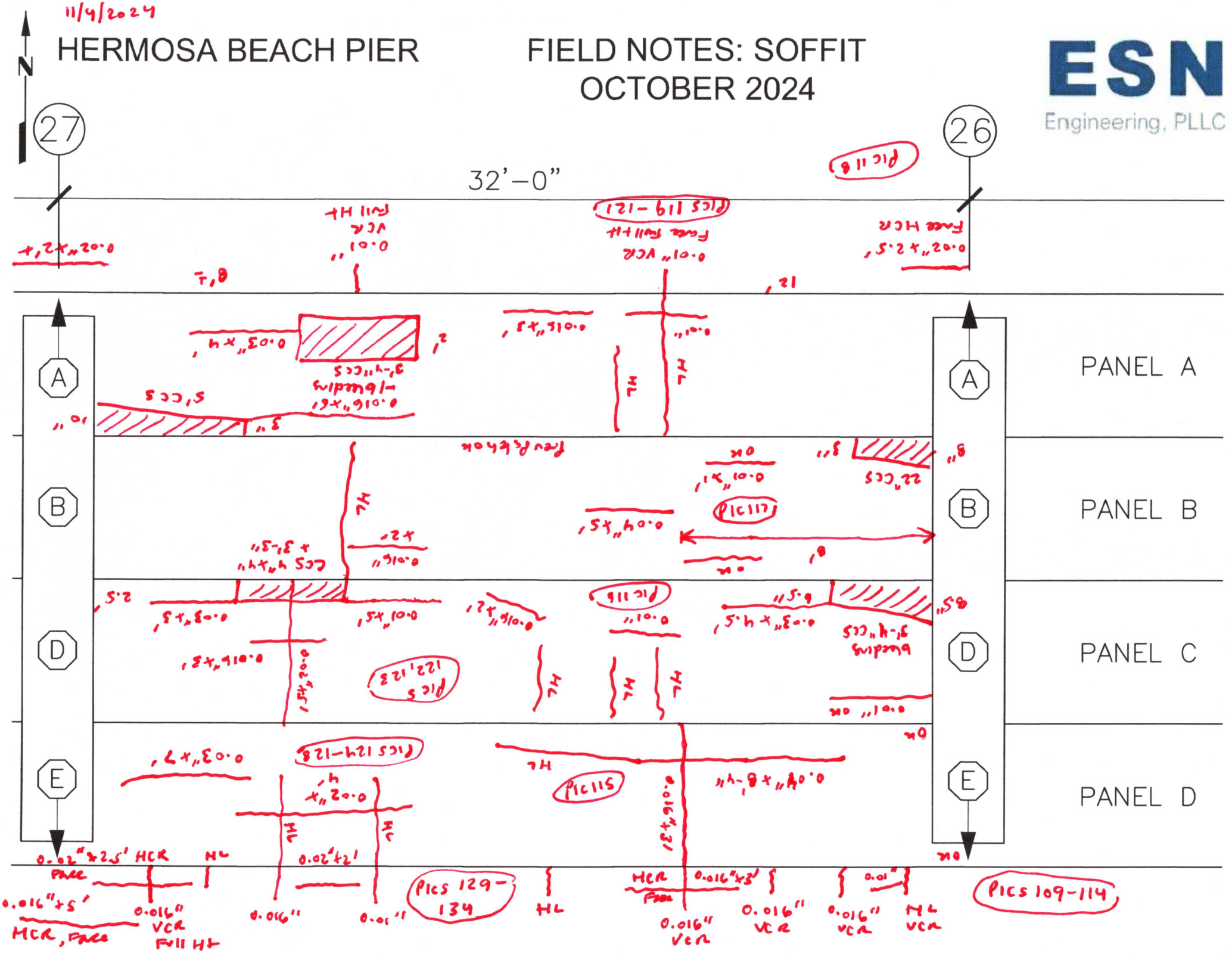


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

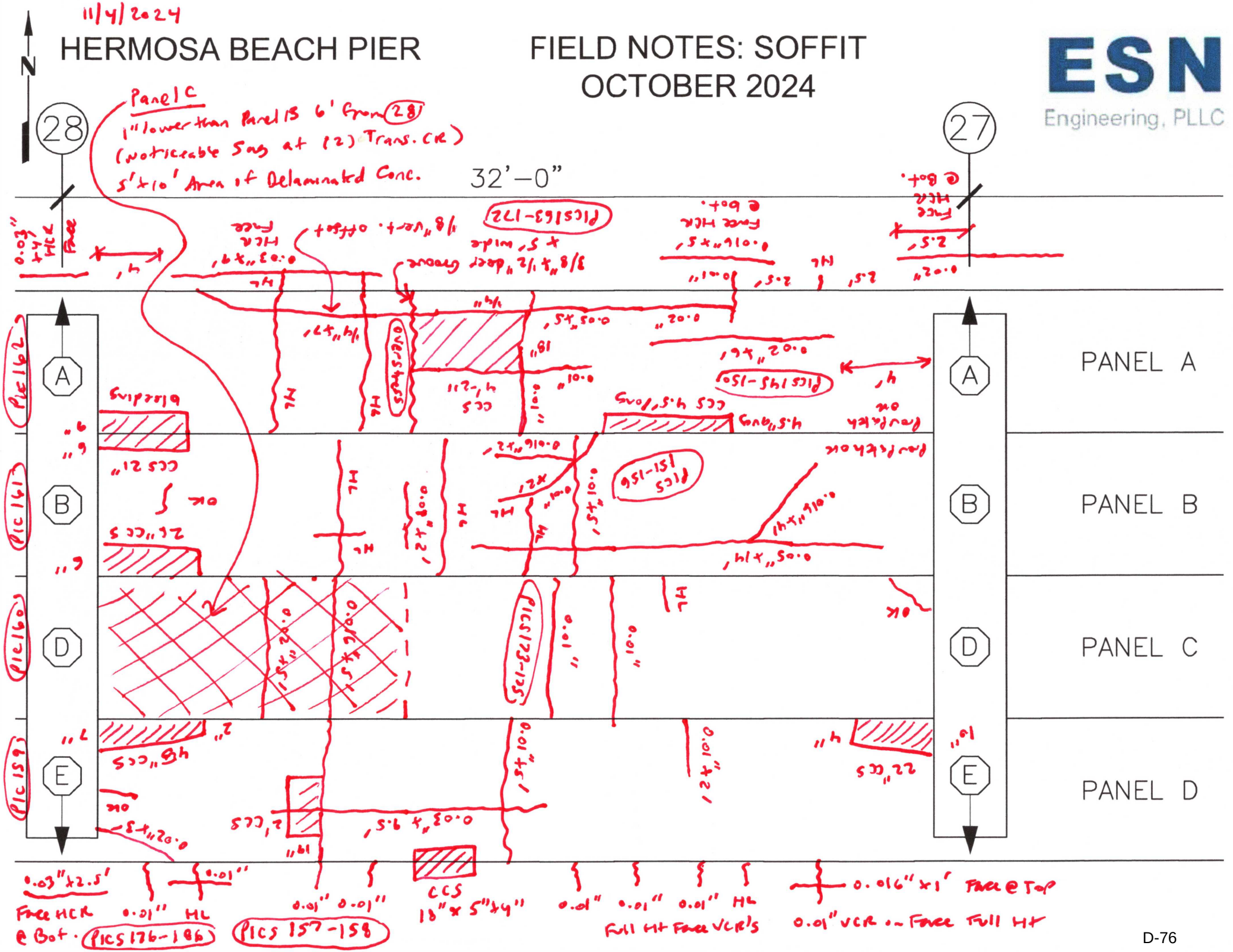


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

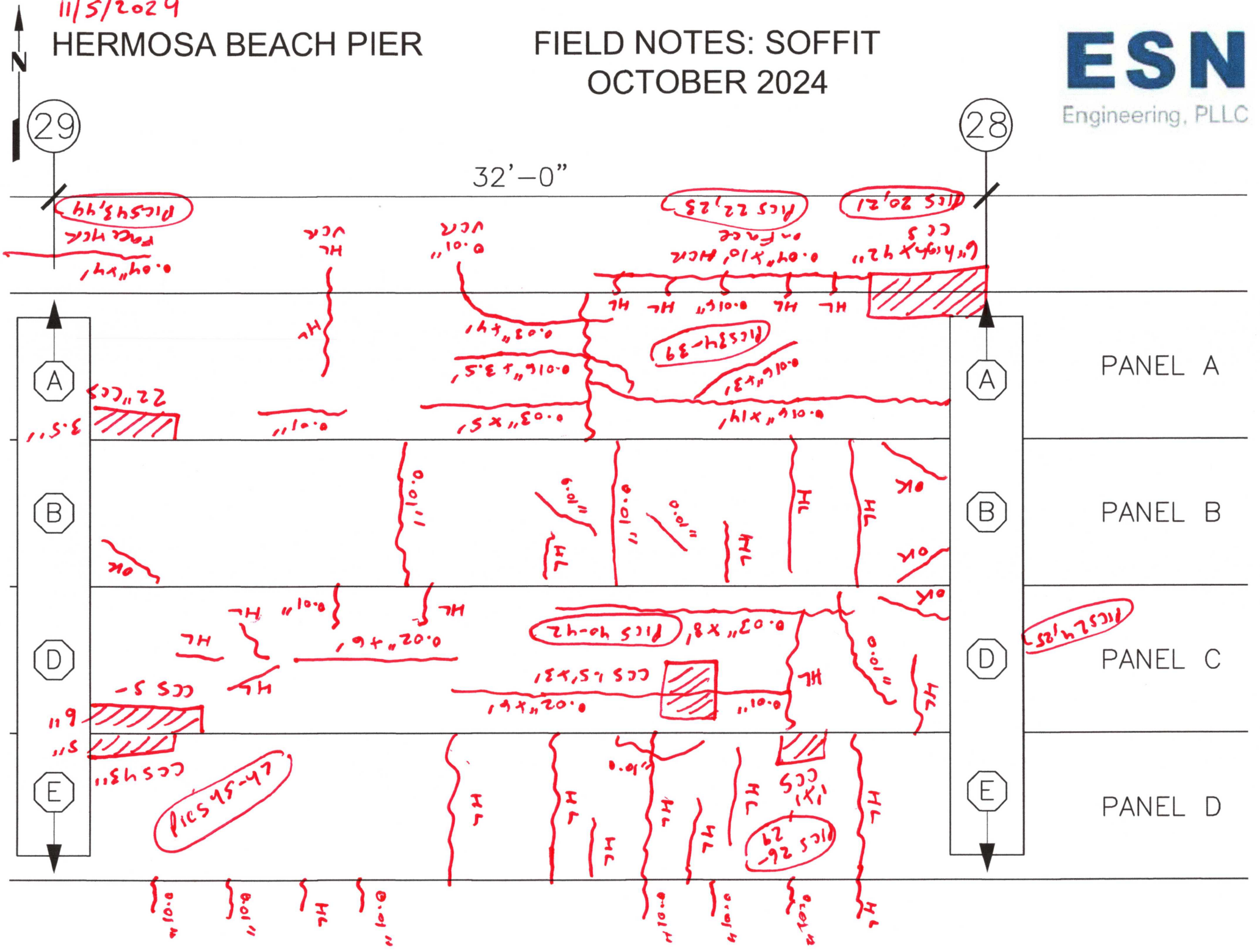


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

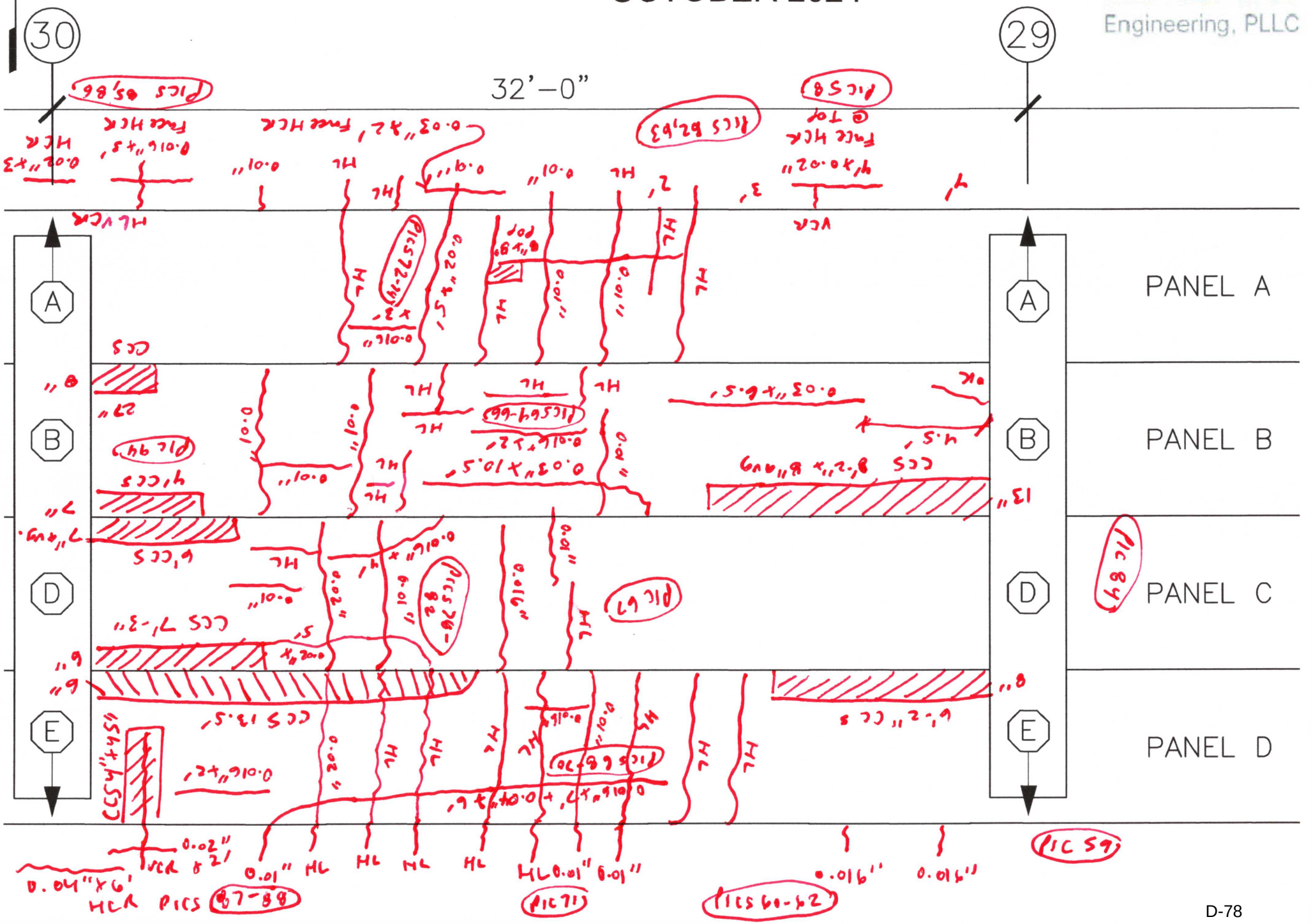


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC



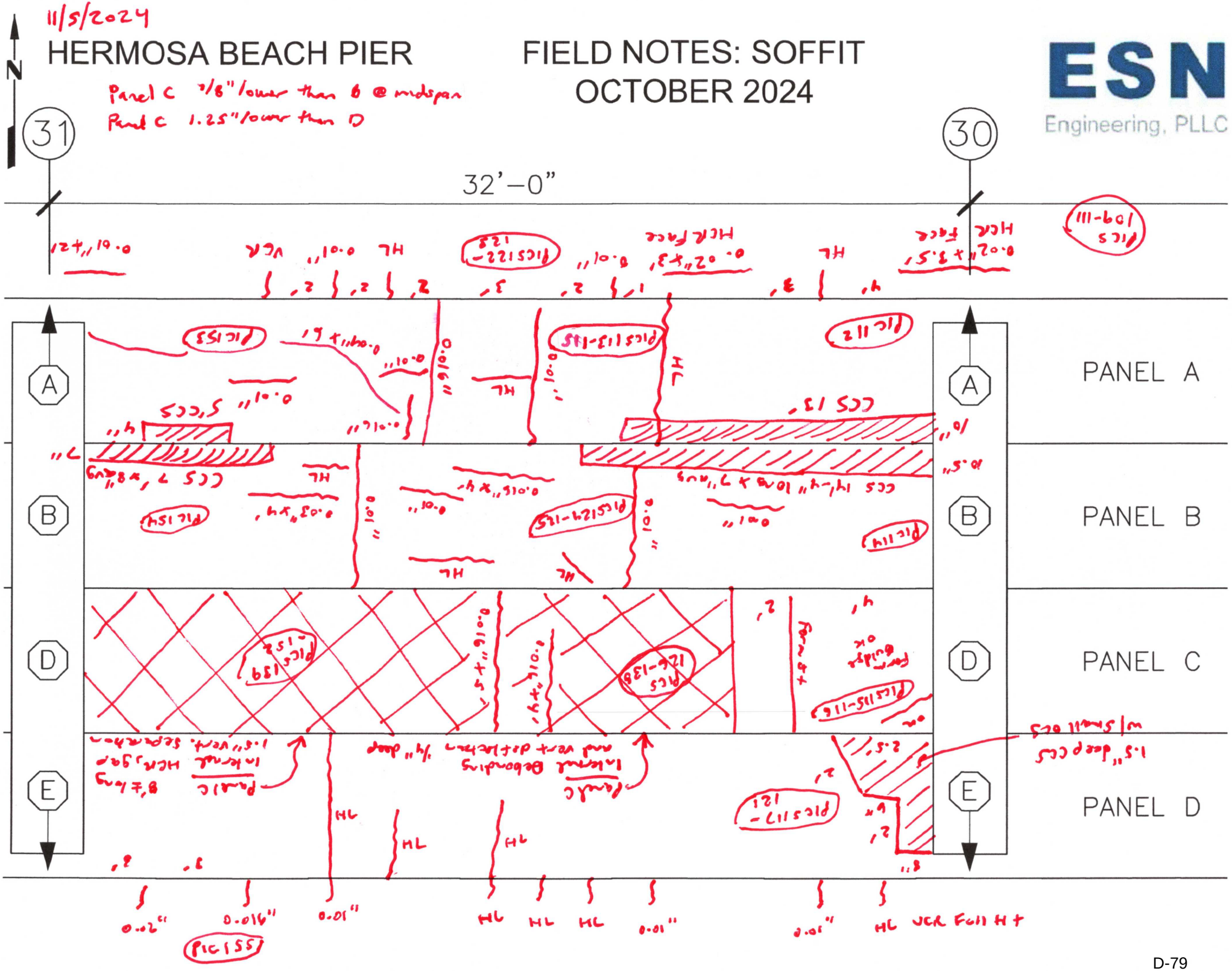
11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

Panel C 3/8" lower than B @ midspan
Panel C 1.25" lower than D

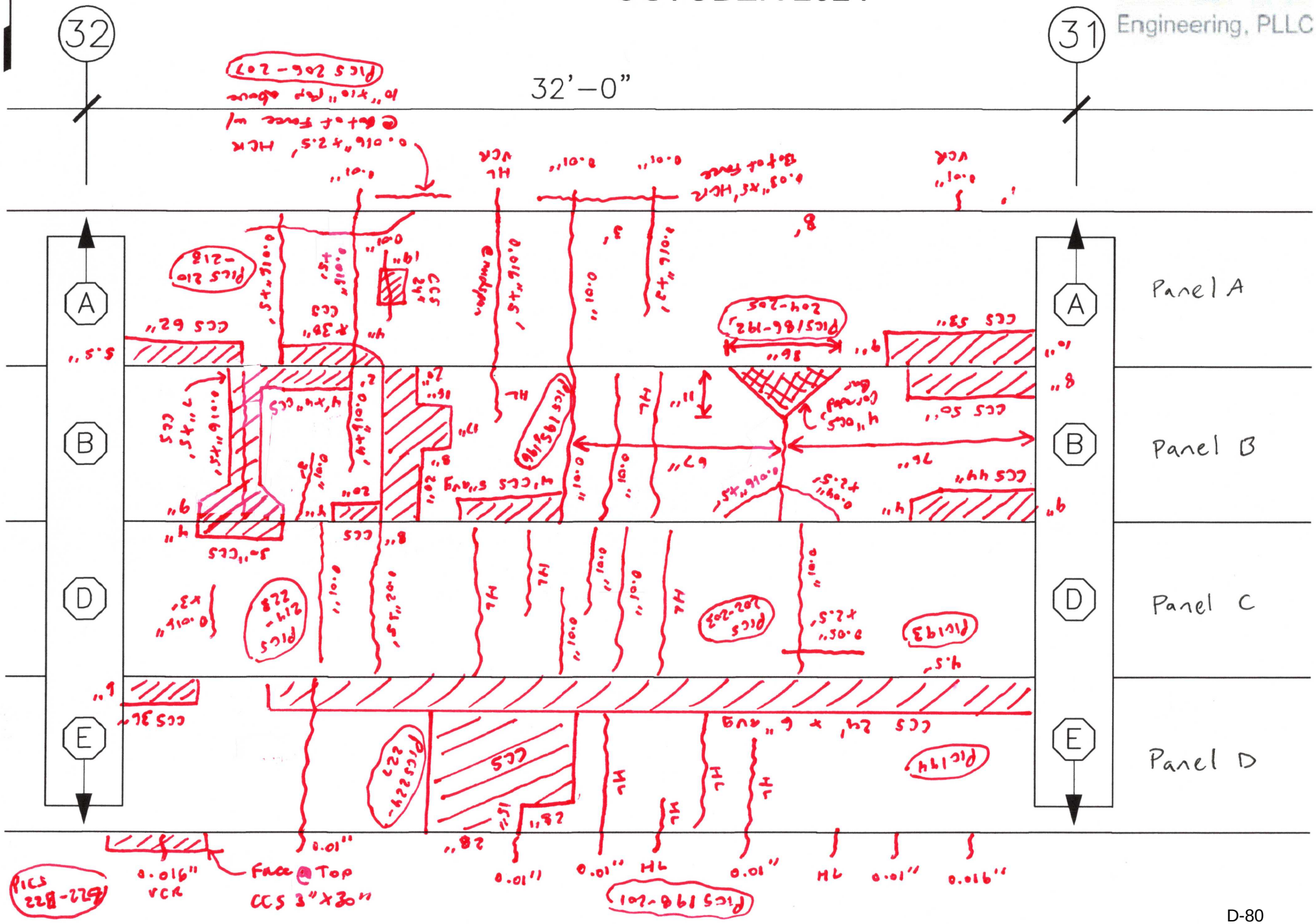


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

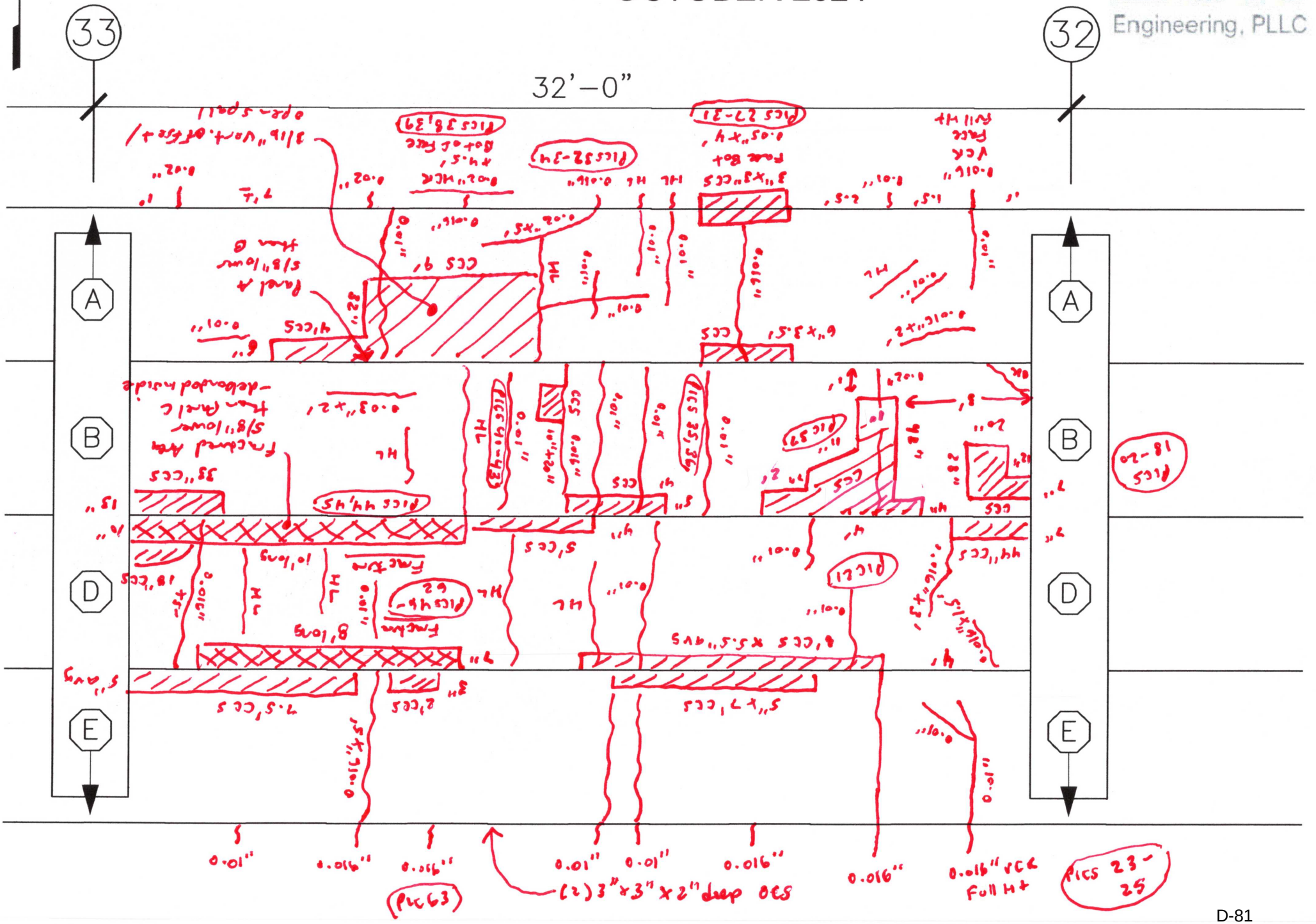


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

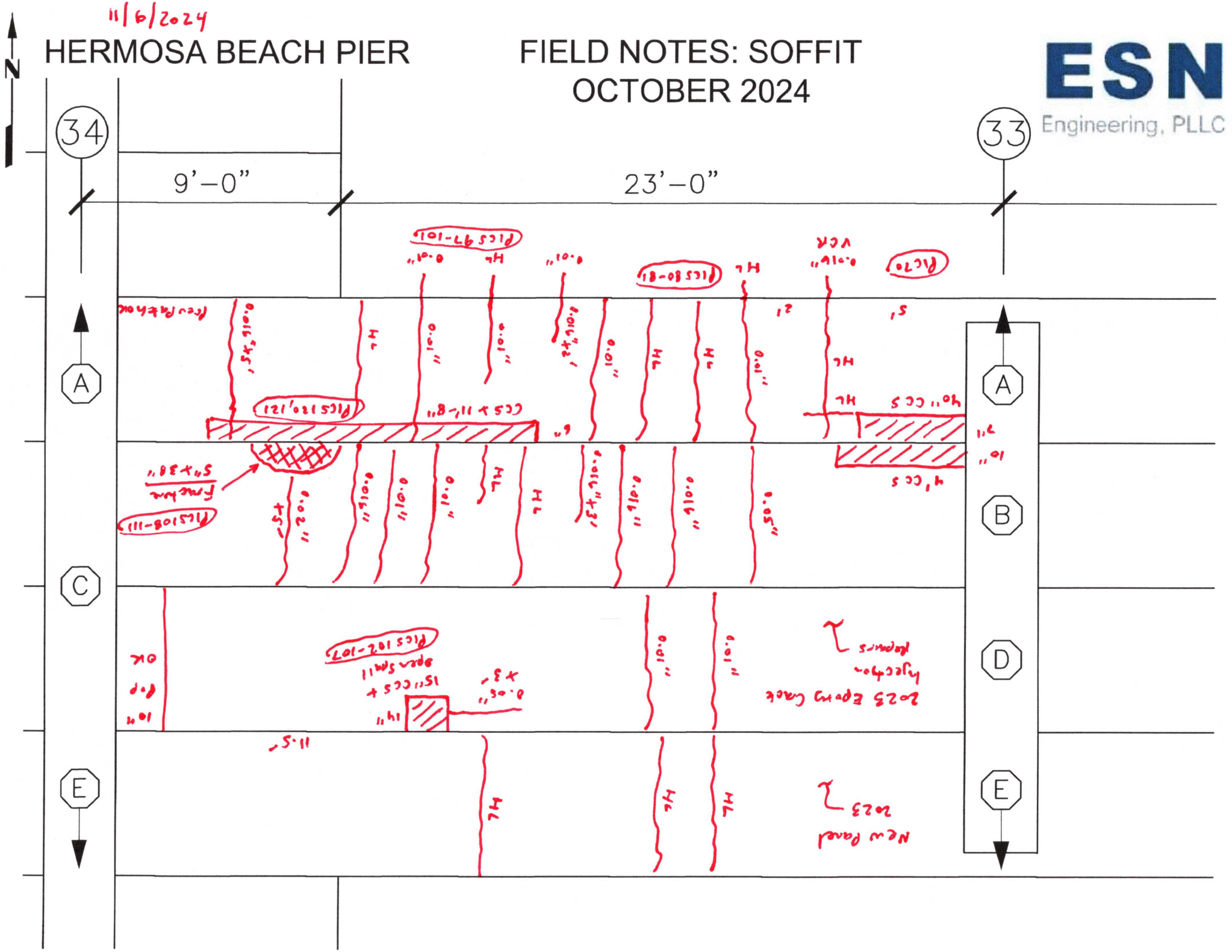


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

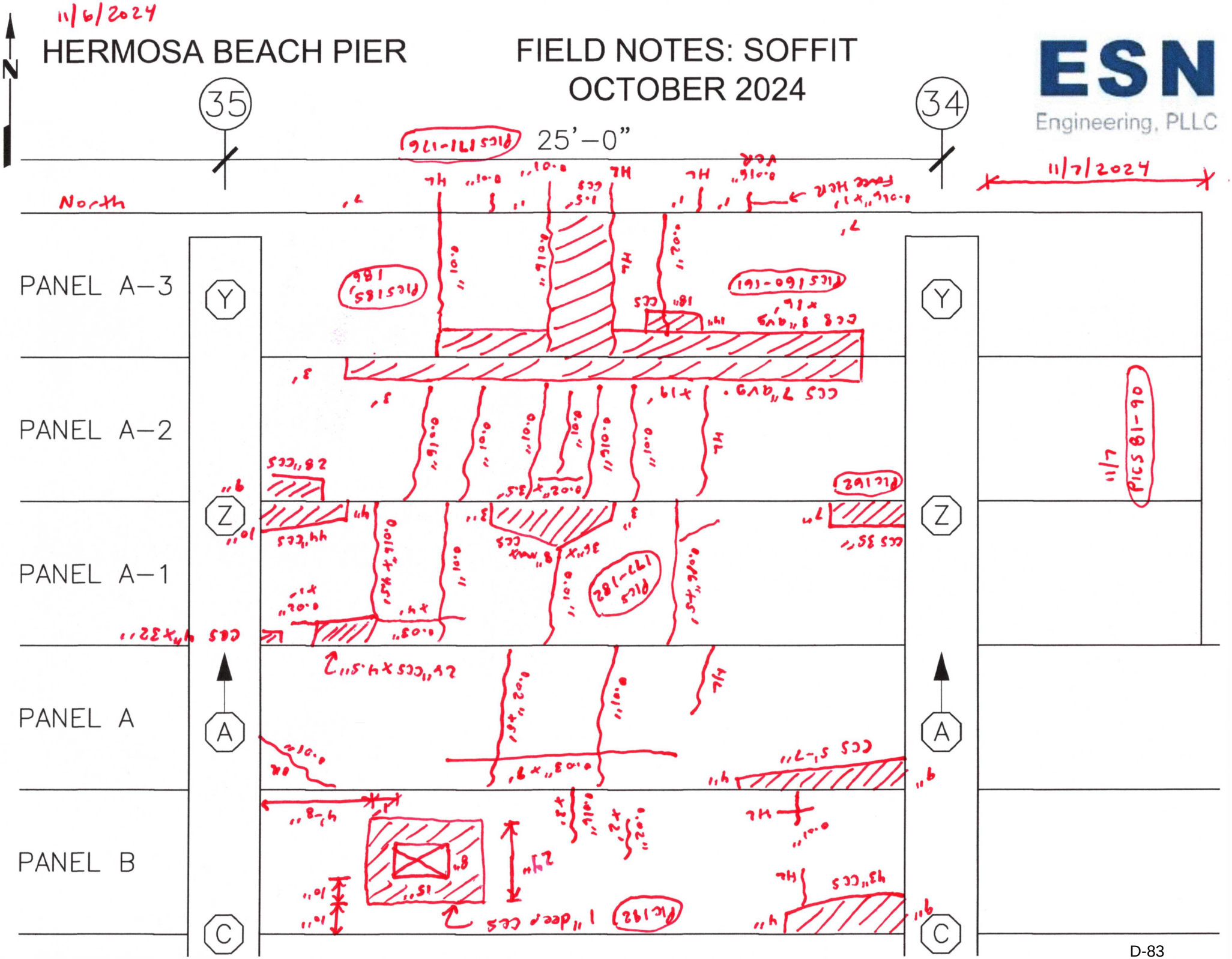


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC

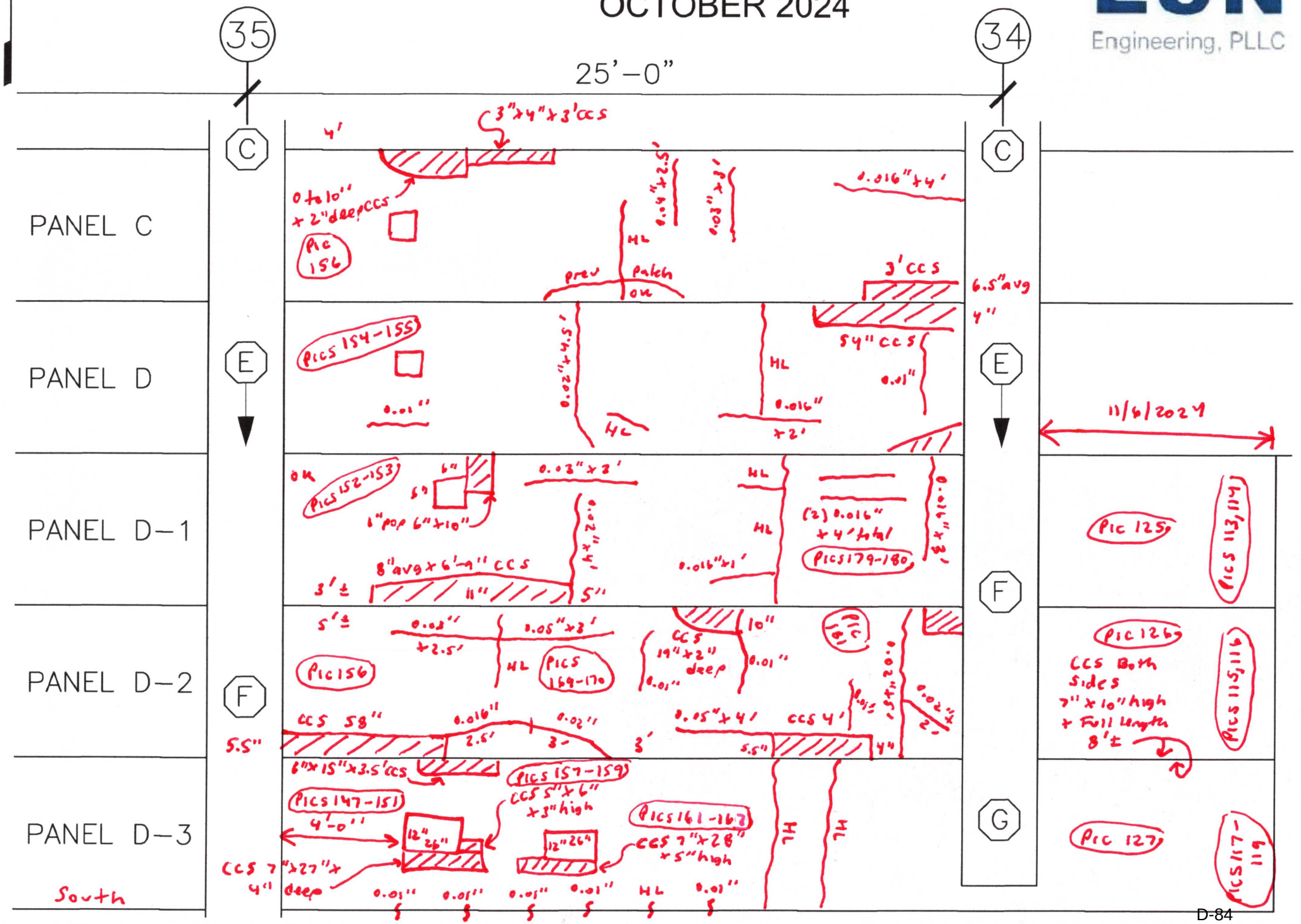


11/7/2024

HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

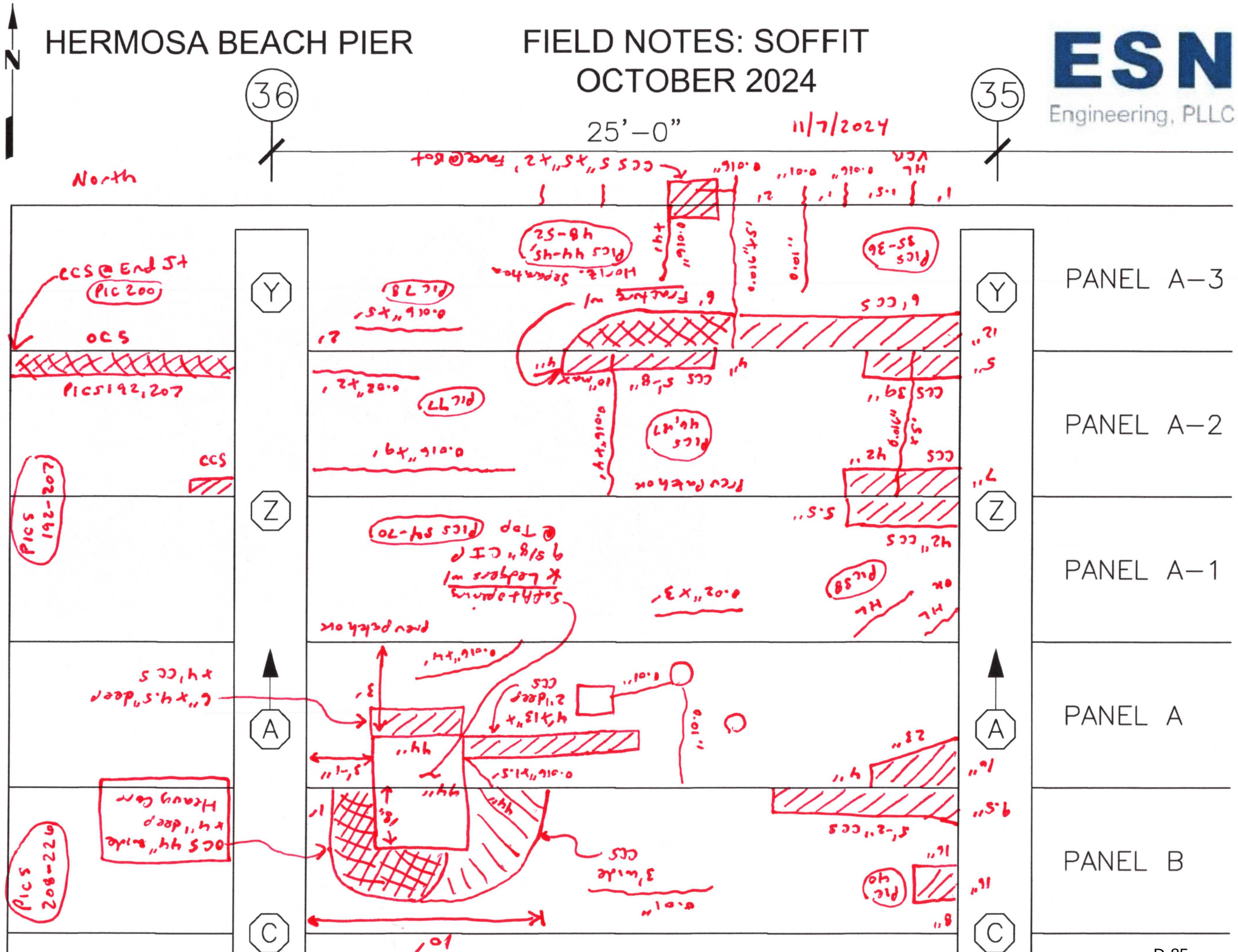
ESN Engineering, PLLC

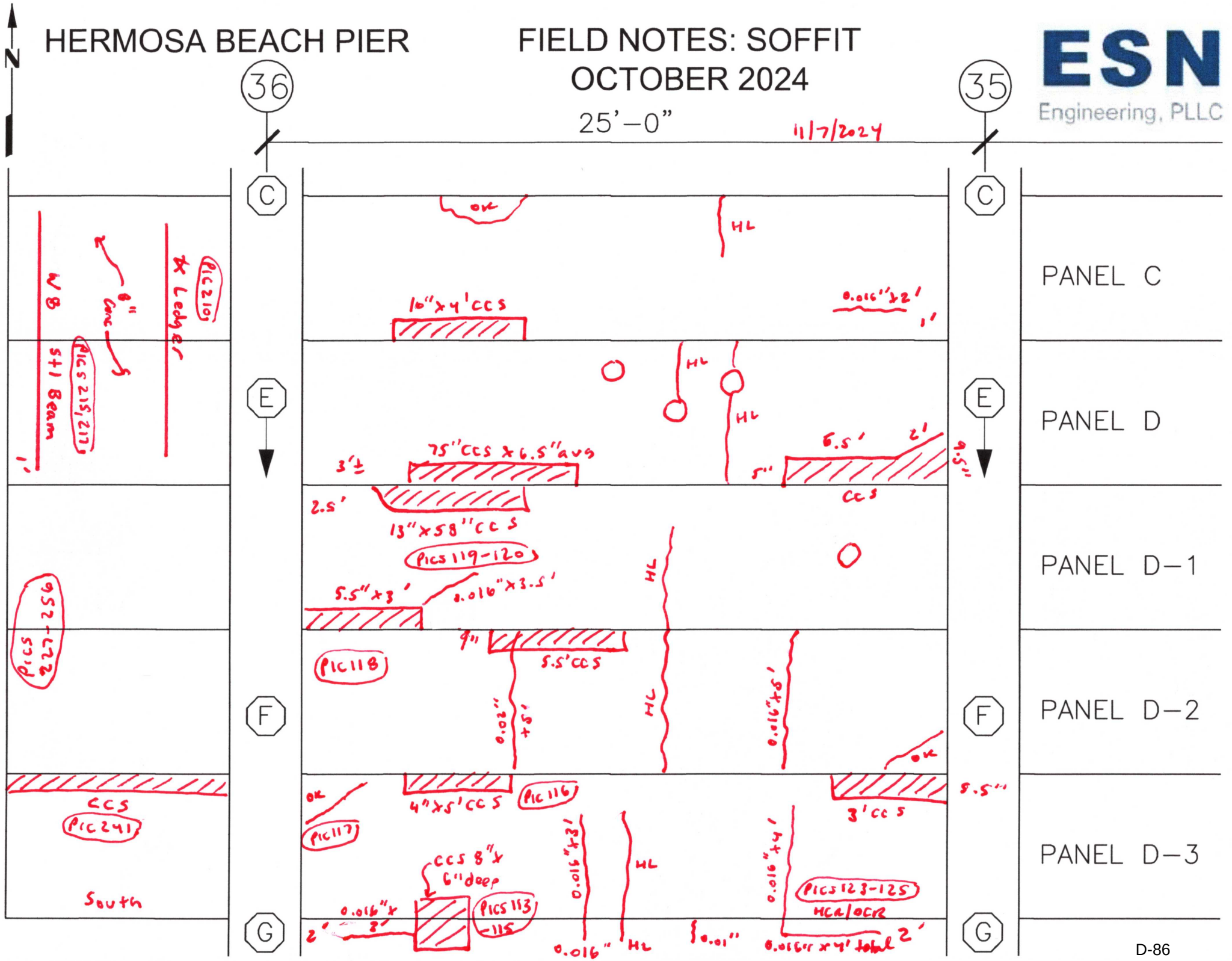


HERMOSA BEACH PIER

FIELD NOTES: SOFFIT
OCTOBER 2024

ESN Engineering, PLLC



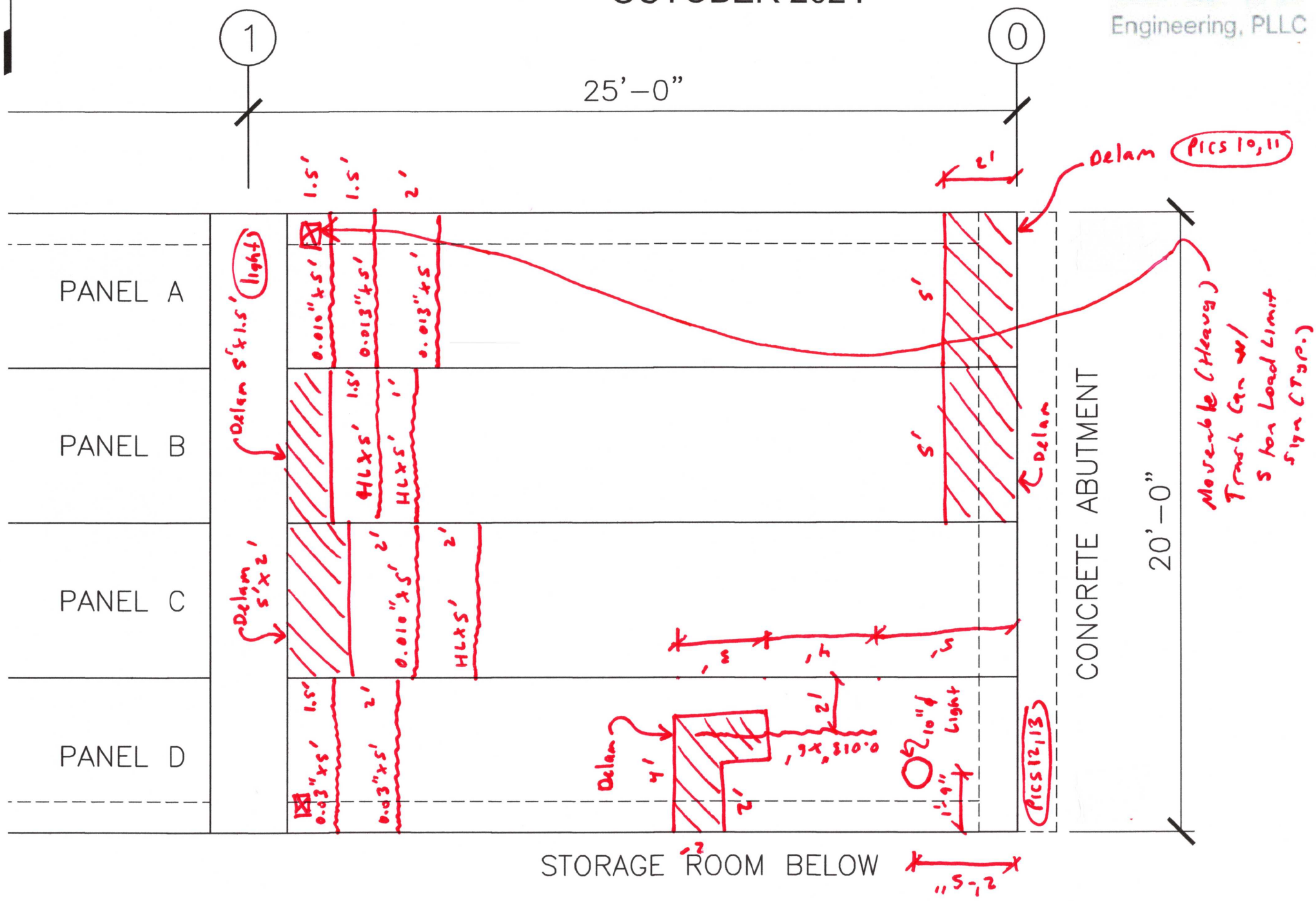

HERMOSA BEACH PIER
FIELD NOTES: SOFFIT
OCTOBER 2024
ESN
Engineering, PLLC
N
36
35
25'–0"
11/7/2024
C
E
F
G
PANEL C
PANEL D
PANEL D–1
PANEL D–2
PANEL D–3
NB
8" Conc
5+1 Beam
Pics 215,217
Pic 210
Ledger
Pics 227-256
CCS
Pic 241
South
OK
HL
10"x4' CCS
0.016"x2'
1'
3'±
7.5" CCS x 6.5" avg
6.5'
2'
5"
6.5"
CCS
2.5'
13"x58" CCS
Pics 119-120
5.5"x3'
0.016"x3.5'
9"
5.5' CCS
Pic 118
0.02"
+5'
0.016"x5'
Pic 116
4"x5' CCS
Pic 117
3' CCS
5.5"
CCS 8"x 6" deep
0.016"x 3'
Pics 113 -115
0.016"x3'
0.016"
0.01"
0.016"x4'
Pics 123-125
HCA/OCR
0.016"x4' total
2'

10/17/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

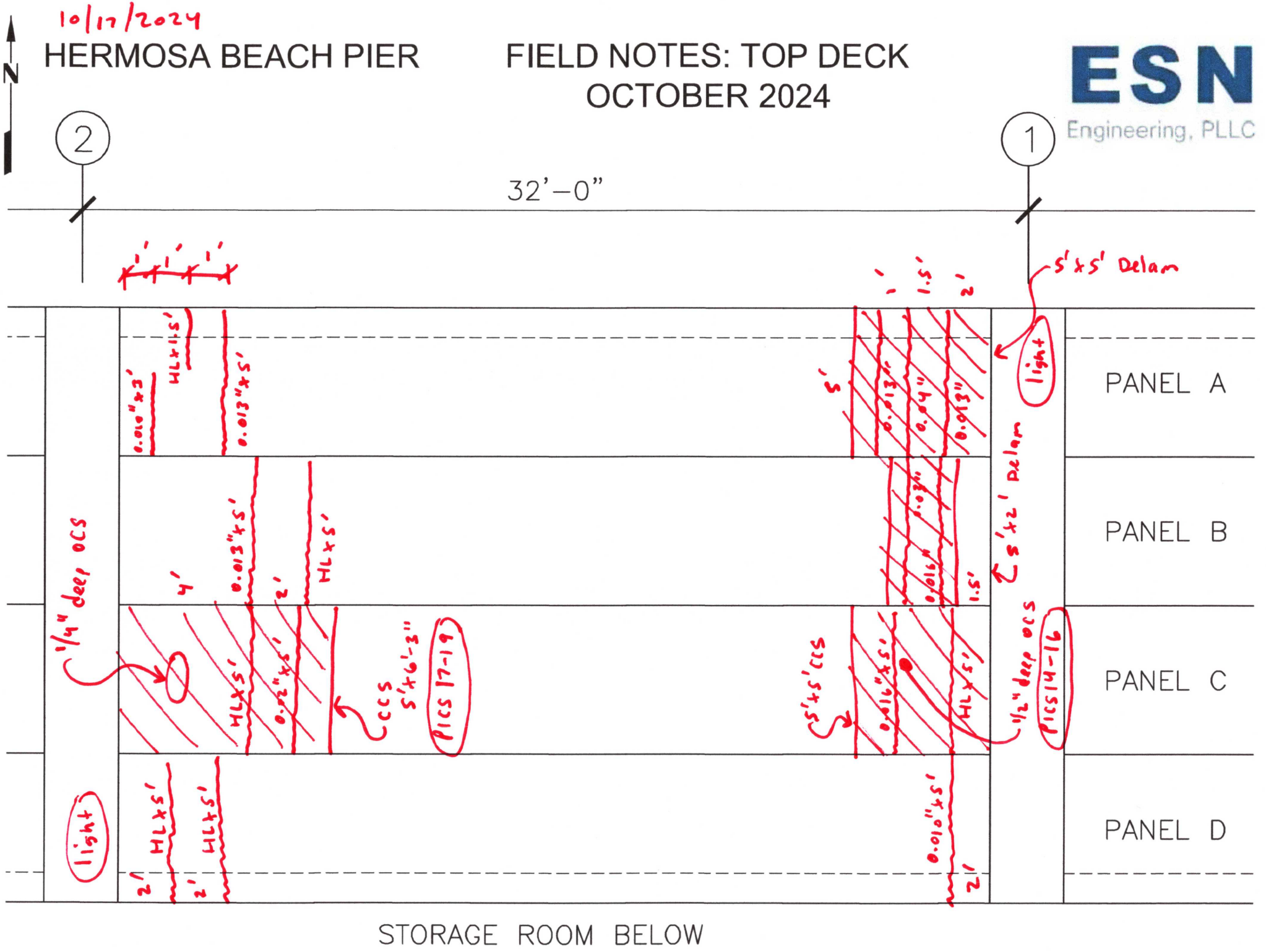


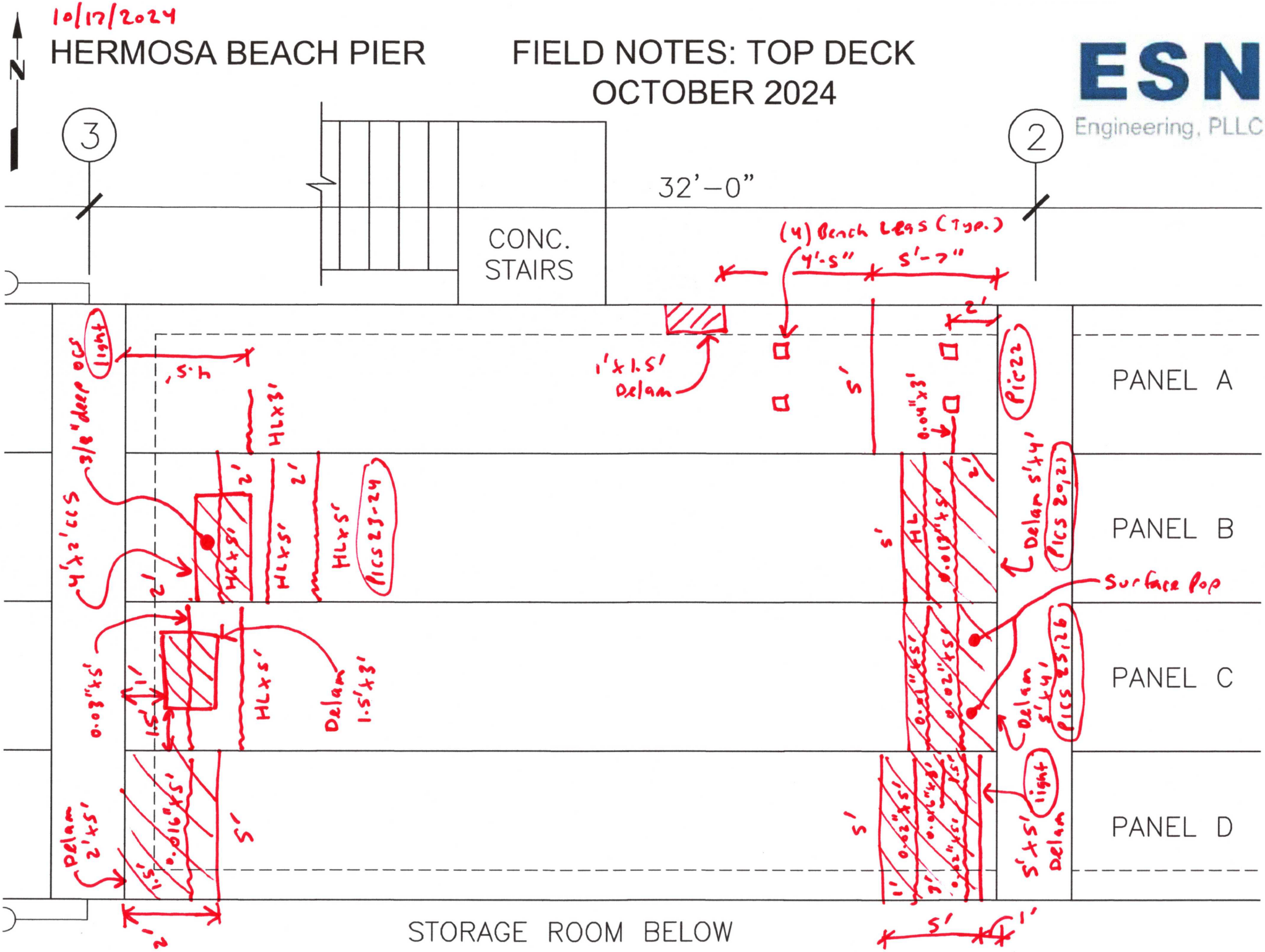
10/17/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC



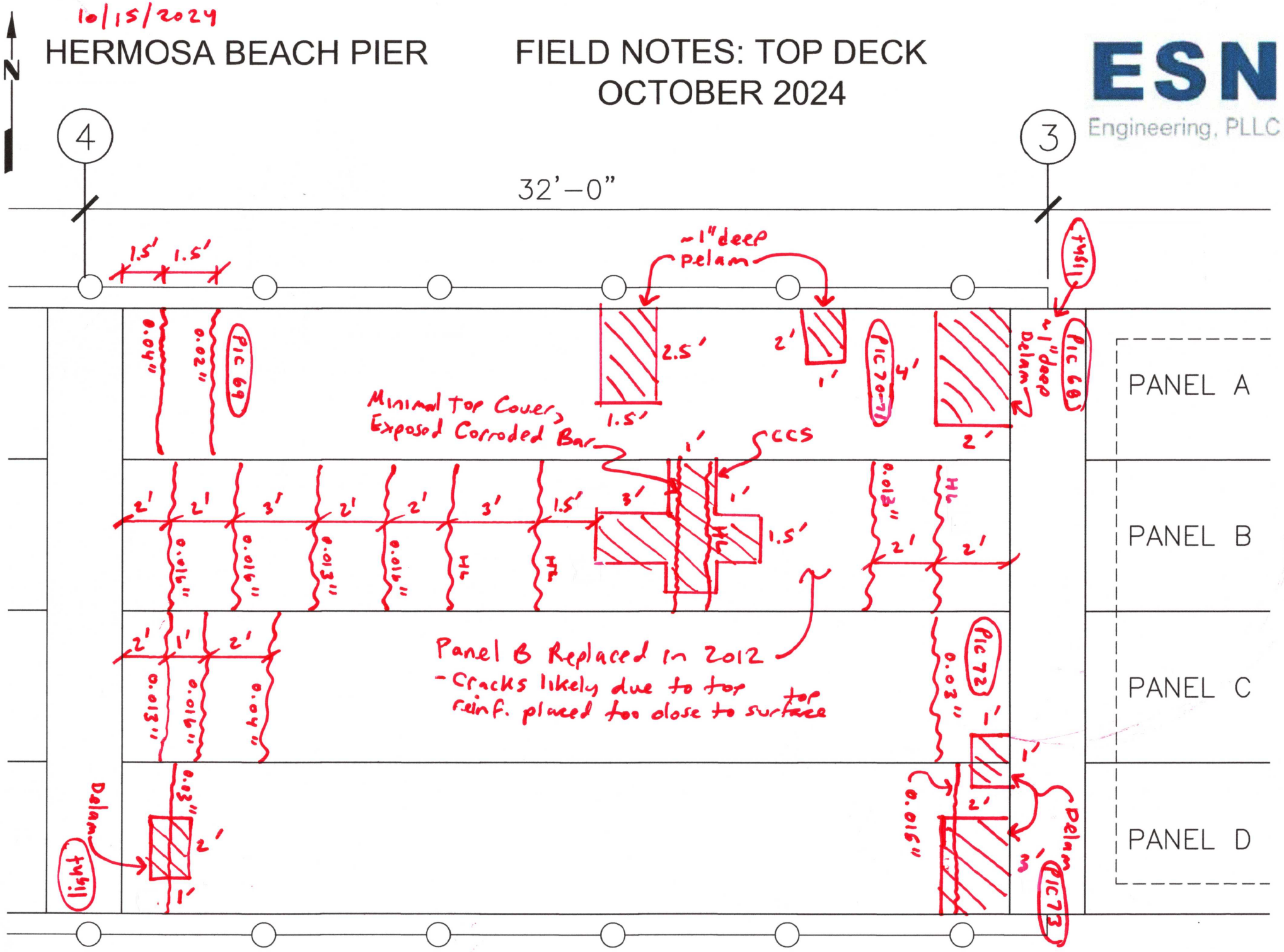

10/17/2024
HERMOSA BEACH PIER
FIELD NOTES: TOP DECK
OCTOBER 2024
ESN
Engineering, PLLC
N
3
2
32'-0"
CONC.
STAIRS
(4) Bench Legs (Typ.)
4'-5"
5'-7"
PANEL A
PANEL B
PANEL C
PANEL D
STORAGE ROOM BELOW
1'x1.5' Delam
5'
2'
Pics22
Delam 5'x4'
Pics 20,21
Surface Pop
Delam 5'x4'
Pics 23,24,25
Delam 5'x5'
light
Delam 2'x5'
1'-5"
1'-2"
5'

10/15/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

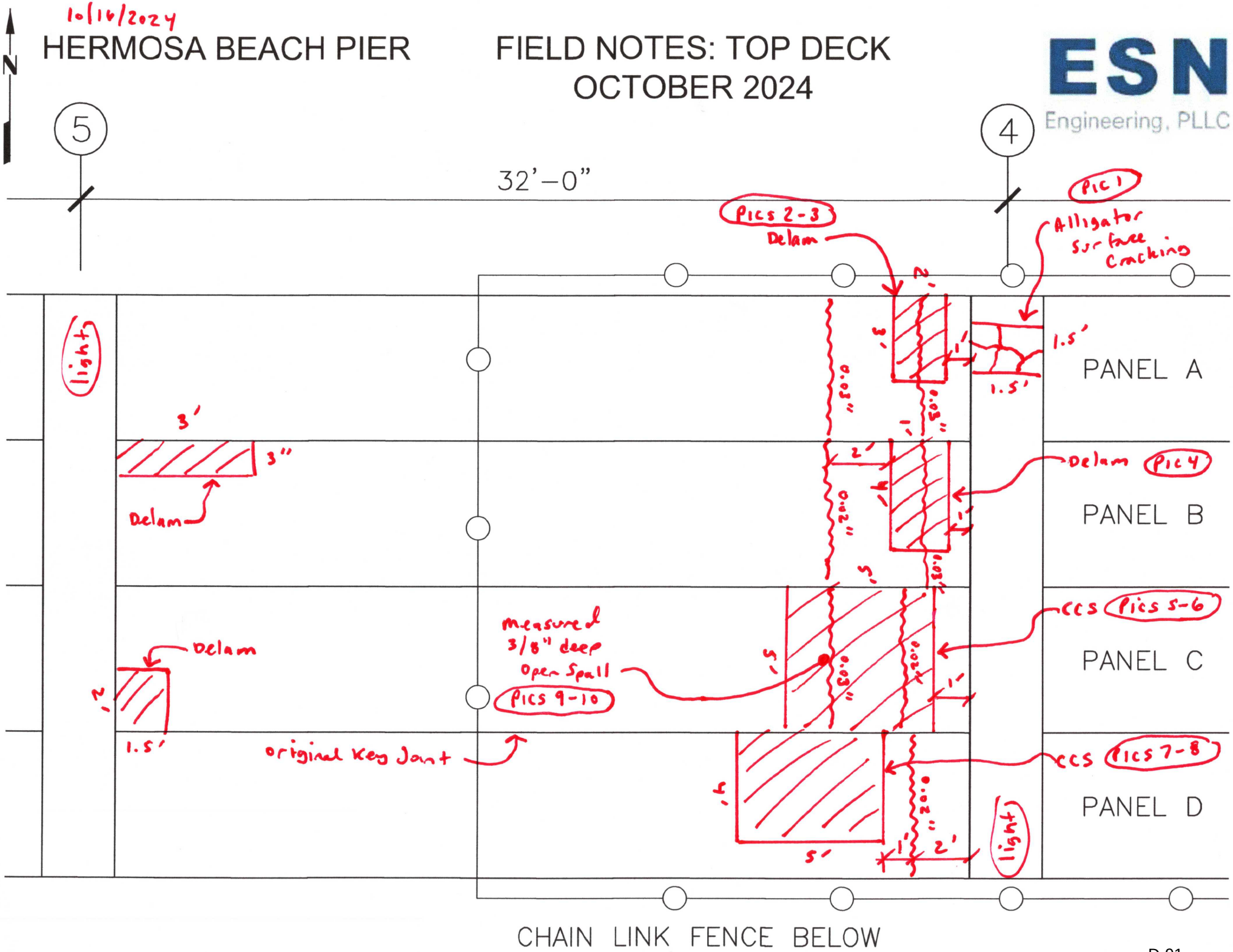


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

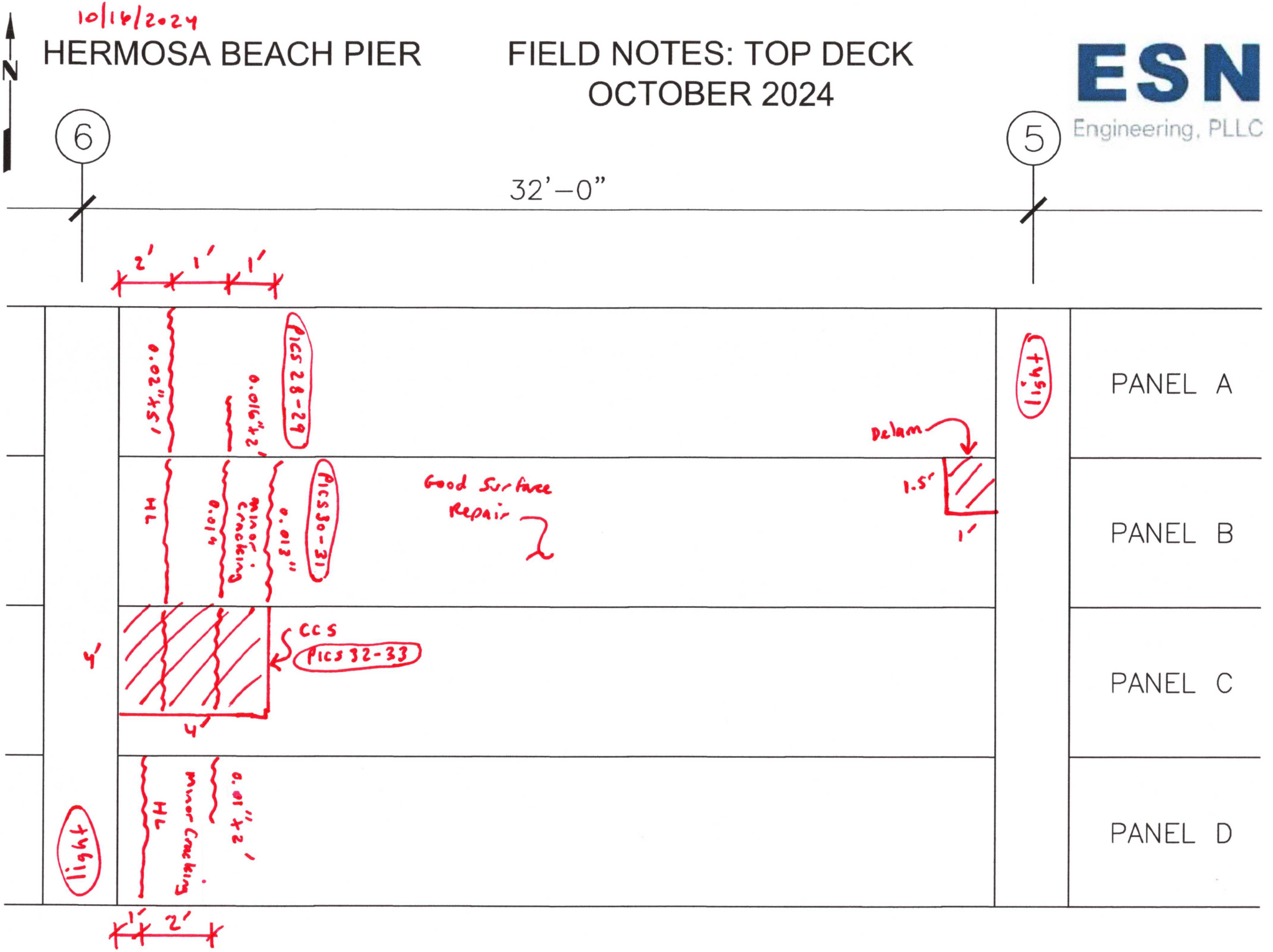


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

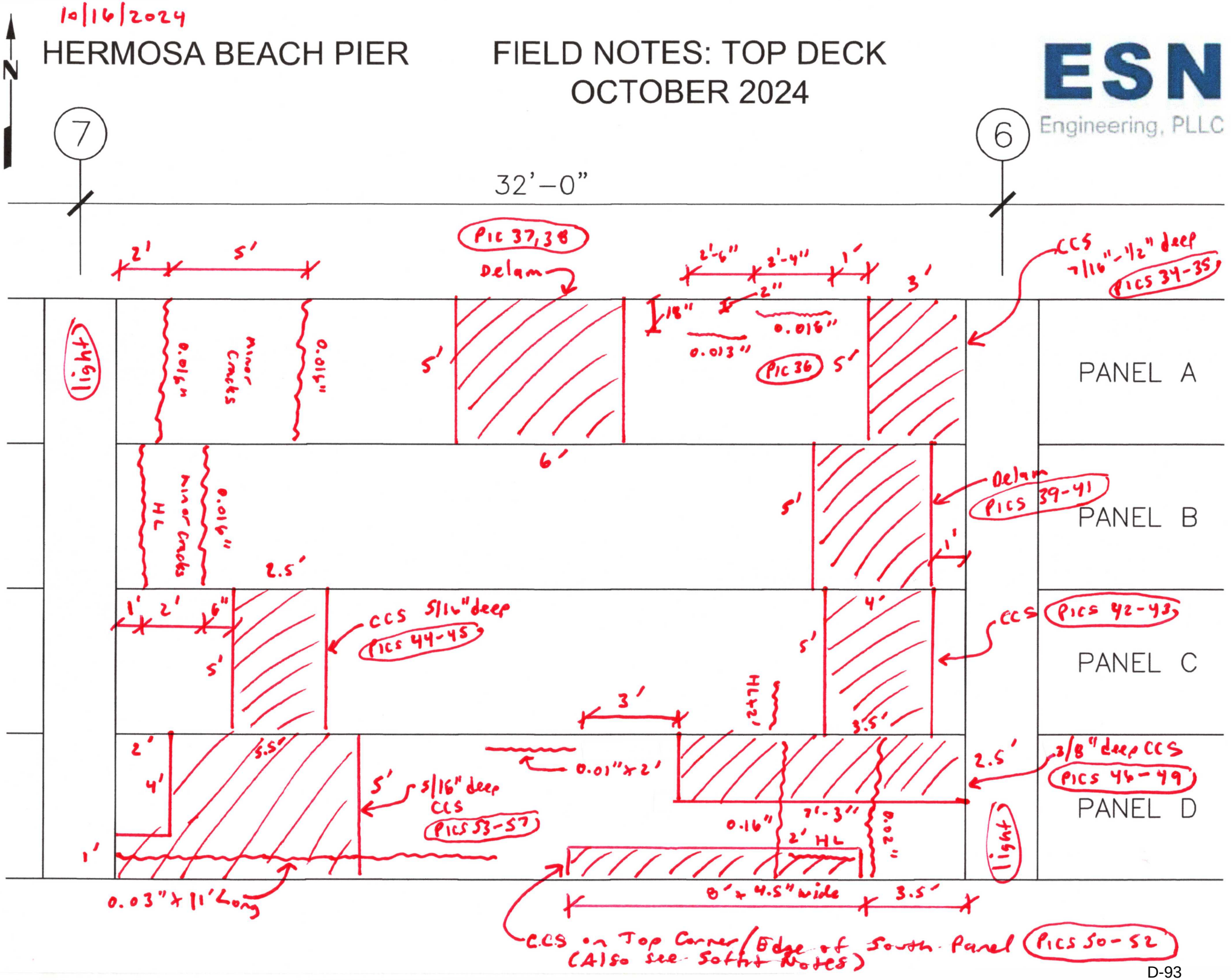


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

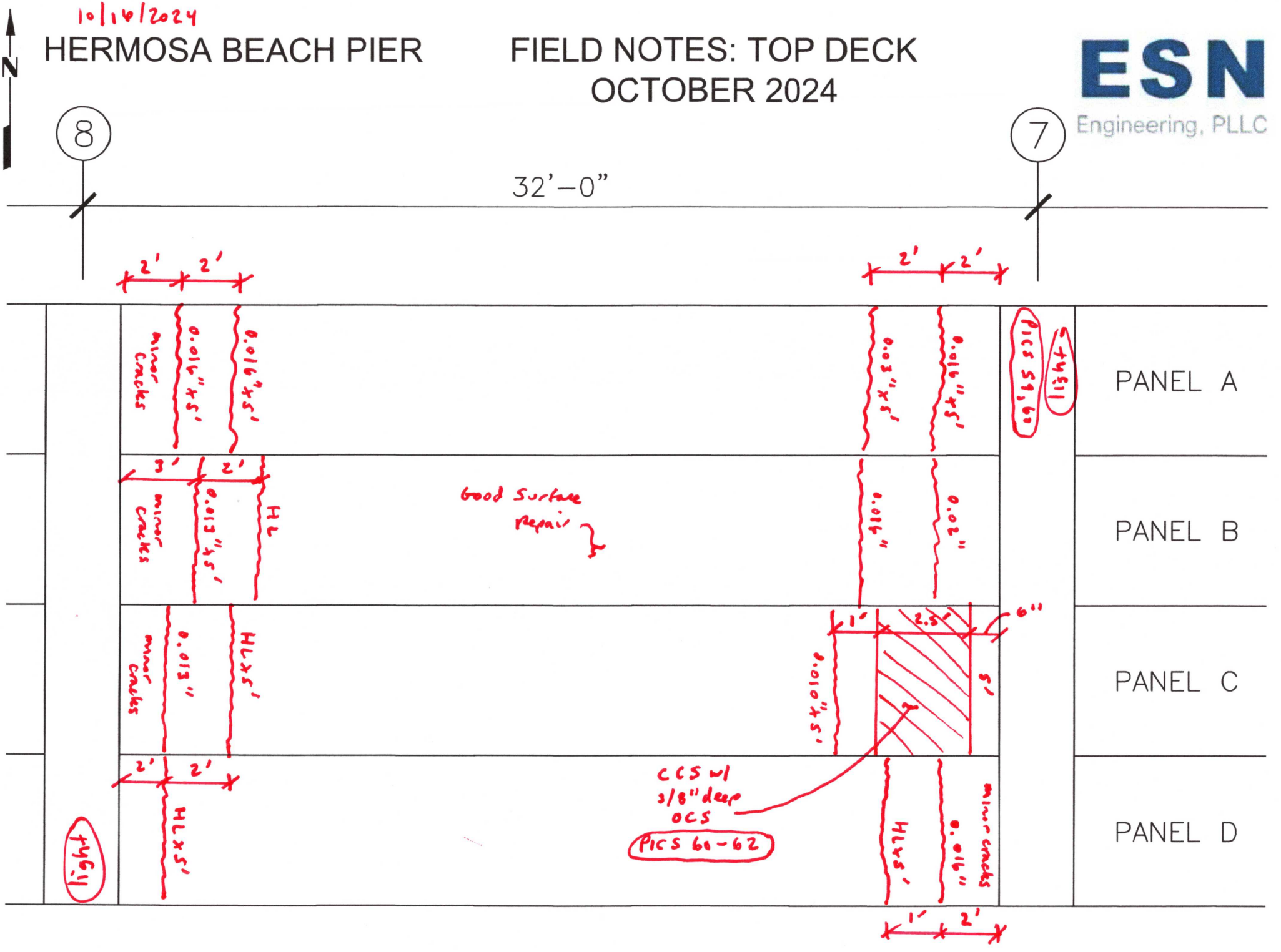


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

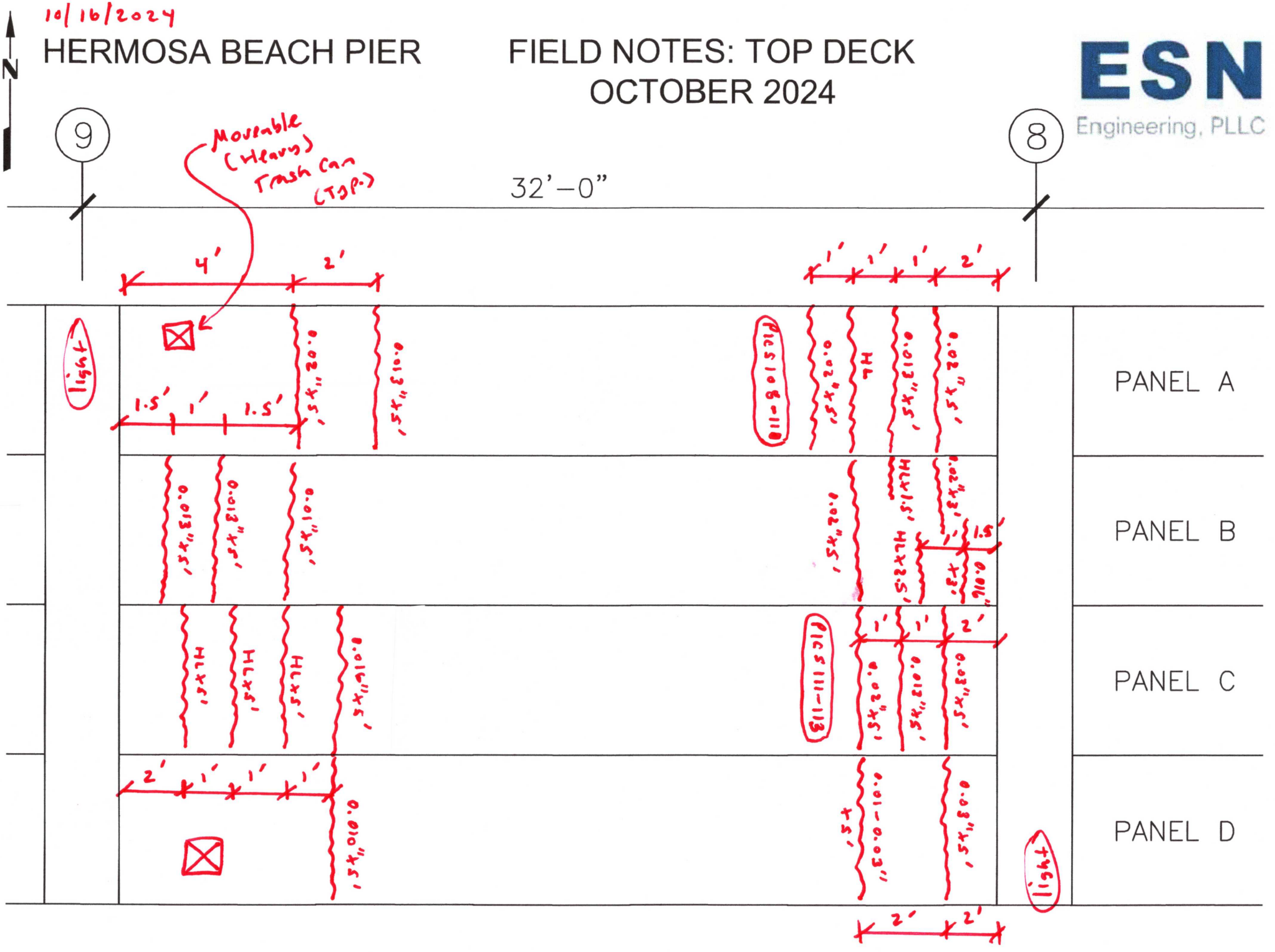


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

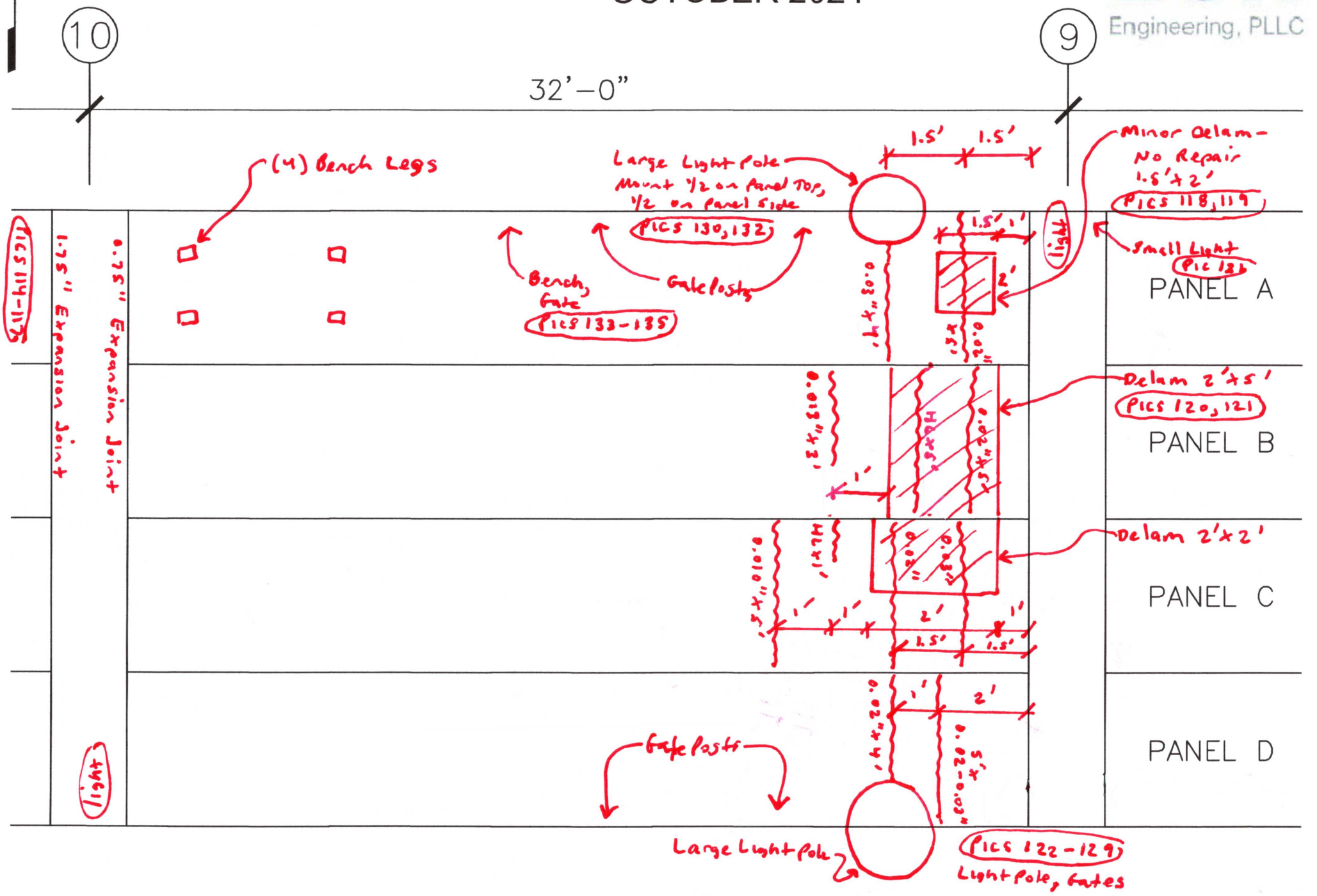


10/10/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

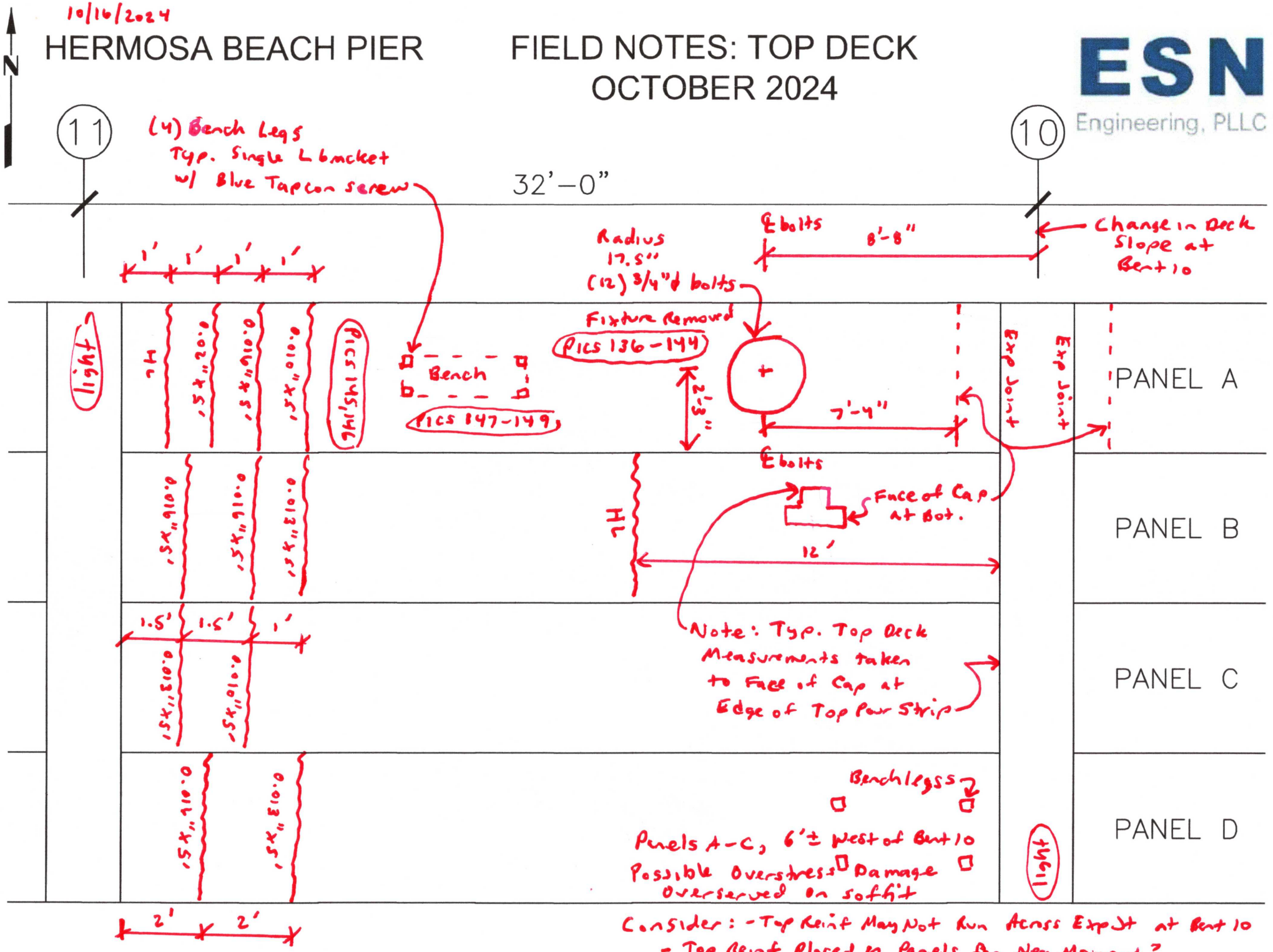


10/16/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

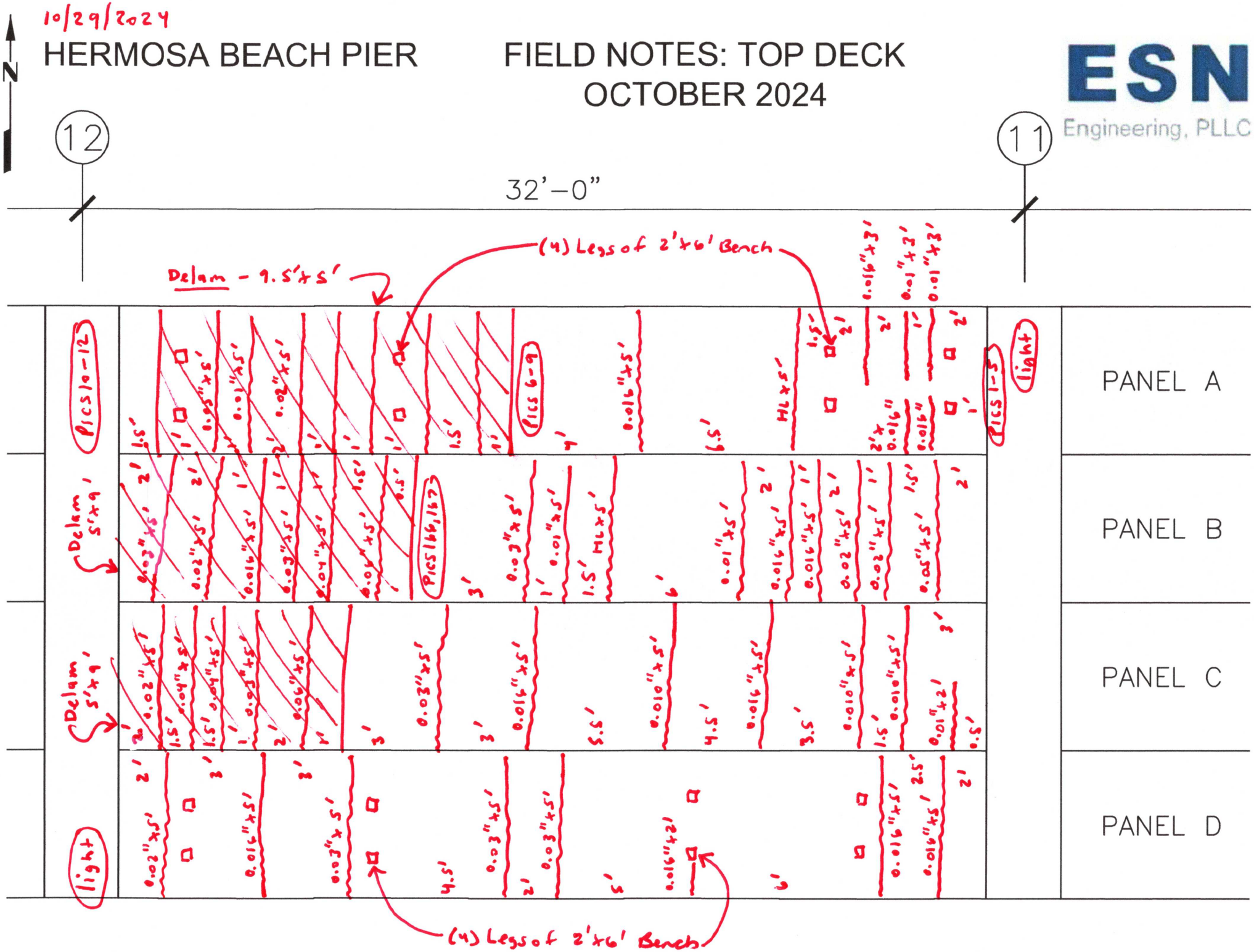


10/29/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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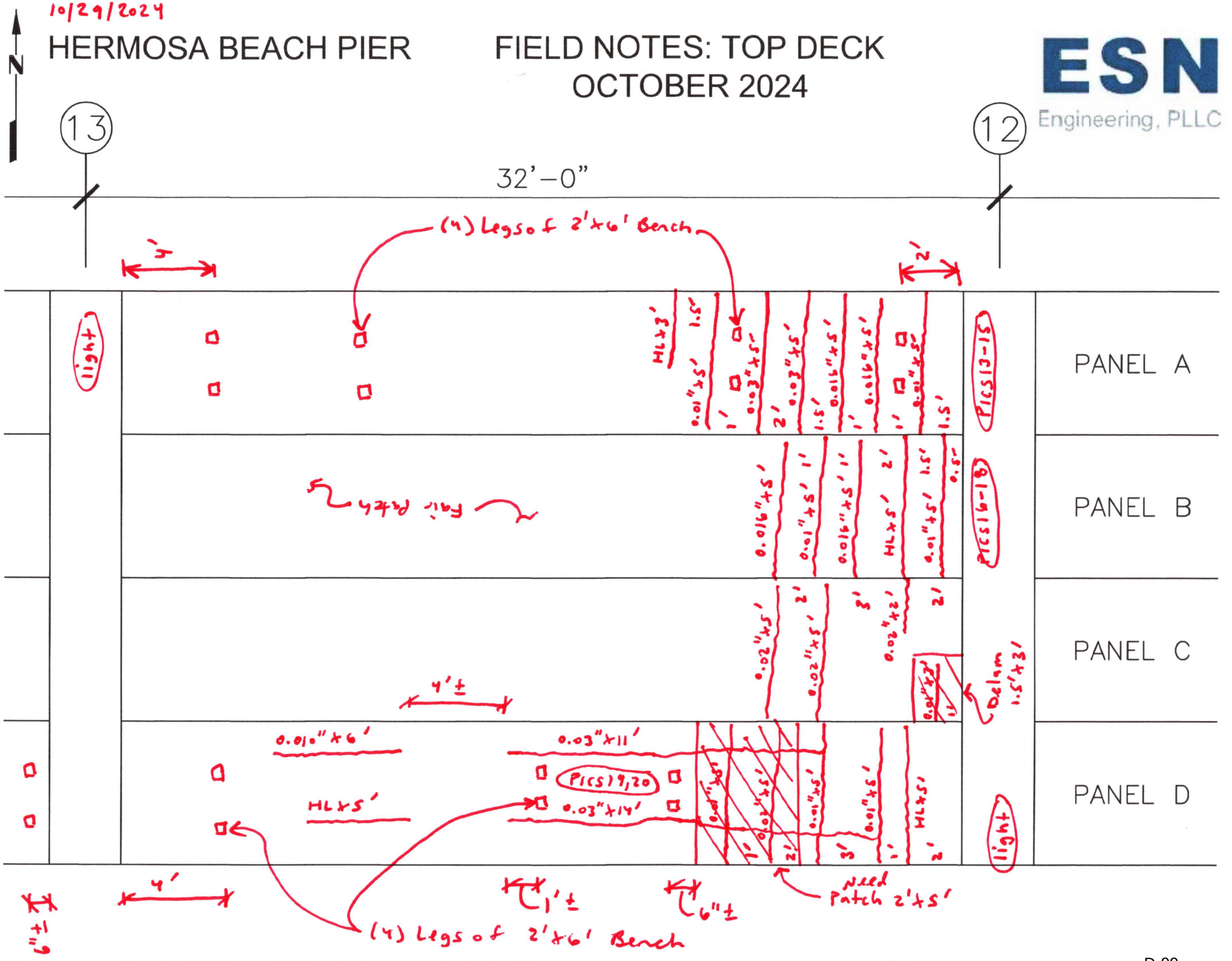


10/29/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

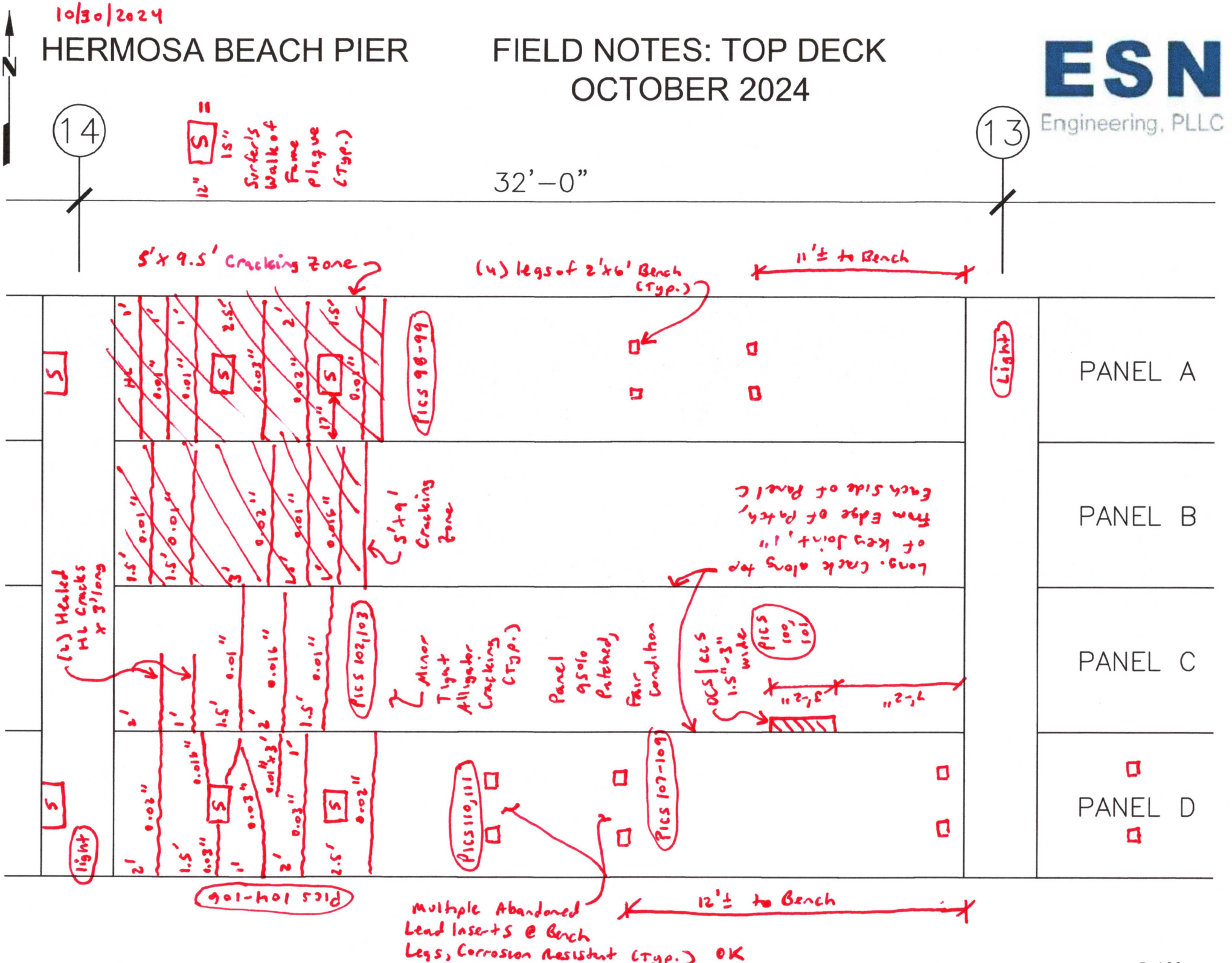


10/30/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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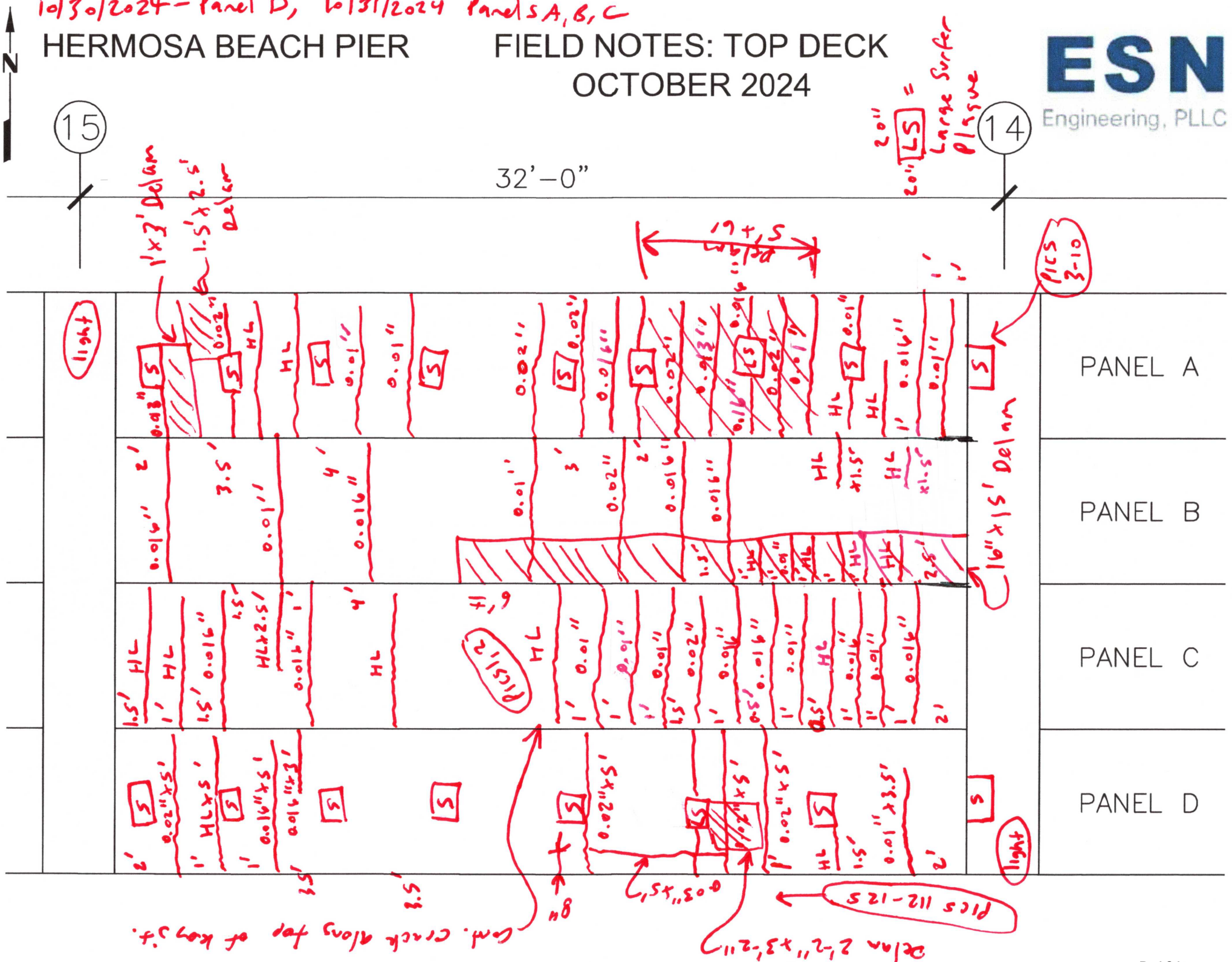


10/30/2024 - Panel D, 10/31/2024 Panels A, B, C

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

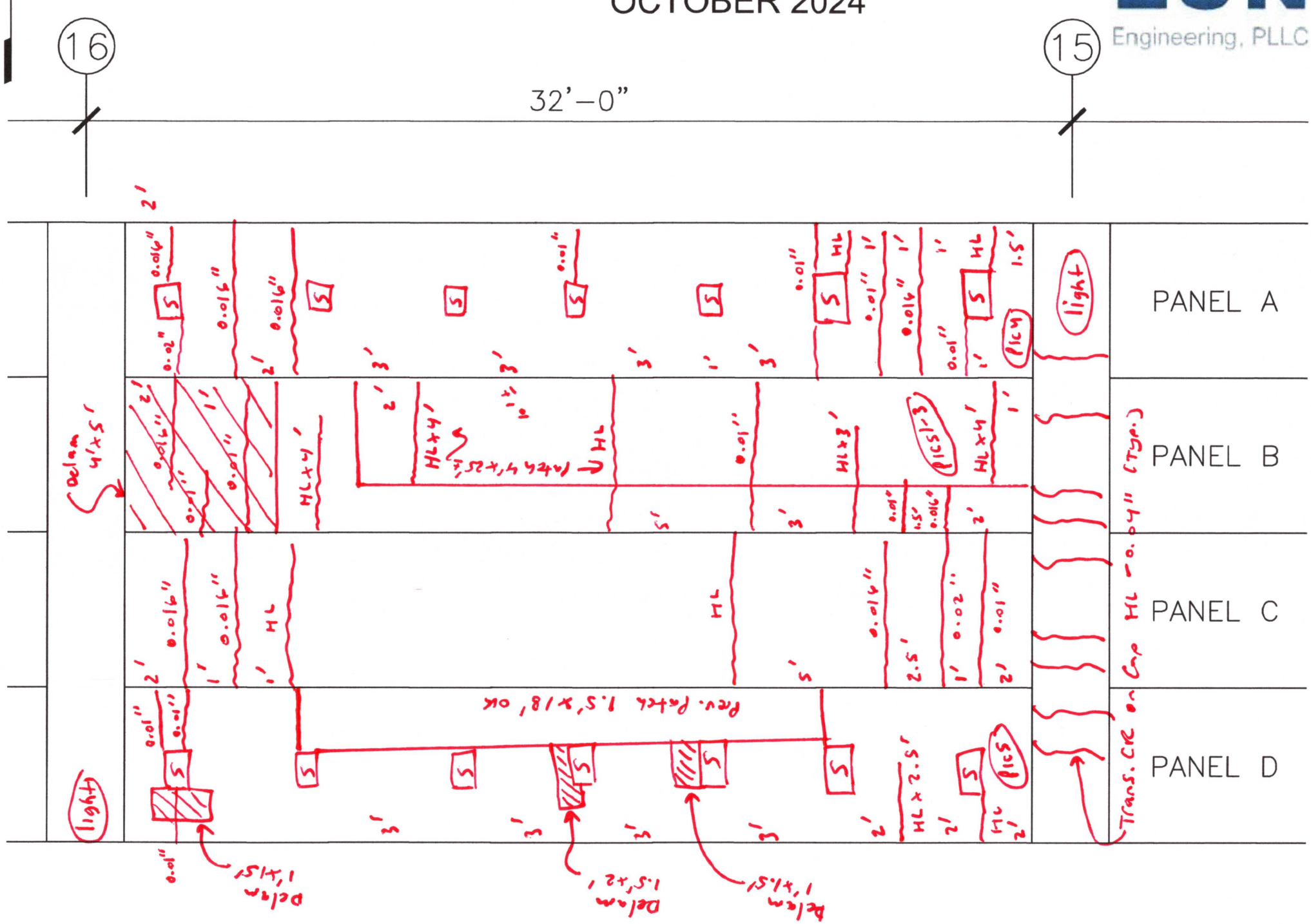


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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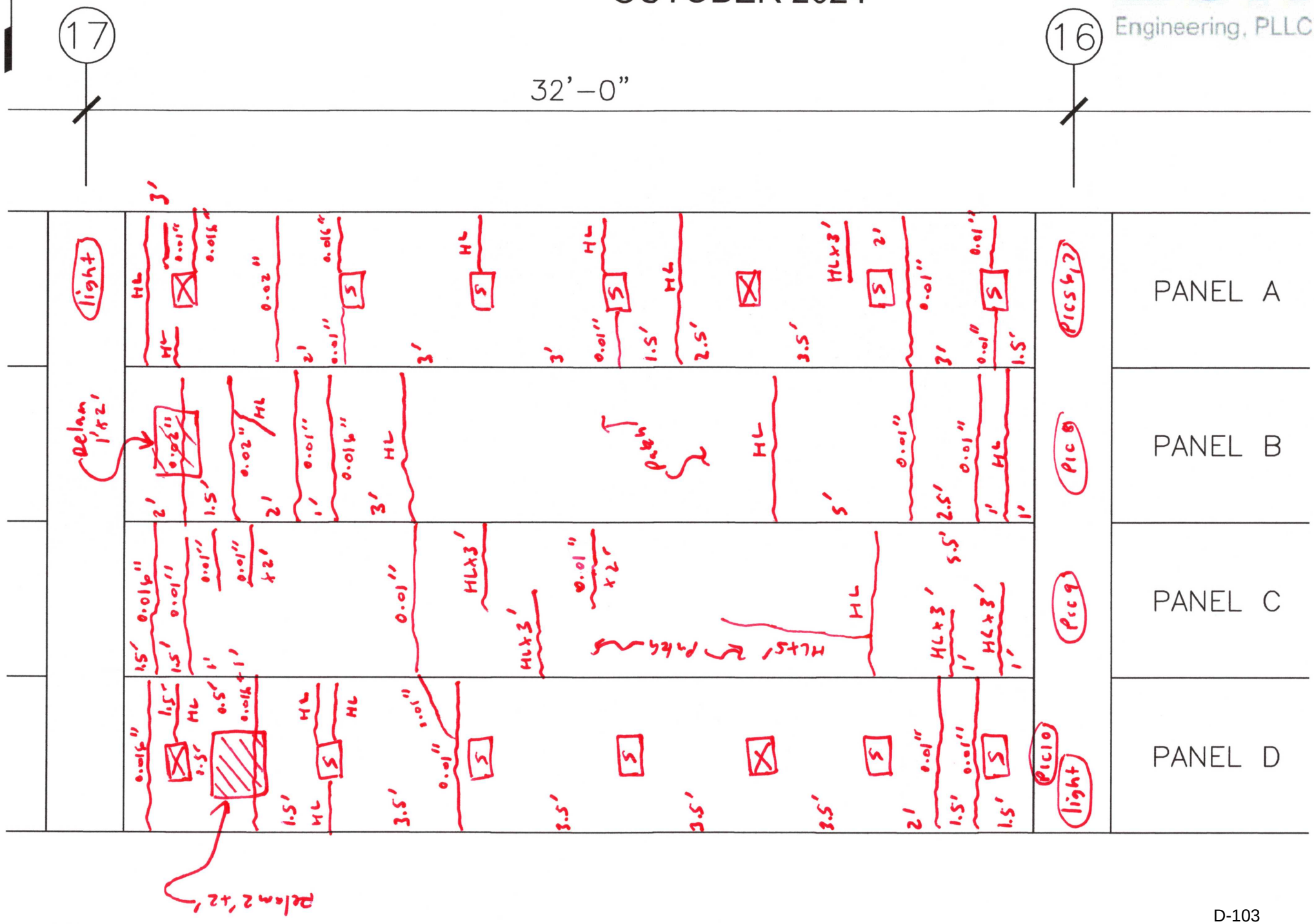


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

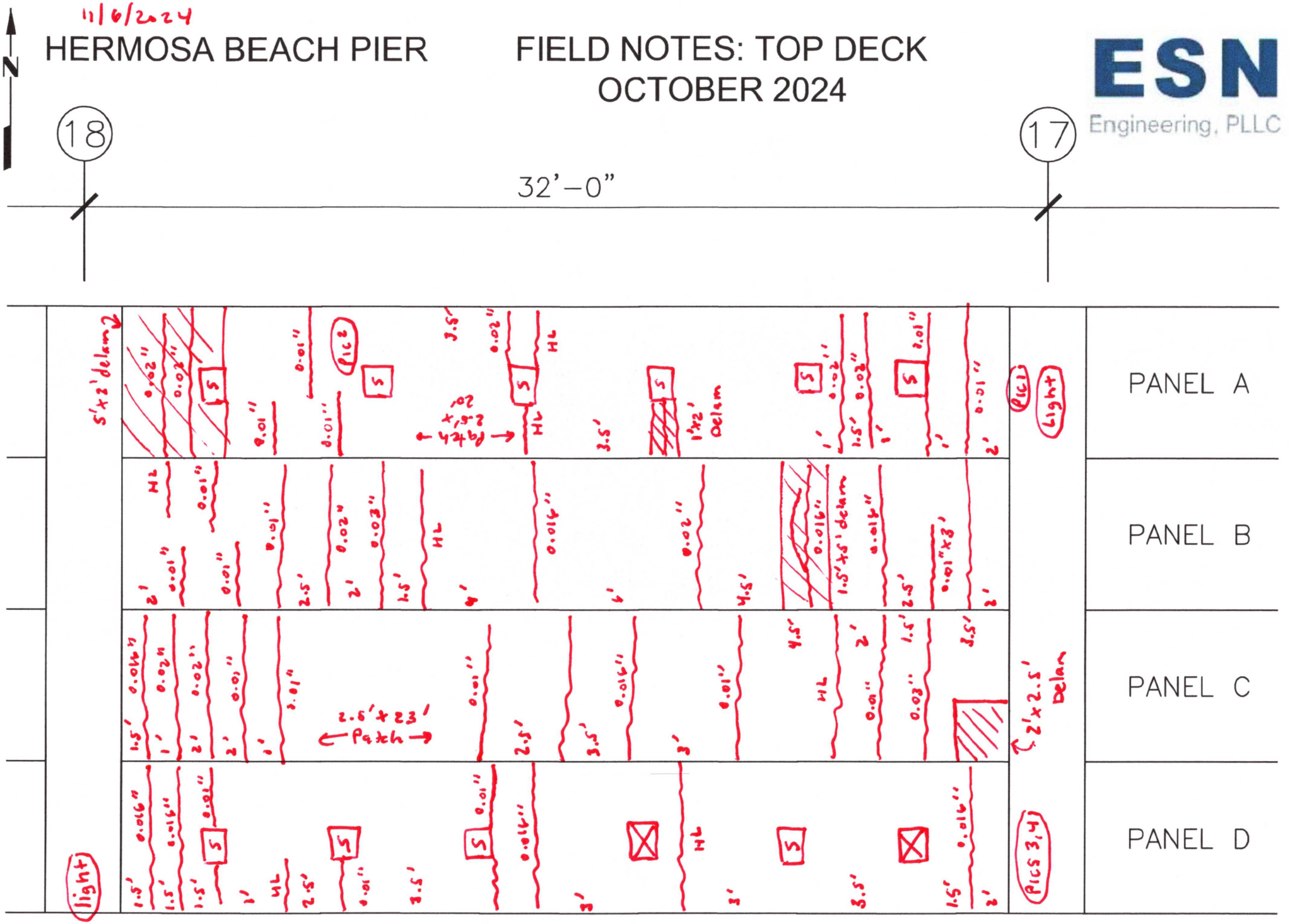


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

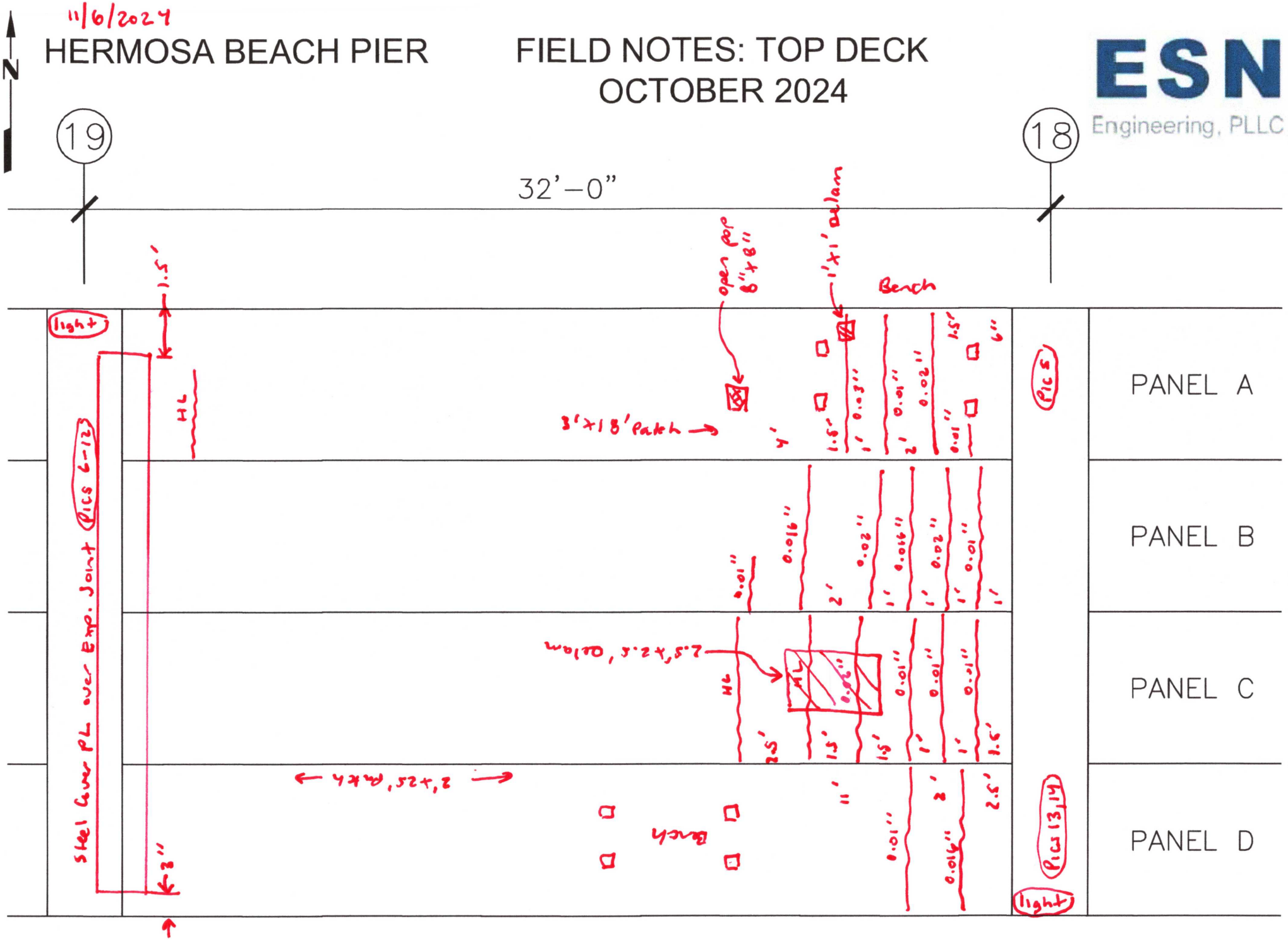


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

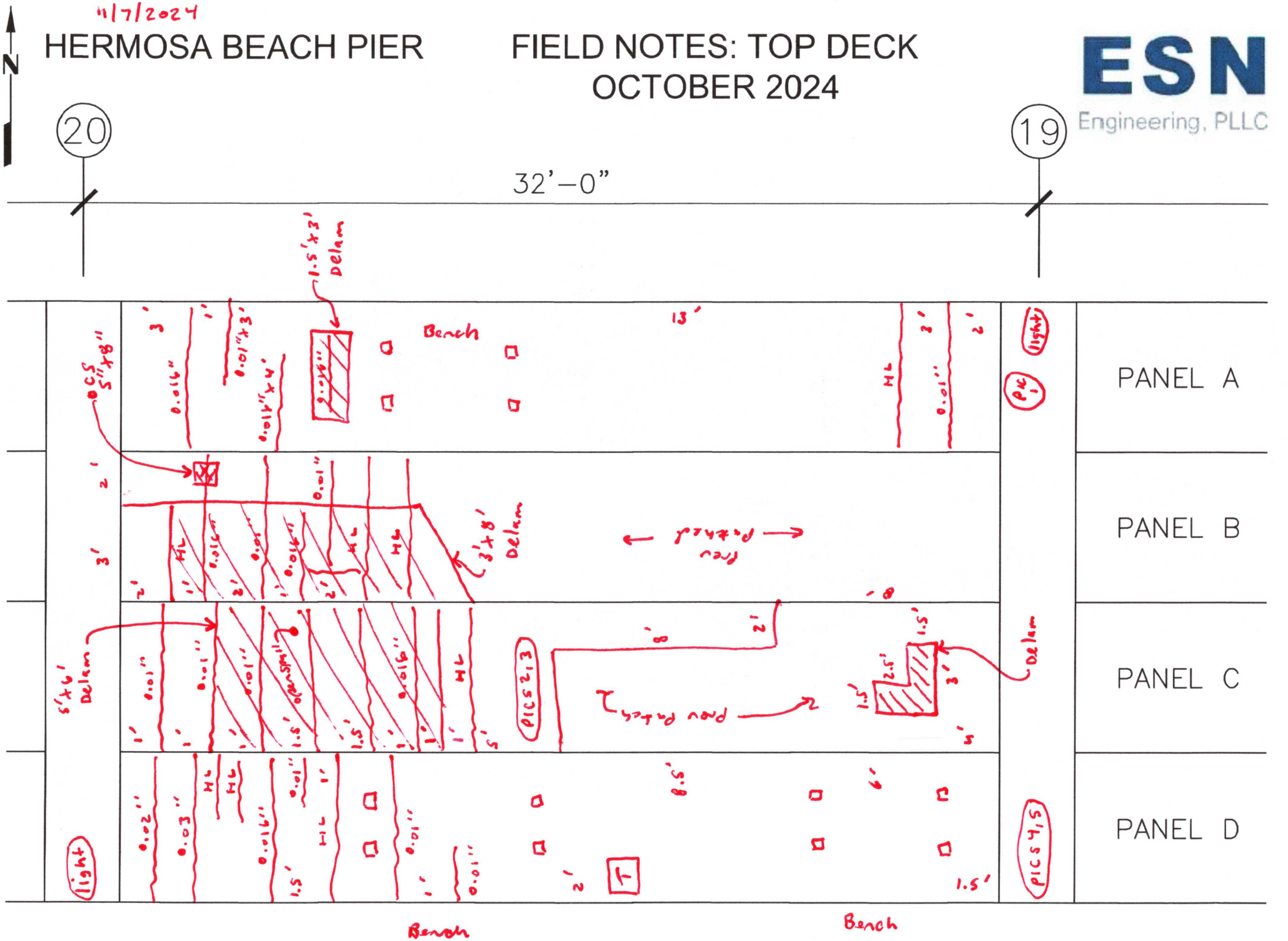


11/7/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

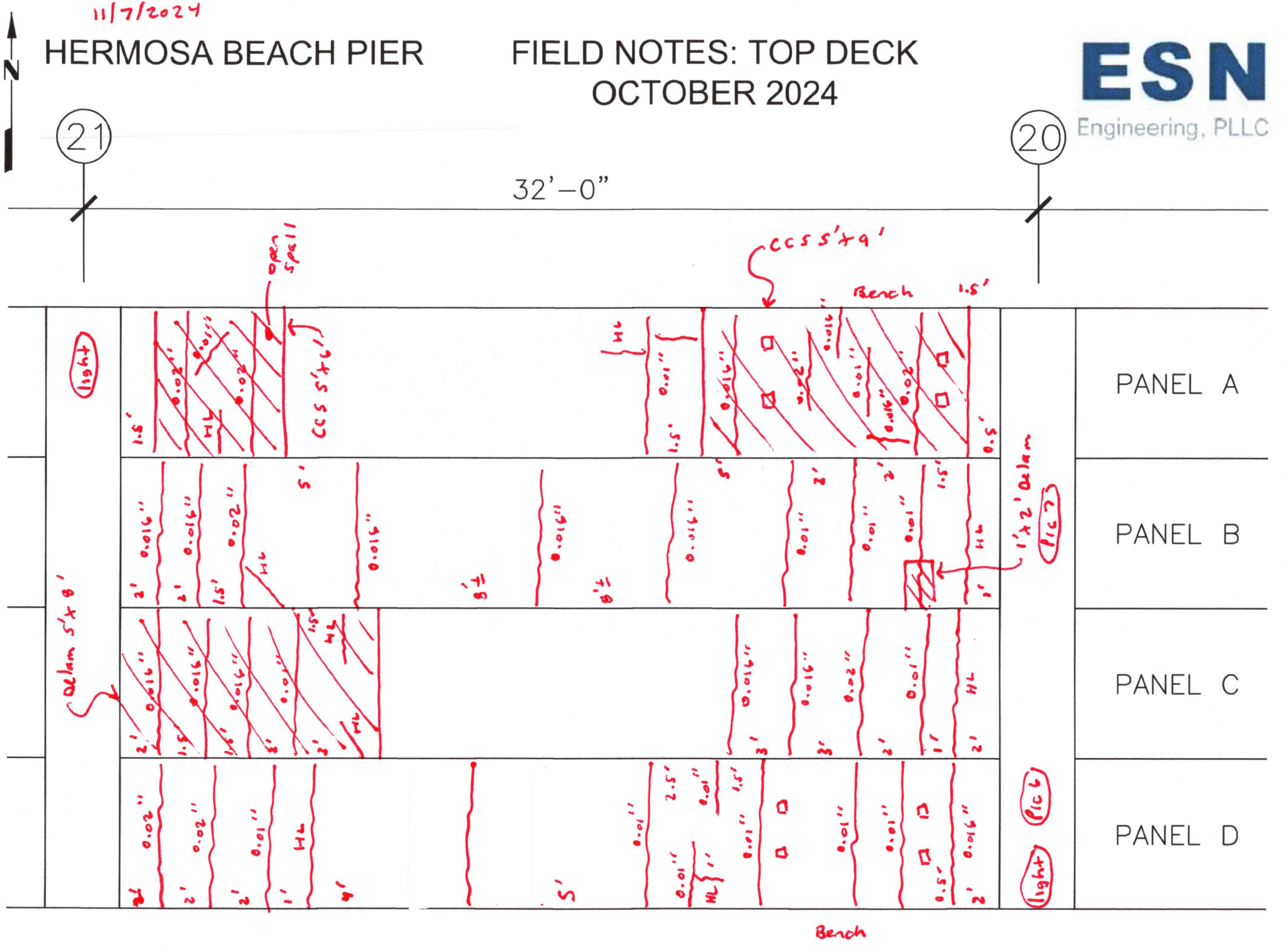


11/7/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

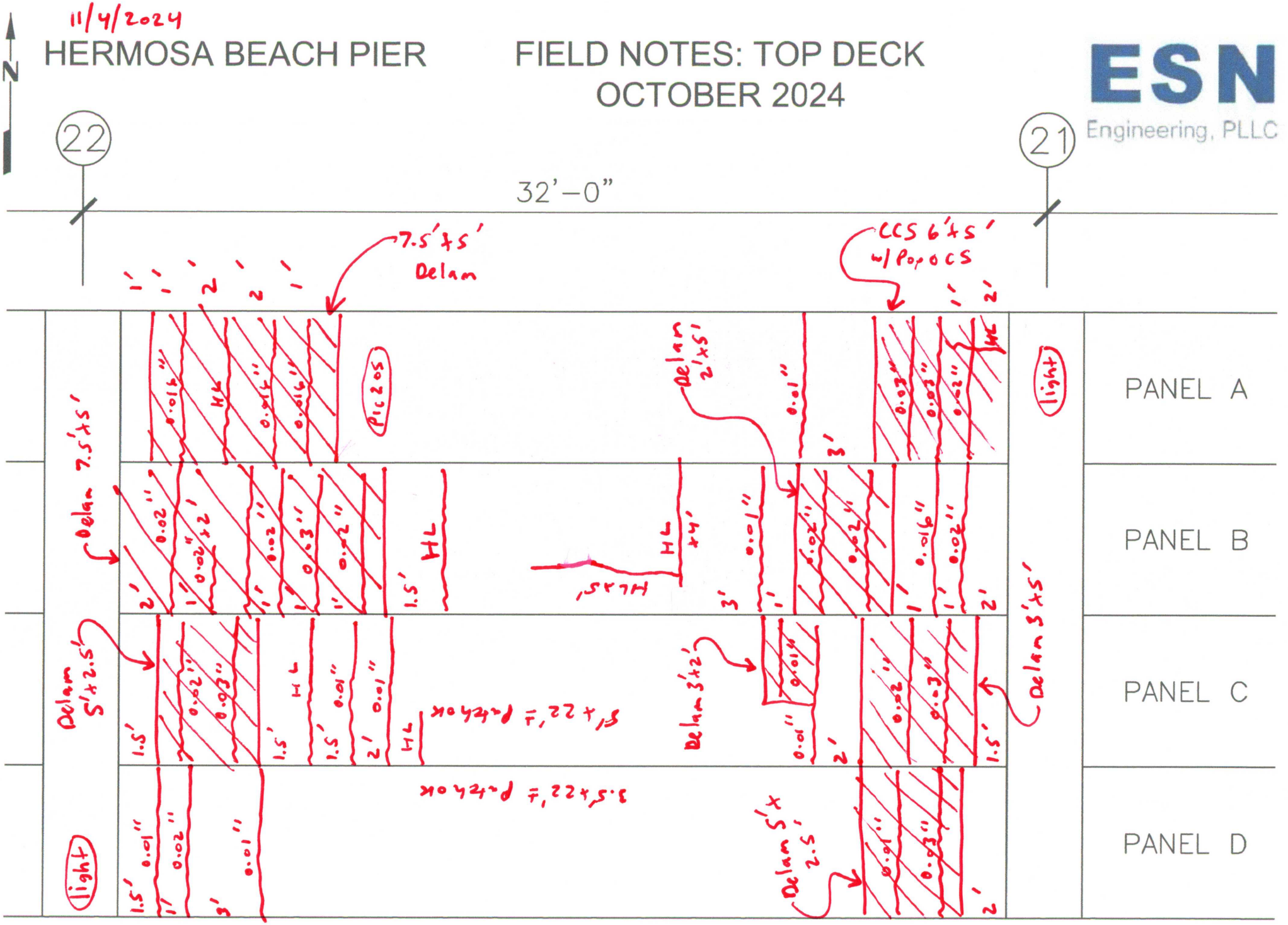


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

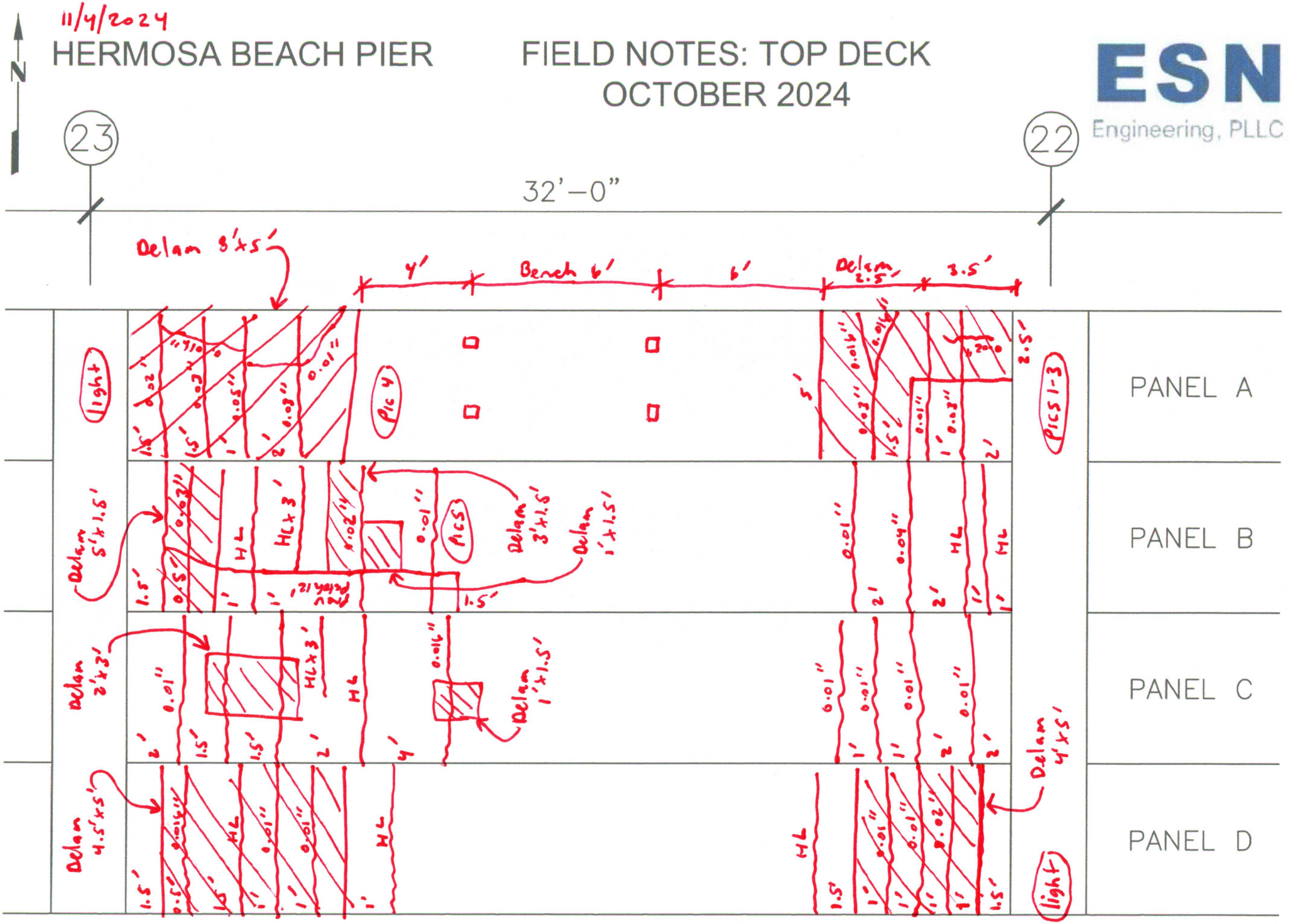


11/4/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

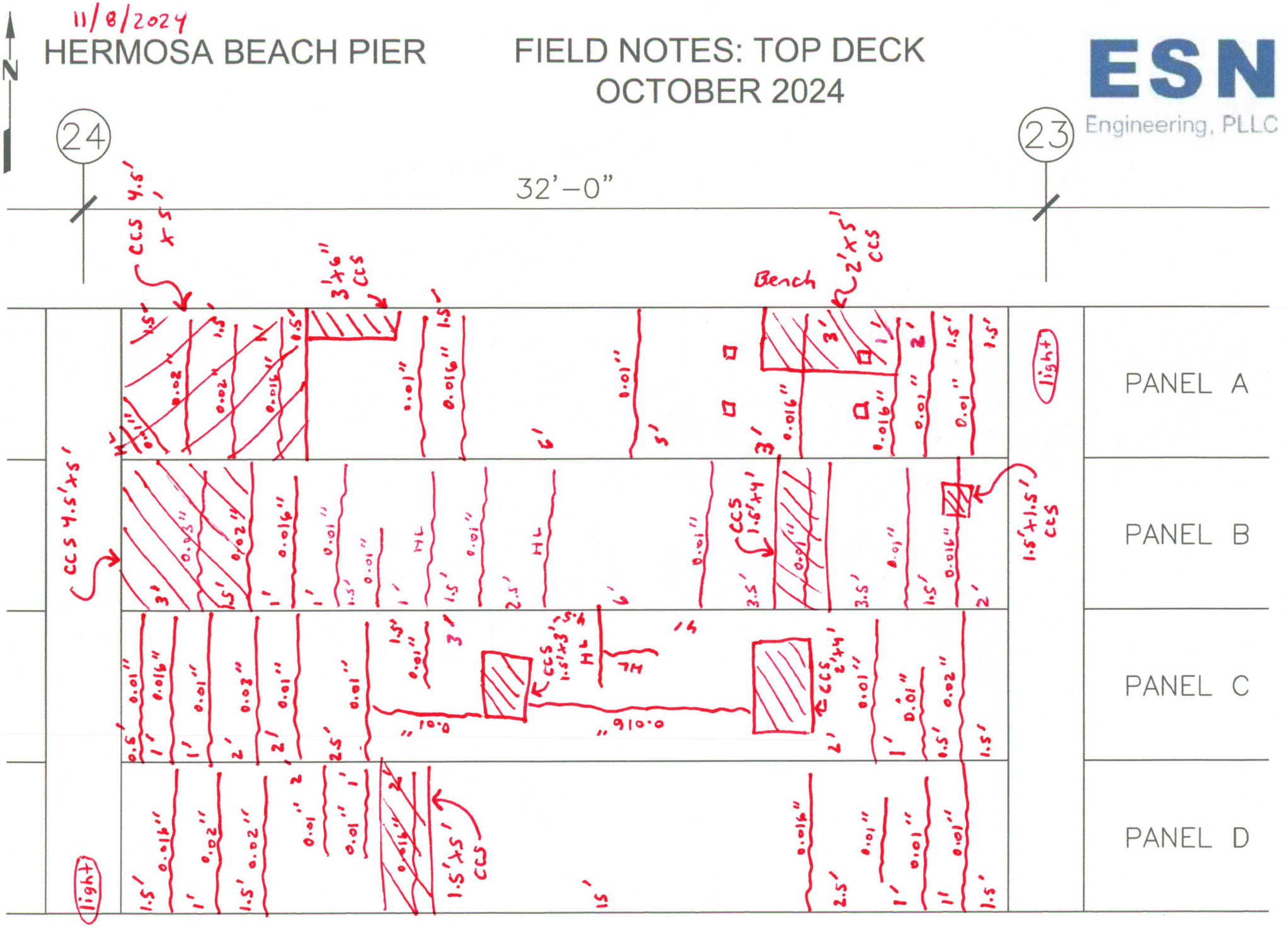


11/8/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

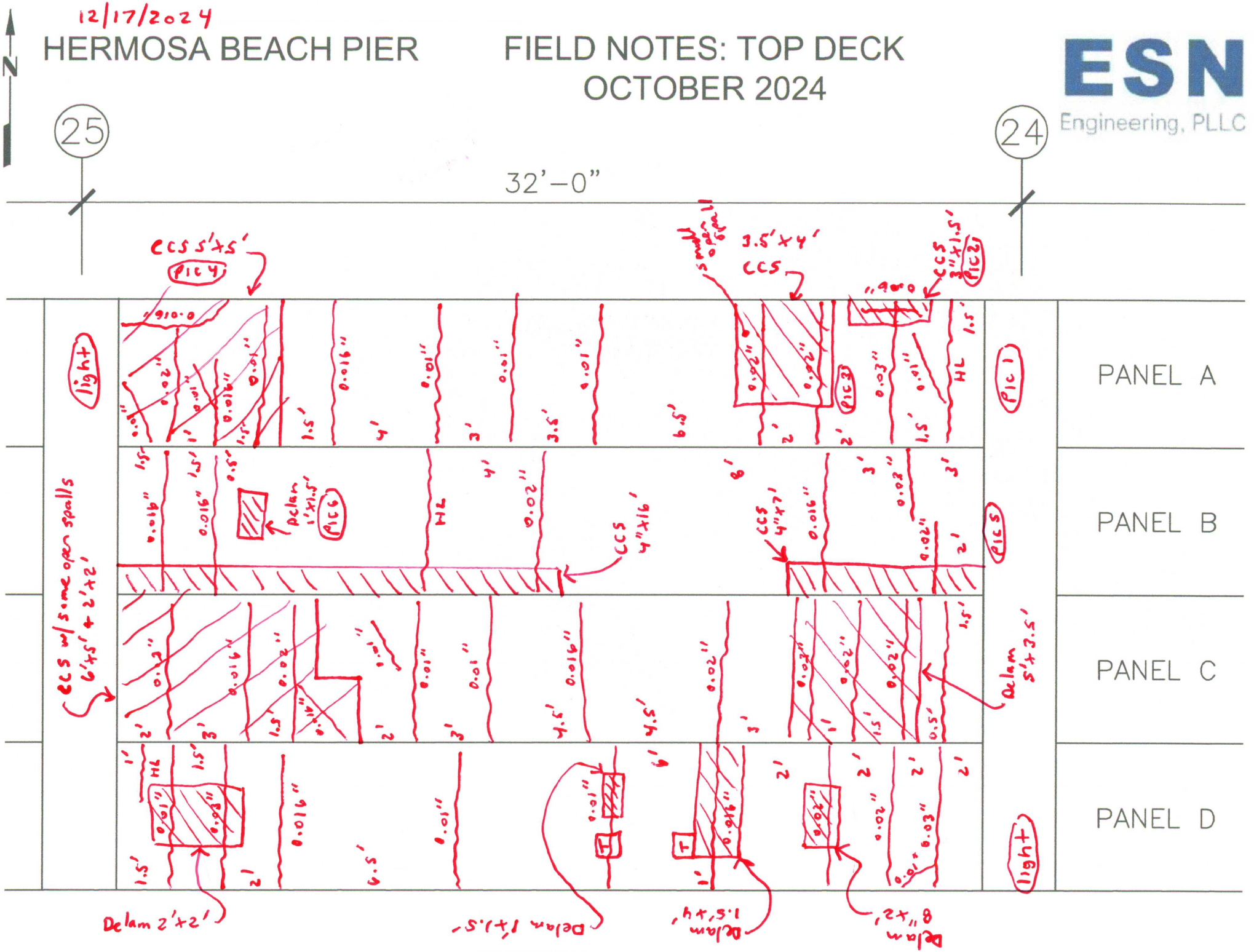


12/17/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

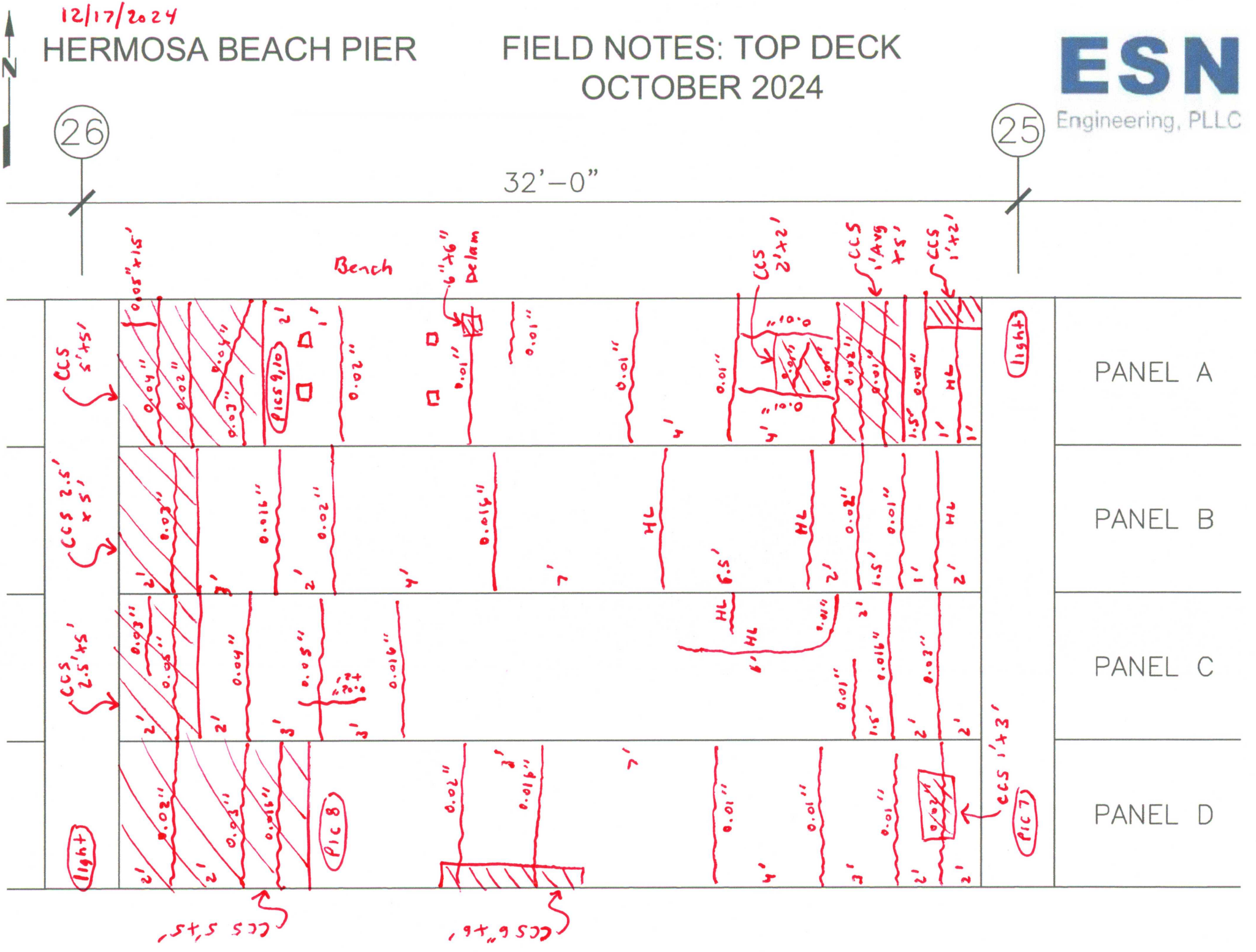


12/17/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

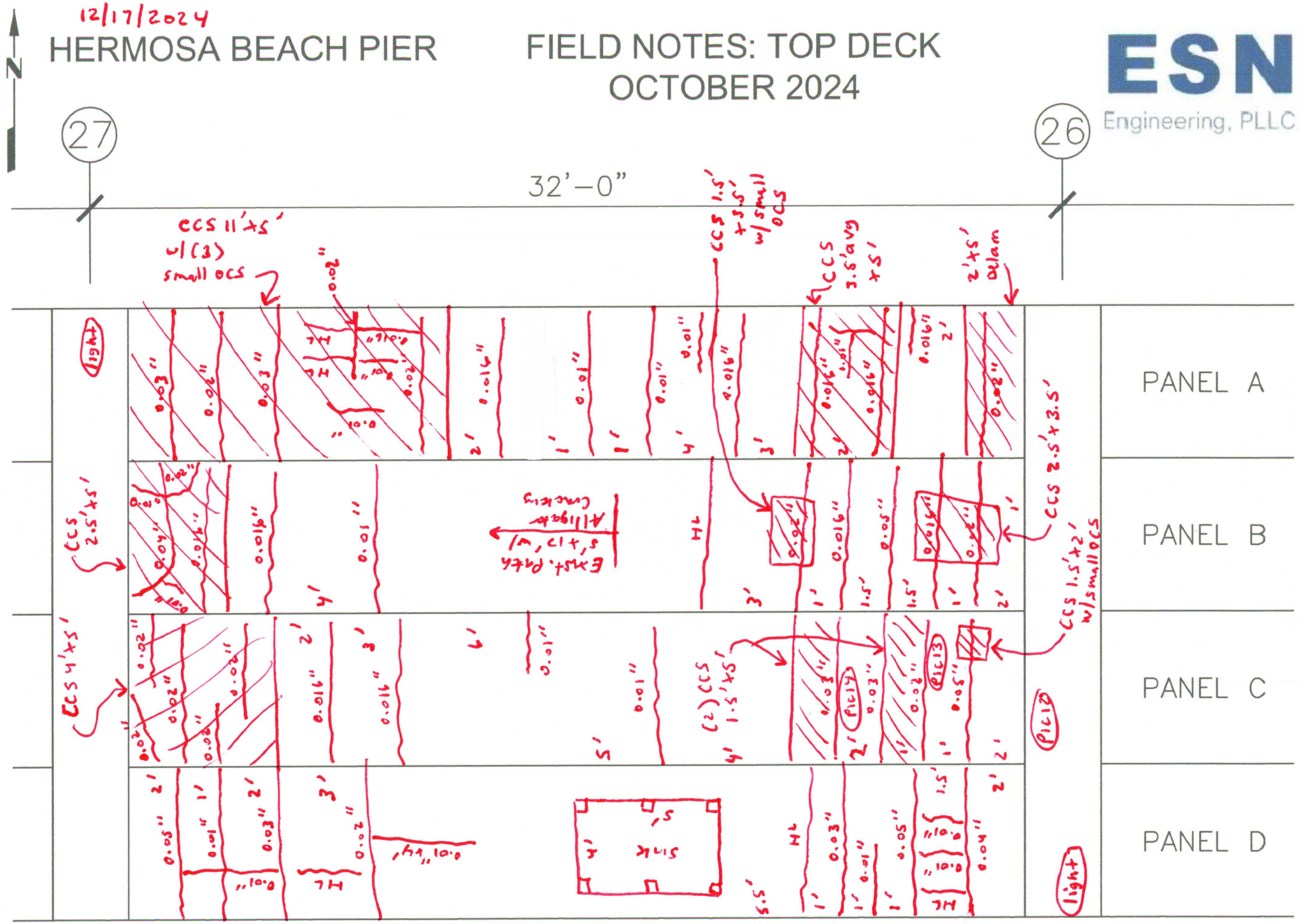


12/17/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

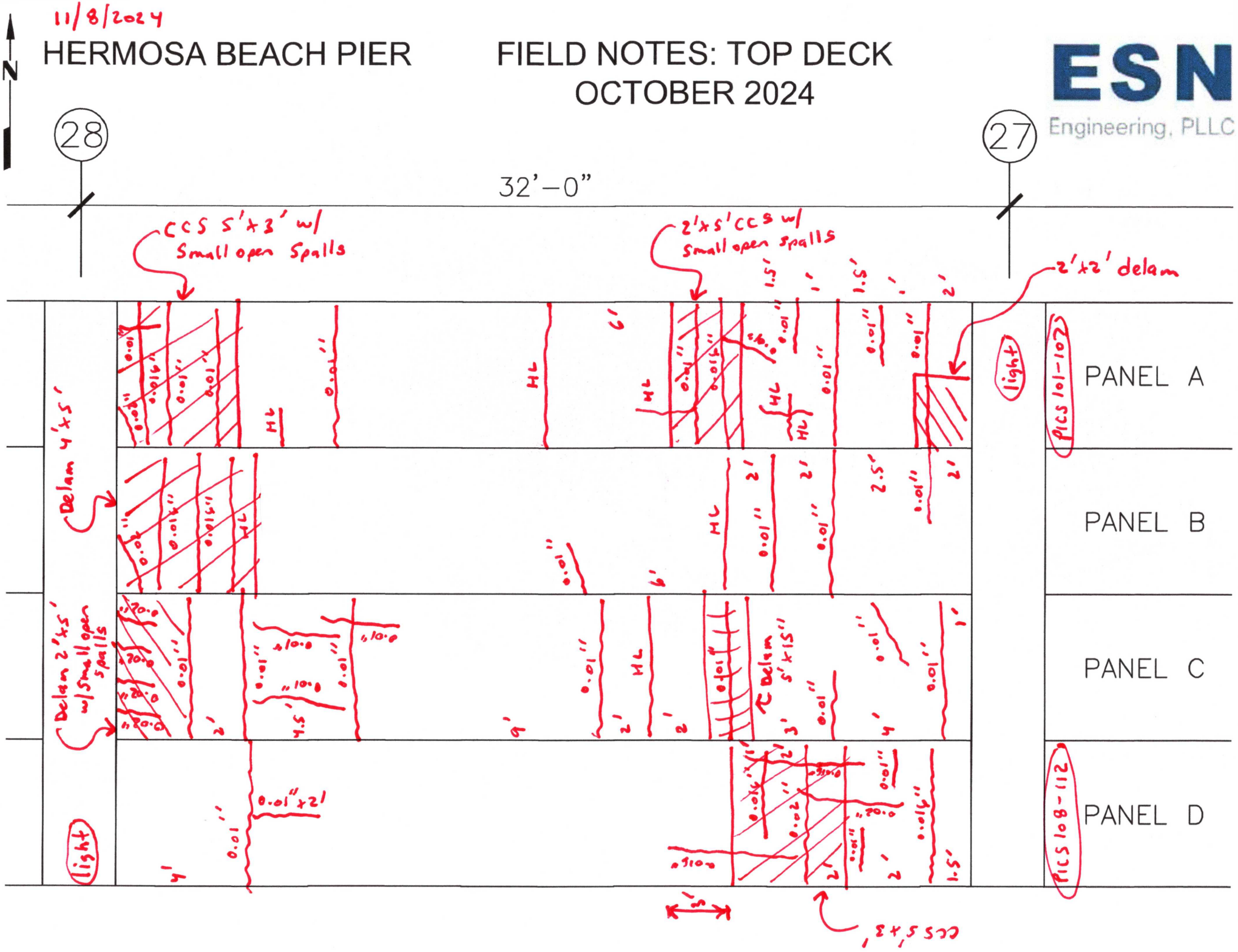


11/8/2024

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FIELD NOTES: TOP DECK
OCTOBER 2024

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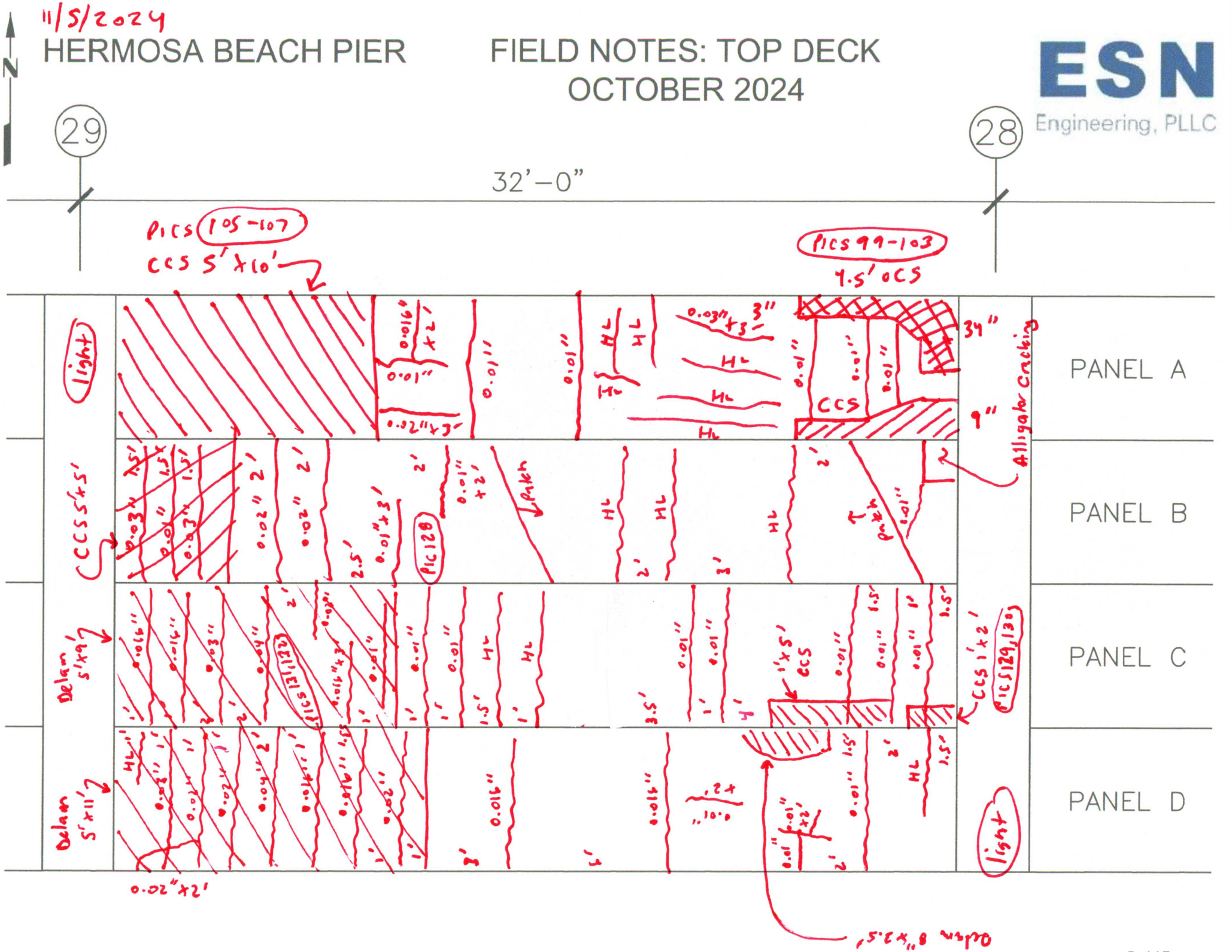


11/5/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

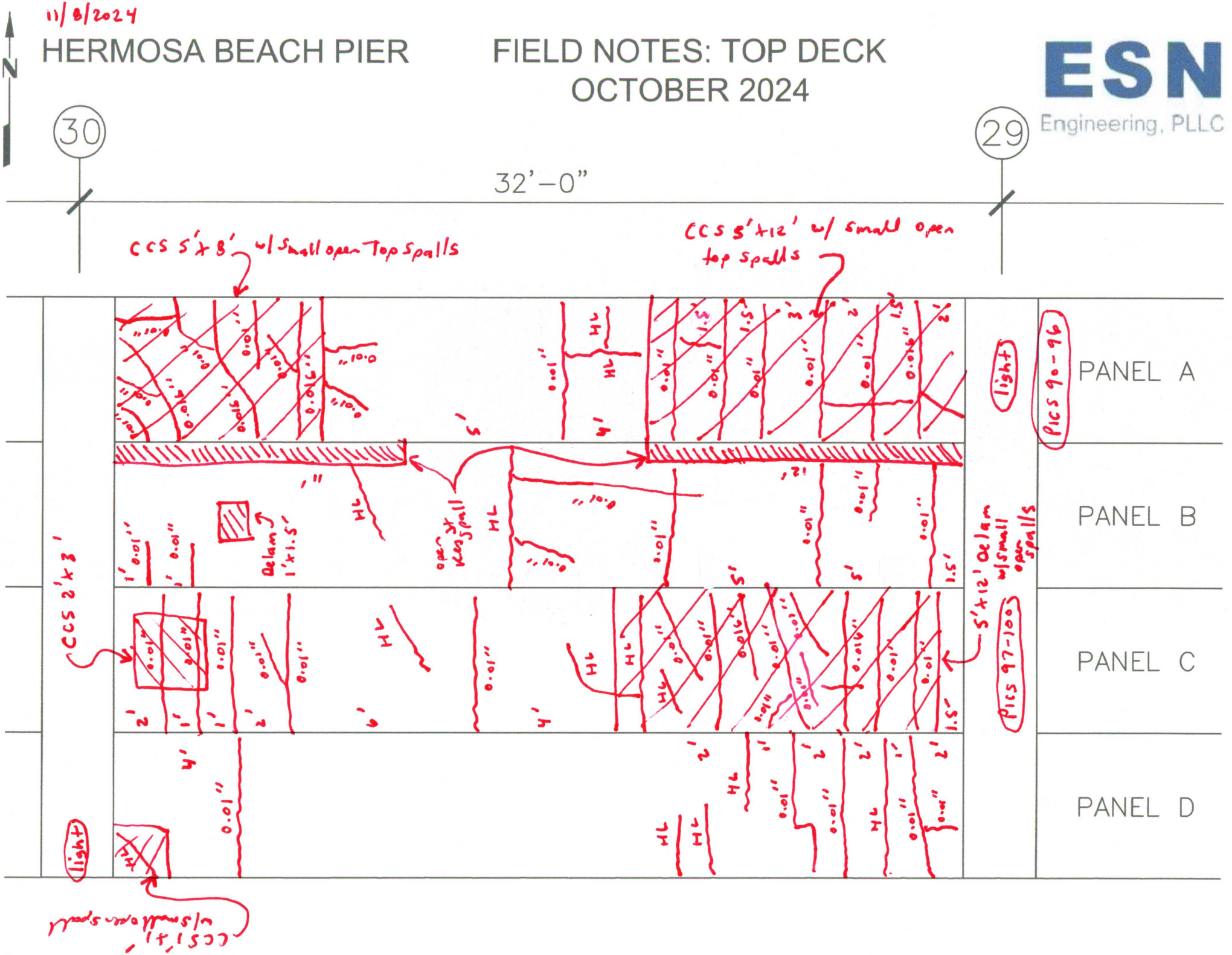


11/8/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

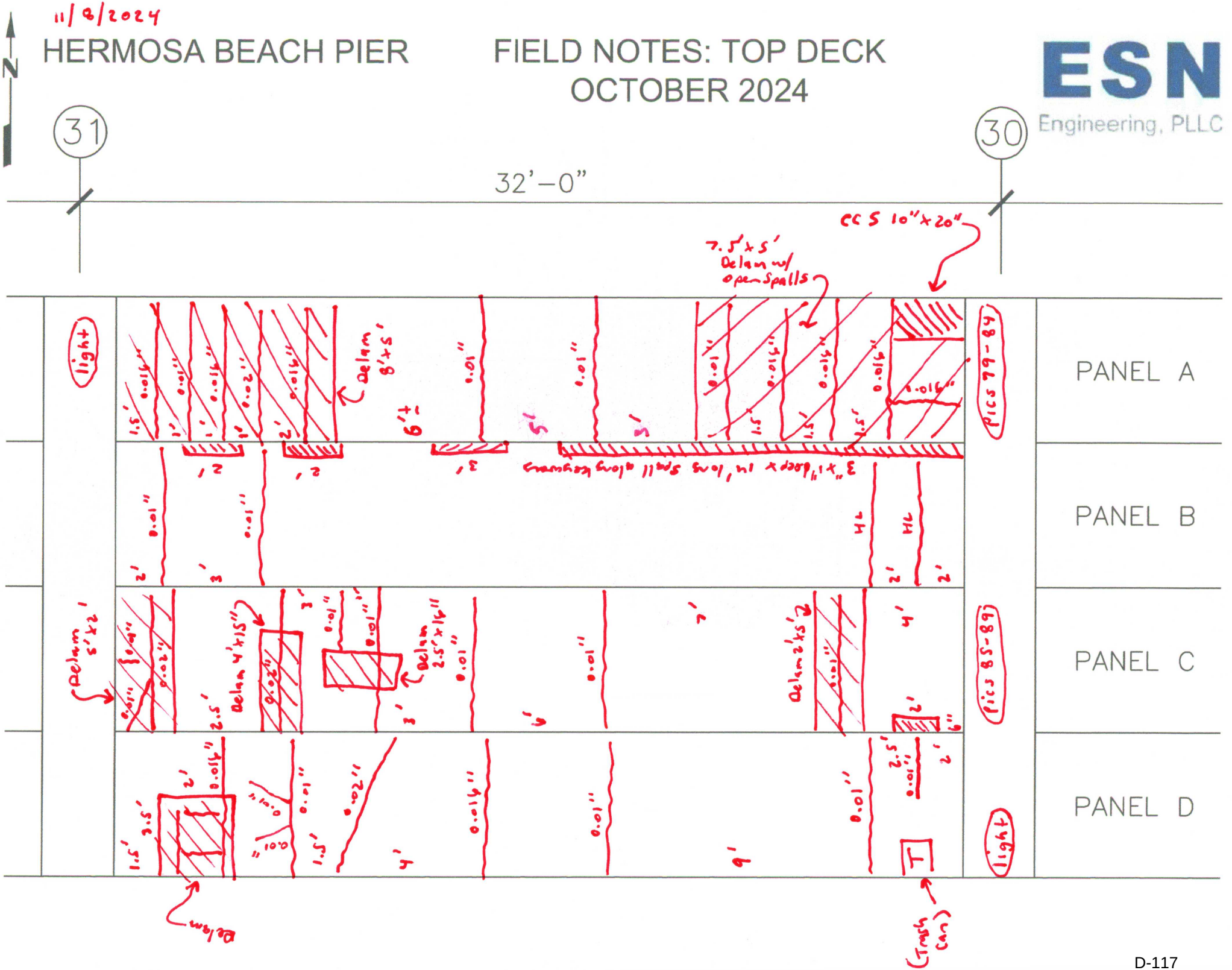


11/8/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

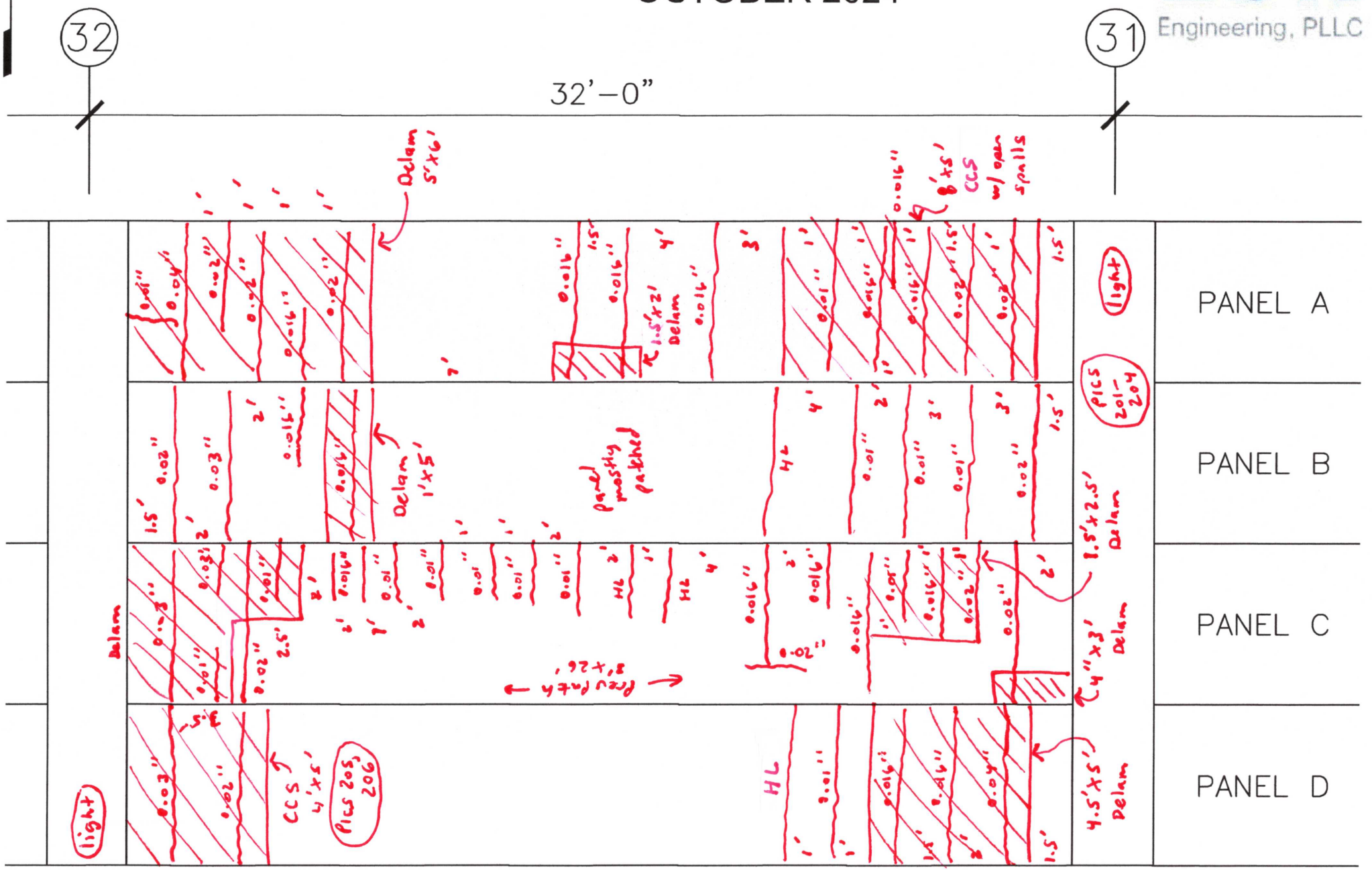


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

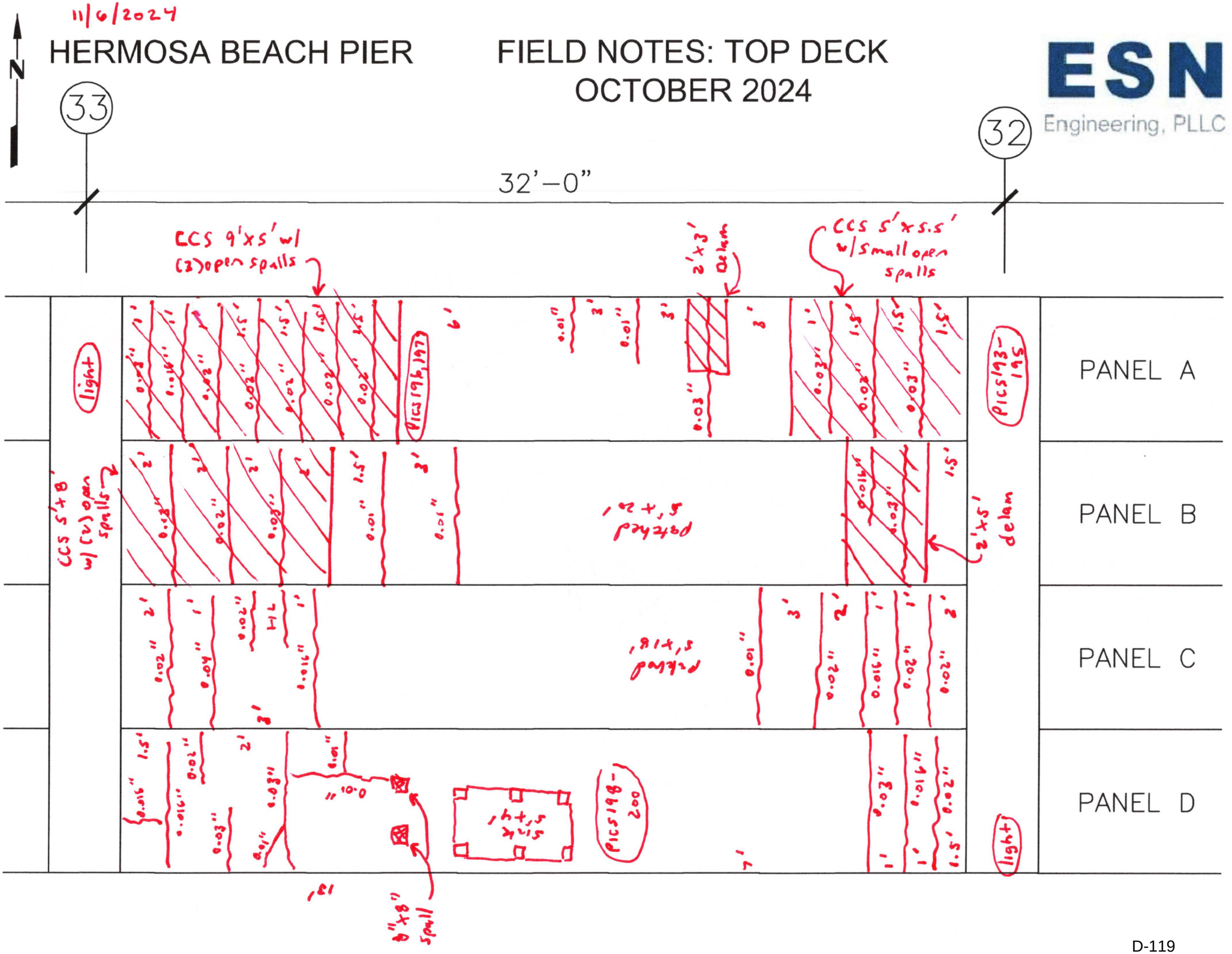


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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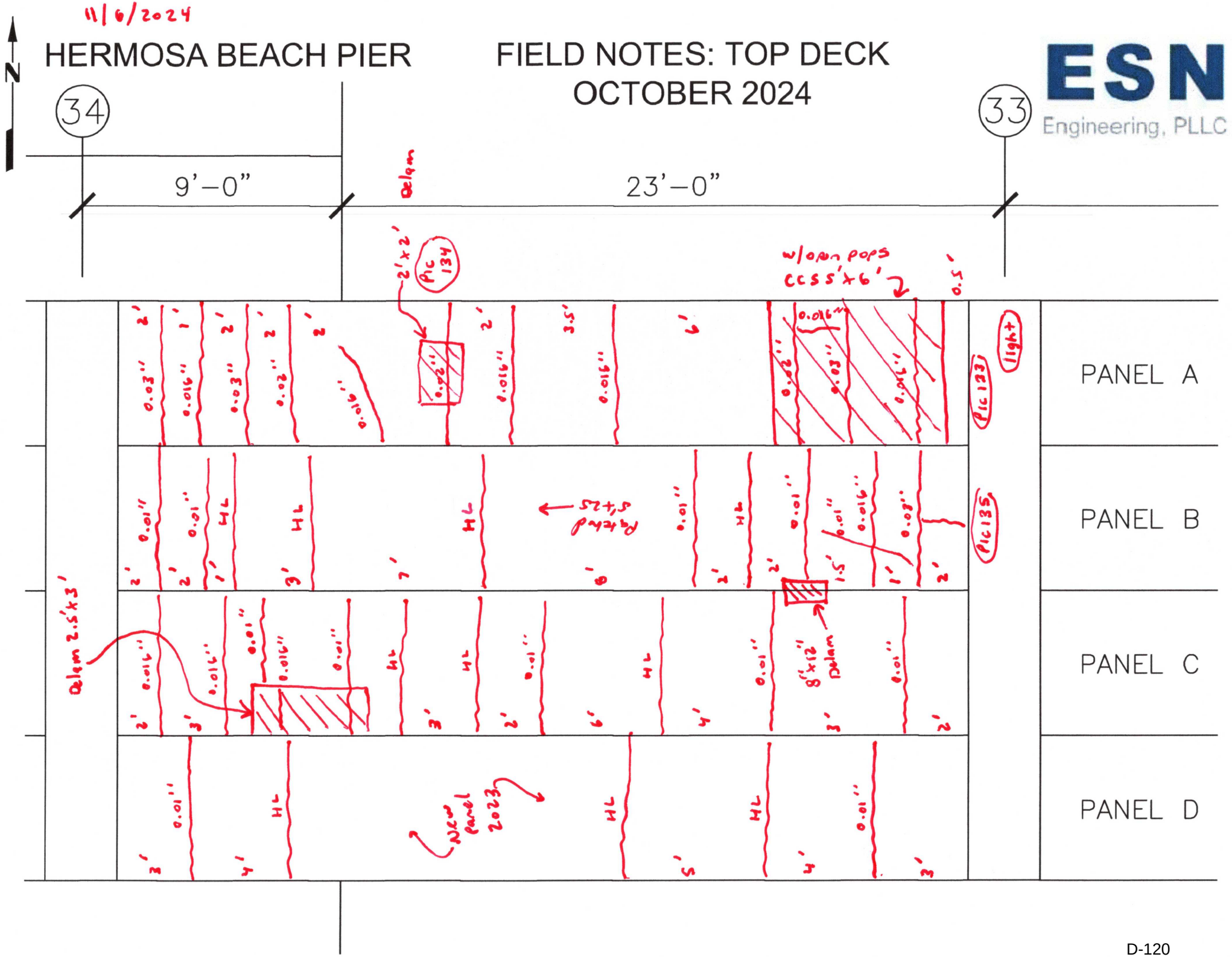


11/6/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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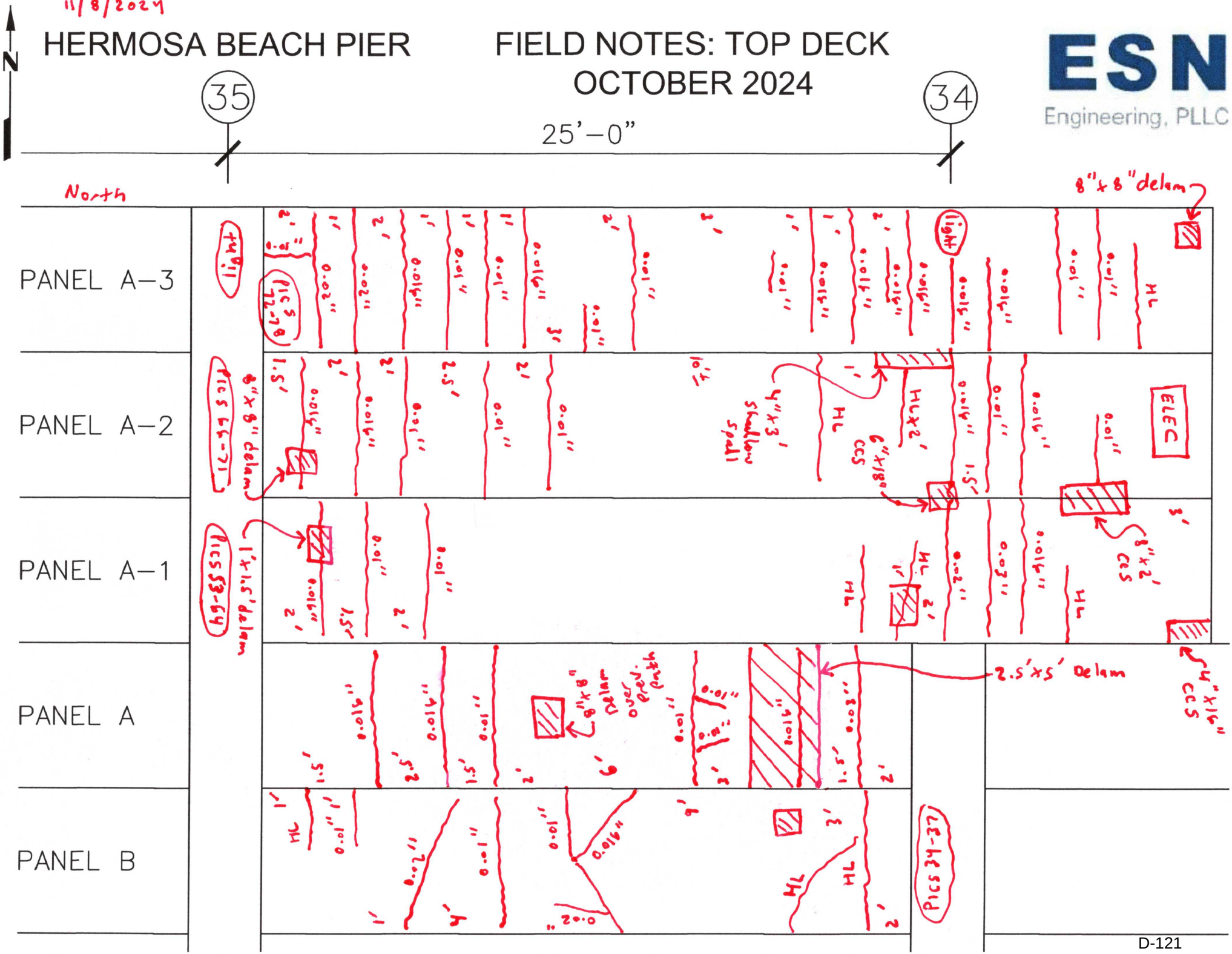


11/8/2024

HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

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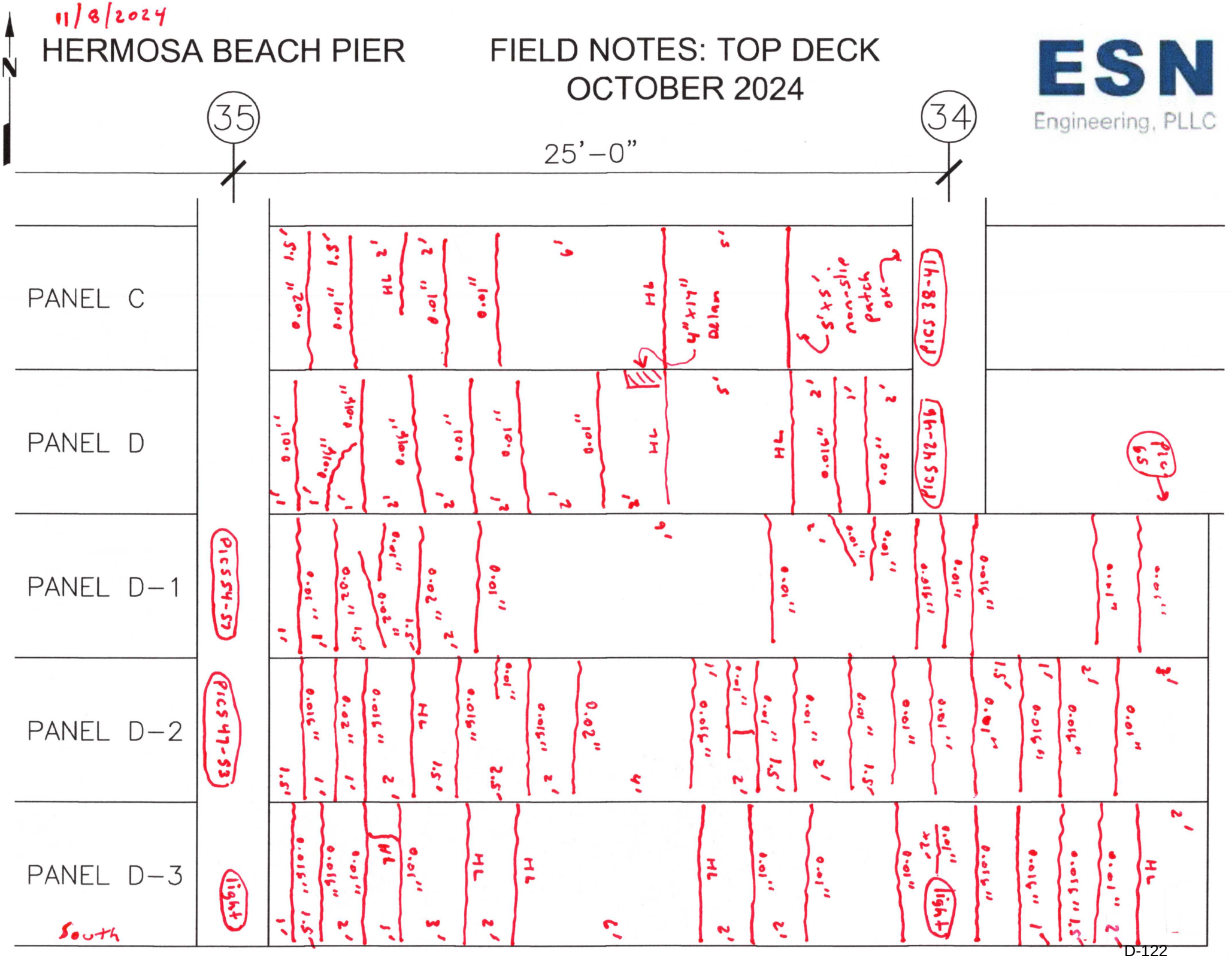


11/8/2024

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FIELD NOTES: TOP DECK
OCTOBER 2024

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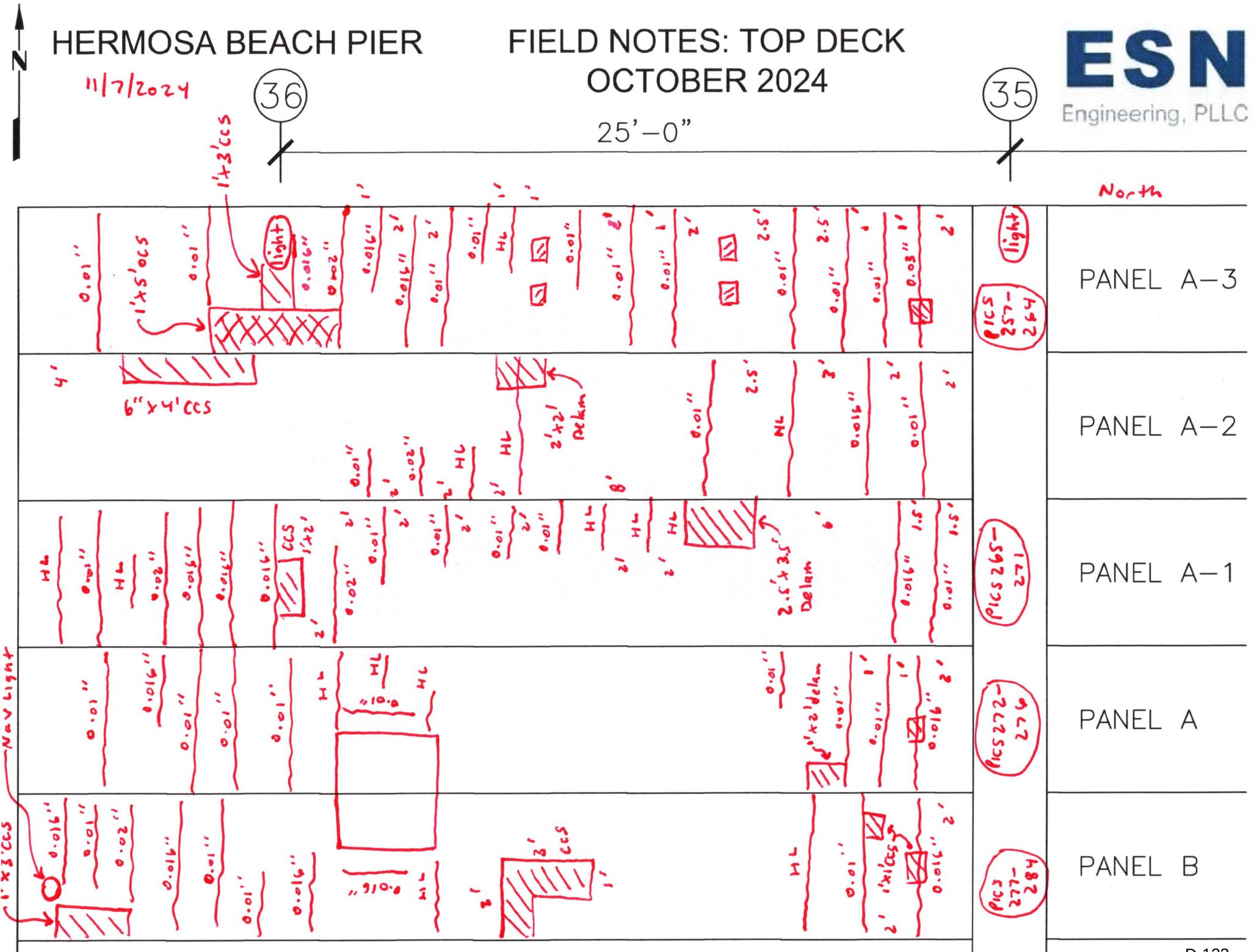


HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

ESN Engineering, PLLC

11/7/2024

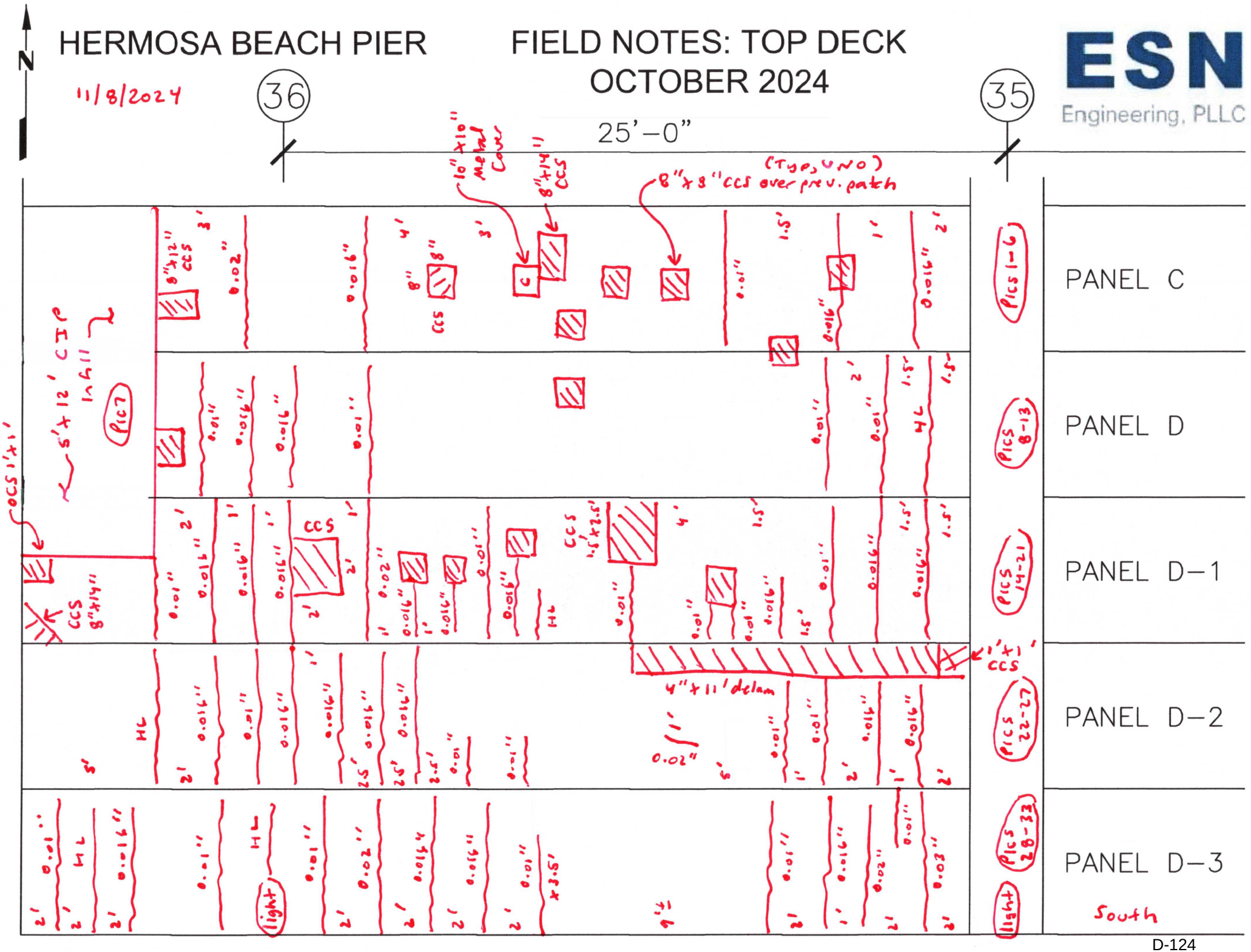


HERMOSA BEACH PIER

FIELD NOTES: TOP DECK
OCTOBER 2024

11/8/2024

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Hermosa Beach Pier - 2024 Condition Assessment

Panel Repair Recommendations (within 5 years)

ESN Engineering, PLLC

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
0-1	A			0.83						
0-1	B			1.46						
0-1	C			0.83						
0-1	D	10		1.00						
1-2	A			2.08						
1-2	B			0.83						
1-2	C		5	4.69						Top: 1/4" deep OCS Bot: Panel C is 3/8" lower than B & 1/4" lower than D
1-2	D									
2-3	A		5	2.63						
2-3	B			2.33						Top: 3/8" deep OCS
2-3	C			2.29						Top: Surface pops
2-3	D		10	2.92						
3-4	A			1.15						
3-4	B	15	25	0.92						Panel replaced in 2012. Top: shallow top cover, exposed rebar
3-4	C	15								
3-4	D			1.00						
4-5	A	5		0.83						
4-5	B	5		0.42	0.19	0.97				
4-5	C			2.33						Top: 3/8" OCS
4-5	D	5		1.67						
5-6	A	7				0.43				
5-6	B			0.13		1.06				
5-6	C			1.33		0.92				
5-6	D		3							
6-7	A	13		3.75		0.57				Top: 1/2" OCS

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
6-7	B	5		1.67						
6-7	C		5	2.50						Top: 5/16" OCS
6-7	D	6		3.97		2.94				Top: 5/16" OCS
7-8	A	20								
7-8	B	10				0.57				
7-8	C			1.04						Top: 3/8" OCS
7-8	D	5				0.88				
8-9	A	15				0.38				
8-9	B	10				0.38				
8-9	C	10								
8-9	D	5								
9-10	A	9				1.07				
9-10	B			0.83		0.44				
9-10	C			0.83		0.54				
9-10	D	9				0.83				
10-11	A	10				4.75		**60**		Soffit: Overstress damage, Panel A is 3/32" lower on south side of longitudinal crack
10-11	B	10				3.57		**60**		Soffit: Overstress damage
10-11	C					6.22		**80**		Soffit: Overstress damage, Panel C has 1/8" vertical offset at longitudinal crack
10-11	D		13							*Soffit: Consider Shear Key Repair at East End at Panel C*
11-12	A	12	8	3.96		1.38				
11-12	B	30	8	3.75		0.50				
11-12	C	15	4	3.75		0.22				
11-12	D	37				2.03				
12-13	A	14	11			5.18				Soffit: Fracture 8' from Bent 12
12-13	B	10	2			8.01		**110**		Soffit: Fracture 10' from Bent 12. Panel B is 1-1/16" lower than Panel A 7' from Bent 12.

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
12-13	C	12		0.38		12.94		**110**		Soffit: Fracture 11' from Bent 12. Panel C is 1/4" lower than Panel D 12' from Bent 12.
12-13	D	15	8	0.83		1.15				
13-14	A		10	3.96		2.12				
13-14	B		17	3.75		0.33		**110**		Soffit: Fracture 5' from Bent 13, North side of panel is 1/8" lower
13-14	C	5			0.20	0.70		**110**		Top: Key joint cracks each side Soffit: Fracture 8' from Bent 13, Missing piece of concrete (no corrosion), Panel C is 5/8" lower than D
13-14	D	28				2.13				
14-15	A	20	13	3.06		0.94				
14-15	B	22		1.67		1.68				
14-15	C	35				2.29				
14-15	D	23	5	0.94						
15-16	A	19	2			3.34				
15-16	B	2	10	1.67		4.93		**110**		Soffit: Fracture with 9"x2'x5" deep void, 50% rebar section loss
15-16	C	15	10	0.50		5.25				
15-16	D		7			5.72				
16-17	A	5	22			4.21				
16-17	B	10	11	0.17		0.97				
16-17	C	5	8			1.50		**90**		Soffit: Panel C is 1/2" lower than D 8.5' from Bent 17
16-17	D	5	20	0.83		6.05				
17-18	A	12	7	1.00		16.94				
17-18	B	25	18	0.63						
17-18	C	25	8	0.42		4.67				
17-18	D	20	2			8.97		**70**		

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
18-19	A	10	9			12.04				Soffit: Significant cross section spalled including along shear key
18-19	B	20	14			2.38				
18-19	C		13	0.52		14.74				
18-19	D	5				15.00		**100**		Soffit: Significant region of delaminated concrete
19-20	A	9	13	0.38		7.38	0.75			
19-20	B		8	2.17						Top: Includes small OCS
19-20	C		15	3.19		9.14				Top: Includes small OCS
19-20	D	15	4			23.35				
20-21	A		6	6.25		4.93				Top: Includes small OCS
20-21	B	30	5	0.17						
20-21	C	15	17	3.33						
20-21	D	15	31			2.33				
21-22	A		22	5.63		5.73				Top: Includes small OCS
21-22	B		12	8.33		1.22		**110**		Soffit: Significant region of delaminated concrete
21-22	C		15	2.29		7.58				
21-22	D		14	1.04		11.08				
22-23	A		26	5.10						
22-23	B	5	2	1.13		2.08				
22-23	C		10	0.63		4.13				
22-23	D		38	3.54		6.82				
23-24	A	11	16	2.83		11.90				
23-24	B	5	17	3.00		5.59				
23-24	C	23	15	1.04						
23-24	D	20		0.63		6.25				
24-25	A	10	14	3.57		0.13				Top: Includes small OCS
24-25	B	24		0.13	1.92	9.06				
24-25	C	10	19	4.29		1.34				Top: Includes small OCS
24-25	D	15	19	1.74		4.33				
25-26	A	5	65	3.02		2.01		**70**		

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
25-26	B	20	5	1.04		4.61				
25-26	C	27	27	1.04		1.29				
25-26	D	10	25	2.75		6.17				
26-27	A	12	18	6.88		3.31				Top: Includes small OCS
26-27	B	15	7	2.52		0.25				
26-27	C	10	18	4.17		1.01				Top: Includes small OCS
26-27	D	34	40							
27-28	A		37	2.42		3.09				Top: Includes small OCS Soffit: Overstress damage - 3/8"x1/2" groove w/ vertical offset 13' from Bent 28
27-28	B		22	1.67		0.65				
27-28	C		10	1.35		16.67		**110**		Top: Includes small OCS Soffit: West 10' delaminated, Panel C 1" lower than B 6' from Bent 28
27-28	D	7	16	1.25		2.14				
28-29	A	6	44	4.38	0.56	0.18	0.56			
28-29	B	10		2.08						
28-29	C		20	13.00		2.00				
28-29	D	10		4.78		0.83				
29-30	A		20	8.33						Top: Includes small OCS
29-30	B		19	0.13	1.44	3.09				
29-30	C		19	5.50		2.38				Top: Includes small OCS
29-30	D		27	0.08		8.62				
30-31	A		22	6.46		4.17				Top: Includes small OCS
30-31	B		8		1.31	4.38				
30-31	C								**Replace**	Soffit: Internal Delamination & 1.5" vertical separation & gap
30-31	D	10	3	0.83		1.89				
31-32	A	5	26	6.67		3.35				Top: Includes small OCS
31-32	B	17	16	0.42		5.96	0.46			

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
31-32	C	11	11	0.25	0.25	0.28				
31-32	D			3.54		11.51				
32-33	A								**Replace**	Top: Includes small OCS Soffit: 3/16" vertical offset at open spall 8' from Bent 33, Panel A 5/8" lower than B
32-33	B		6	4.17		6.75				Top: Includes small OCS
32-33	C								**Replace**	Soffit: Longitudinal fractures NW & SW sides, Panel C 5/8" lower than fractured area
32-33	D	32	18			2.88	0.02			
33-34	A	34	9	3.33		1.62				Top: Includes surface pops
33-34	B	10	28		0.17	1.55				Soffit: Fracture 7' from 34 on North side
33-34	C	10	3	0.63			0.49			2023 Epoxy crack injection repairs
33-34	D									Panel replaced in 2023
34-35	A-3	45	6			6.64				
34-35	A-2	20	14		0.81	0.58				
34-35	A-1	15	15	0.58	1.42	40.71				
34-35	A	15	14	1.04		1.07				
34-35	B	8	5			0.86				
34-35	C	5	9			1.07				
34-35	D	23	7		1.25	0.83				
34-35	D-1	24	15			1.91				
34-35	D-2	45	22			1.71				
34-35	D-3	25				3.19				
35-36	A-3	17	17	0.67		3.68				Top: Includes small OCS
35-36	A-2	5	20	0.33	0.50	1.13	1.96			Soffit: Fracture north side w/ horizontal separation 6' from Bent 35
35-36	A-1	20	3	1.15		0.53				
35-36	A	8	4	0.17		1.81				

Bents	Panel	Crack Injection (LF)		Spall Repairs (CF)				FRP Laminate (SF)	Replace Panel	Notes
				Top Deck		Soffit / Edge				
		Top	Soffit	Deck	Shear Key	CCS	OCS			
35-36	B								Replace	Soffit: OCS w/ heavy corrosion at soffit opening
35-36	C	20	2	4.11		1.11				
35-36	D	10				2.38				
35-36	D-1	25	4	3.28		2.20				Top: Includes small OCS
35-36	D-2	30	10	0.08	0.92	1.38				
35-36	D-3	35	10			3.01				
	Total =	**1552 LF**	**1417 LF**	**2910 SF**	**11 CF**	**478 CF**	**4 CF**	**1300 SF**	**4 LOC**	

Panel Repair Assumptions

1) All cracks 0.016" or larger are repaired with epoxy injection unless included in spall repair area or panel is replaced.
2) Top deck CCS and delamination repair depth is assumed to be 1".
3) Top deck OCS repair quantities are added to CCS repair quantities and shown in Top Deck Spall Repairs column.
4) Top deck key joint spalls are assumed to be 3" deep.
5) Soffit CCS repairs are assumed to be 3" max. deep.
6) FRP Laminate repairs are assumed to extend 5' past repair area at each end to develop bond.

Abbreviations

LF = Linear Feet
SF = Square Feet
CF = Cubic Feet
LOC = Location
Bot. = bottom
CCS = Closed Corrosion Spall
OCS = Open Corrosion Spall
FRP = Fiber-Reinforced Polymer

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APPENDIX E: BUDGETARY COST ESTIMATES FOR NEAR TERM PROJECTS

BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 10/14/2025	SHEET: 1 OF 2

ACTIVITY AND LOCATION:	A/E CONTRACT NUMBER	IDENTIFICATION NUMBER
Structural Repairs Budgeting Hermosa Beach, CA	ESTIMATED BY: **ESN ENGINEERING, PLLC**	CATEGORY CODE NUMBER
PROJECT TITLE: **Municipal Pier Structural Condition Assessment** **Hermosa Beach, California**	STATUS OF DESIGN: Condition Assessment Report	DELIVERY ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEAR TERM STRUCTURAL REPAIRS - HIGH PRIORITY (Repairs within 1-2 Years)								
SOFFIT CONCRETE REPAIRS IN BAYS 10-11, 12-13, 13-14, 15-16, 16-17, 17-18, 18-19, 21-22, 25-26, 27-28, 30-31, 32-33 & 35-36								
Deck Panel Concrete Repairs (13 Bays Over Water ~ 54 Panels ~35% of Total Deck Panels)								
Epoxy Crack Injection - Deck Soffit	620	LF	$55	$34,100	$75	$46,500	$130	$80,600
Soffit Spall Repairs - Demo, Rebar, Prep, Patch, Finish	250	CF	$675	$168,750	$1,850	$462,500	$2,525	$631,250
Shoring for Deep Soffit Spalls - Steel Transverse Beams	6	LOC	$4,250	$25,500	$10,500	$63,000	$14,750	$88,500
SOFFIT FRP REPAIRS TO PANELS 10-11: A, B & C; 12-13: B & C; 13-14: B & C; 15-16: B; 16-17: C; 17-18: D; 18:19: D; 21-22: B; 25-26: A & 27-28: C								
Deck Panel FRP Laminate Strengthening (14 Panels)								
Panel Soffit - Fiber Reinforced Polymer (FRP) Laminates	1300	SF	$75	$97,500	$140	$182,000	$215	$279,500
REMOVE & REPLACE PANELS 30-31: C, 32-33: A, 32-33: C & 35-36: B								
Concrete Deck Panels - Remove and Replace (4 Panels)								
Deck Panels - Remove, Cast-in-Place	4	EA	$50,000	$200,000	$125,000	$500,000	$175,000	$700,000
Mobilization and Demobilization	1	LS			$100,000	$100,000	$100,000	$100,000
Pedestrian Traffic Control	1	LS			$40,000	$40,000	$40,000	$40,000
Add'l Scaffolding for Soffit Repairs (Small Volume Bays)	1	LS			$50,000	$50,000	$50,000	$50,000
Scaffolding, Formwork & Shoring - Included in Individual Unit Prices Unless Noted Otherwise								

BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 10/14/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Structural Repairs Budgeting Hermosa Beach, CA	A/E CONTRACT NUMBER		IDENTIFICATION NUMBER
PROJECT TITLE: **Municipal Pier Structural Condition Assessment** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Condition Assessment Report		CATEGORY CODE NUMBER DELIVERY ORDER NUMBER

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEAR TERM STRUCTURAL REPAIRS - HIGH PRIORITY (Repairs within 1-2 Years)								
Raw Construction Cost Subtotal								**$1,970,000**
Construction General Requirements								
Jobsite Controls	2.0%							$39,400
BMP's	1.0%							$19,700
Waste Management Plan	1.0%							$19,700
Performance Bonding	1.0%							$19,700
Contractor Overhead and Profit	15.0%							$295,500
Burdened Cost SUBTOTAL	**20.0%**							**$2,364,000**
Construction Design & Administration								
Design Plans & Specifications	2.9%							$68,600
Environmental Permitting	1.9%							$44,900
Special Inspections	3.0%							$70,900
Construction Contingency	25.0%							$591,000
Construction Administration	3.0%							$70,900
Designer Construction & Bid Support	1.5%							$35,500
TOTAL PROGRAM COST IN 2025 DOLLARS	**37.3%**							**$3,246,000**
TOTAL PROGRAM COST IN 2027 DOLLARS			*Assumes*	*4%*	*Inflation*			**$3,511,000**

BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 10/14/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Structural Repairs Budgeting Hermosa Beach, CA	A/E CONTRACT NUMBER		IDENTIFICATION NUMBER
PROJECT TITLE: **Municipal Pier Structural Condition Assessment** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Condition Assessment Report		CATEGORY CODE NUMBER DELIVERY ORDER NUMBER

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
NEAR TERM STRUCTURAL REPAIRS - MEDIUM PRIORITY (Repairs in 3-5 Years)								
SOFFIT CONCRETE REPAIRS IN BAYS 11-12, 14-15, 19-20, 20-21, 22-23, 23-24, 24-25, 26-27, 28-29, 29-30, 31-32, 33-34 & 34-35								
Deck Panel Concrete Repairs (12 Bays Over Water ~ 52 Panels + ~ 24 Panels Over Beach) ~ 45% of total deck soffit								
Epoxy Crack Injection - Deck Soffit	800	LF	$55	$44,000	$75	$60,000	$130	$104,000
Soffit Spall Repairs - Demo, Rebar, Prep, Patch, Finish	240	CF	$675	$162,000	$1,850	$444,000	$2,525	$606,000
DECK TOP SURFACE REPAIRS (Top Repairs to Portions of ~90% of Panels)								
Deck Panel Concrete Top Repairs								
Epoxy Crack Injection - Deck Top Surface	1550	LF	$10	$15,500	$15	$23,250	$25	$38,750
Top Surface Spall Repairs - Demo, Prep, Patch, Finish	3000	SF	$40	$120,000	$65	$195,000	$105	$315,000
PILE CAP SPALL REPAIRS (Spall Repairs to Portions of ~80% of Pile Caps)								
Pile Cap Concrete Repairs								
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	220	CF	$675	$148,500	$1,750	$385,000	$2,425	$533,500
Epoxy Crack Injection - Pile Caps (6 locations)	130	LF	$55	$7,150	$70	$9,100	$125	$16,250
Mobilization and Demobilization	1	LS			$100,000	$100,000	$100,000	$100,000
Pedestrian Traffic Control	1	LS			$65,000	$65,000	$65,000	$65,000
Add'l Scaffolding for Soffit Repairs (Small Volume Bays)	1	LS			$90,000	$90,000	$90,000	$90,000
Scaffolding, Formwork & Shoring - Included in Individual Unit Prices Unless Noted Otherwise								

BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 10/14/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Structural Repairs Budgeting Hermosa Beach, CA	A/E CONTRACT NUMBER		IDENTIFICATION NUMBER
PROJECT TITLE: **Municipal Pier Structural Condition Assessment** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Condition Assessment Report		CATEGORY CODE NUMBER DELIVERY ORDER NUMBER

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
NEAR TERM STRUCTURAL REPAIRS - MEDIUM PRIORITY (Repairs in 3-5 Years)								
Raw Construction Cost Subtotal								**$1,869,000**
Construction General Requirements								
Jobsite Controls	2.0%							$37,400
BMP's	1.0%							$18,700
Waste Management Plan	1.0%							$18,700
Performance Bonding	1.0%							$18,700
Contractor Overhead and Profit	15.0%							$280,400
Burdened Cost SUBTOTAL	**20.0%**							**$2,243,000**
Construction Design & Administration								
Design Plans & Specifications	3.0%							$67,300
Environmental Permitting	2.0%							$44,900
Special Inspections	3.0%							$67,300
Construction Contingency	30.0%							$672,900
Construction Administration	3.5%							$78,500
Designer Construction & Bid Support	2.0%							$44,900
TOTAL PROGRAM COST IN 2025 DOLLARS	**43.5%**							**$3,219,000**
TOTAL PROGRAM COST IN 2030 DOLLARS			*Assumes*	*4%*	*Inflation*			**$3,916,000**

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APPENDIX F: INSPECTION PROCEDURE

INSPECTION PROCEDURE

1. INSPECTION INTRODUCTION

To efficiently communicate the results of this inspection to reviewers of this report, it is necessary that common terminology and methodology be established. The following are definitions of standard levels of effort that are required in all inspections and were followed in this inspection. The Scope of Work for all inspections breaks down the total inspection effort into these levels and specifies the amount of work required in each level. The procedures prescribed for most inspections are commonly a combination of at least two of these levels of examination. The terms Level I and Level II, etc., are referred to frequently in the Scope of Work and in each inspection report. Their definitions are as follows:

LEVEL I: General Examination: This level of effort is essentially a "swim-by" overview, which does not involve cleaning of any structural elements and can therefore be conducted much more rapidly than the other levels of examination. The Level I examination should confirm as-built structural plans and detect obvious major damage or deterioration due to overstress (ship impact, ice), severe corrosion, or extensive biological growth and attack.

The underwater inspector shall rely primarily on visual and/or tactile observations (depending on water clarity) to make condition assessments. The observations are normally made over the total exterior surface area of the underwater structure, be it a quaywall, bulkhead, seawall, pile, or mooring.

Visual documentation (utilizing underwater video and/or photography) may be included with the quantity and quality adequate for documentation of the findings which will be representative of the facility condition.

LEVEL II: Detailed Examination: This level of effort is directed toward detecting and identifying damaged/deteriorated areas which may be hidden by biofouling organisms or surface deterioration. At this level, a limited amount of measurements may be made. These data should be sufficient to permit estimates of relative condition of the facility load capacity to be made. Level II examinations will often require cleaning of structural elements. Since cleaning is time consuming, it is generally restricted to areas that are critical or which may be representative of the entire structure itself. The amount and thoroughness of cleaning to be performed is governed by what is necessary to discern the general condition of overall facility.

Visual documentation (utilizing underwater video and/or photography) should be included with the quantity and quality adequate to be representative of the range of facility damage/deterioration.

LEVEL III: Highly Detailed Examination: This level of effort will often require the use of Non-Destructive Testing (NDT) techniques, but may also require the use of partially destructive techniques such as sample coring through concrete and wood structures, physical material sampling, or in-situ surface hardness testing. The purpose of this type of evaluation is to detect hidden or interior damage, loss in

cross-sectional area, and material homogeneity. A Level III examination will usually require prior cleaning. The use of NDT techniques is generally limited to key structural areas, areas that may be suspect or to structural members which may be representative of the underwater structure.

Visual documentation (utilizing underwater video and/or photography) and a sampling of physical measurements should be included with quantity and quality adequate for documentation of the findings which will be representative of the facility condition.

2. INSPECTION REQUIREMENTS

An above and underwater examination was performed at the Municipal Pier in the City of Hermosa Beach, California.

The Level of Examination as applied to this facility was limited to Levels I & II examinations. The Level I examination was performed on 100% of the octagonal precast prestressed concrete piles, cast-in-place concrete pile caps, and precast concrete deck panels. The Level I examination was conducted both above and below water. The Level II Examination was performed on 10% of the concrete piles. These piles were selected by the engineers as a representative sample of the entire structure. Marine growth was removed on the piles in three bands (waterline, mudline, and mid-height) to allow for close inspection.

The objective of this inspection was to inspect the structural elements of the entire pier above and below water to prioritize maintenance needs and obtain required information to develop construction plans for recommended repairs.

3. INSPECTION PATTERN / PROCEDURE

The work was conducted using two engineer divers with one diving tender, depending on the activity and circumstances. The divers were in the same vicinity at all times so that the single tender did not represent a violation of safe diving standards. Communication between divers and tenders was by voice. The Lifeguard Service was notified daily before work began of the inspection plan and informed again once work was finished for the day.

The underside of deck inspection was performed using two access methods. Elements over the beach were inspected using a rough terrain boom lift and elements over the water were inspected by access from a trailerable scaffold rig. The surfaces of the concrete deck panels and pile caps were sounded with a hammer or solid steel headed putter to identify areas of delaminated, weak, damaged, or spalled concrete. A crack width gauge was used to record crack widths greater than hairline width.

The visible concrete deterioration was recorded on underwater slates according to the following types of deterioration: Vertical Crack (VCR); Horizontal Crack (HCR); Diagonal Crack (DCR), Transverse Crack (TC); or Longitudinal Crack; Closed Corrosion Spall (CCS); Open Corrosion Spall (OCS); Corrosion Bleeding; Overstress Fracture; and Delamination.

The surfaces of the concrete deck panels and pile caps were sounded with a hammer to identify areas of delaminated, weak, or spalled concrete.

For the Level II examination, and in areas of anomalies, the piles were struck with a pointed hammer to gauge the soundness of the concrete. The soundness was recorded according to the following nomenclature:

Hard: Pick rebounds without making a significant indentation, usually accompanied by a ringing sound clearly heard in the water.

Firm: Pick rebounds making a small indentation.

Soft: With six blows, ¼ inch to ½ inch indentation can be made.

Very Soft: Six blows remove corner of the pile or in excess of ½ inch to 1 inch of material.

Extremely Soft: Six blows remove in excess of 1 inch of material.

Grid locations are identified using the following nomenclature:

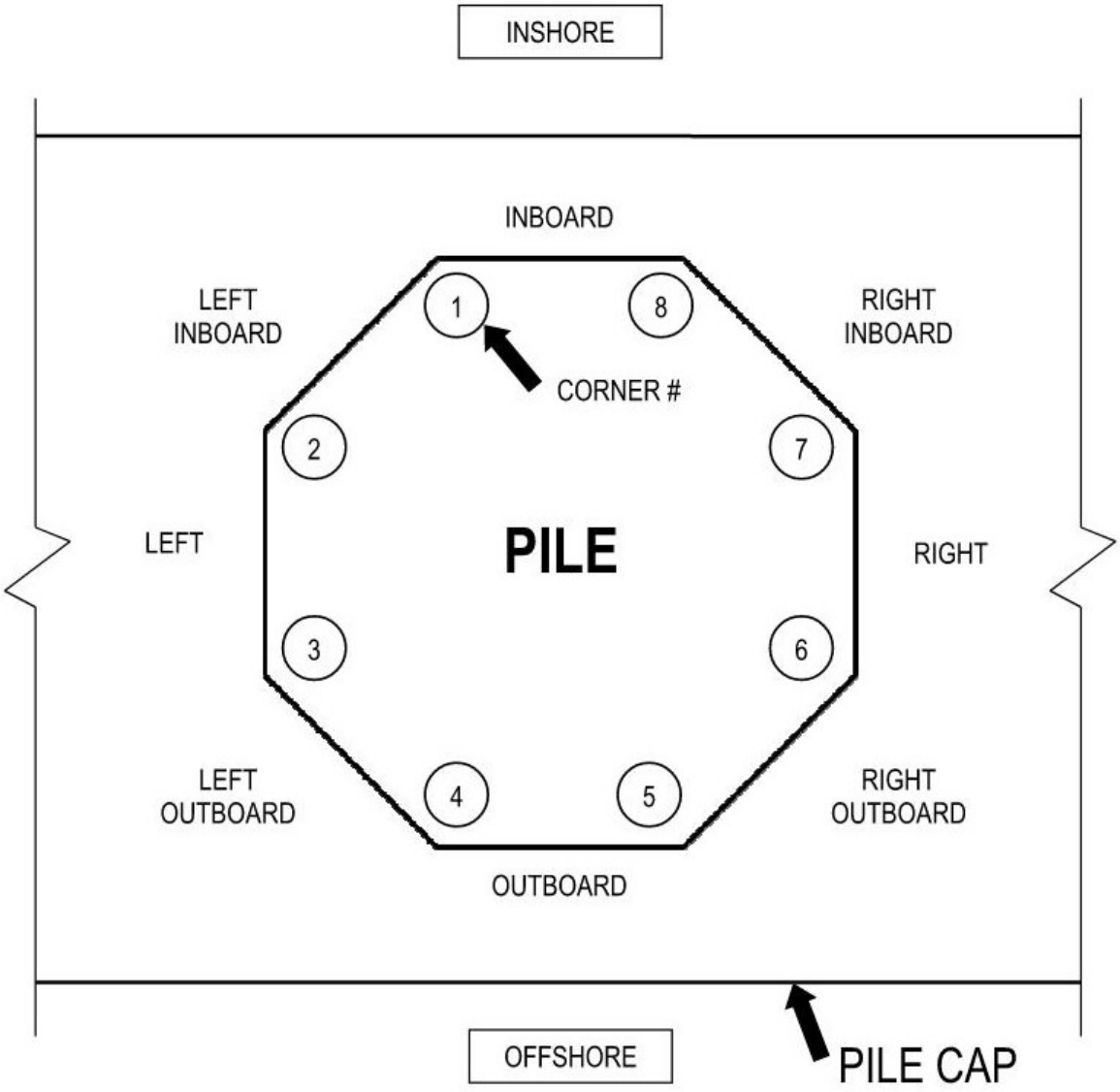
BENT LOCATION: ROW LOCATION (e.g. 16: A)

4. INSPECTION EQUIPMENT

Equipment used in this inspection included the usual divers' equipment with scuba gear. Chipping hammers and bar scrapers were used to clean the piles at the suspect areas. Photographs were taken both above and below water using a SeaLife Micro 3.0 Underwater Camera.

The following figure describes the orientation used for all structural elements:

ORIENTATION KEY



Damage Rating Scale

Damage Rating		Description
No Defects	All	- Sound surface material - Hard material
Minor (Light)	Timber	- Marine borers or fungal decay - No section loss
	Steel	- Up to 15% section loss - Corrosion at less than 50% of perimeter
	Reinforced Concrete	- Surface spalls less than 1” deep - General cracks up to 1/16” in width
Moderate	Timber	- Up to 25% section loss
	Steel	- 15% to 30% section loss - Corrosion at more than 50% of perimeter
	Reinforced Concrete	- Structural cracks up to 1/16” in width - Corrosion cracks up to 1/4” in width
Major (Heavy)	Timber	- 25% to 50% section loss - Full depth checks and splits
	Steel	- 30% to 50% section loss - Partial loss of flange edges or pipe thickness
	Reinforced Concrete	- Structural cracks 1/16” to 1/4” in width - Corrosion cracks wider than 1/4” and open or closed corrosion spalling
Severe	Timber	- Greater than 50% section loss - Partial or complete breakage - Non-bearing condition
	Steel	- Greater than 50% section loss - Structural bends, buckling, or breakage - Displacement at supports - Loose or lost connections
	Reinforced Concrete	- Structural cracks wider than 1/4” - Complete breakage - Complete loss of concrete cover due to corrosion of rebar with greater than 30% rebar section loss - Loss of bearing and displacement at connections - Greater than 30% section loss

Source: “Waterfront Facilities Inspection and Assessment”, ASCE Manuals and Reports on Engineering Practice No. 130, Waterfront Facility Inspection Committee, 2015

Condition Assessment Rating Scale

Rating	CI Rating	Description
Good	90	No visible damage or only minor damage noted. Structural elements may show very minor deterioration, but no overstressing observed. No repairs are required.
Satisfactory	75	Limited minor to moderate defects or deterioration observed but no overstressing observed.
Fair	60	All primary structural elements are sound but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.
Poor	45	Advanced deterioration or overstressing observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
Serious	30	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.
Critical	15	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high-priority basis with strong urgency.

Source: “Waterfront Facilities Inspection and Assessment”, ASCE Manuals and Reports on Engineering Practice No. 130, Waterfront Facility Inspection Committee, 2015.

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APPENDIX G: COST / BENEFIT ANALYSIS – COST ESTIMATES & SCHEDULES

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2035 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	16	EA	$5,000	$80,000	$8,000	$128,000	$13,000	$208,000	$26,000	$416,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	240	CF	$275	$66,000	$1,100	$264,000	$1,050	$252,000	$2,425	$582,000
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	150	LF	$30	$4,500	$40	$6,000	$55	$8,250	$125	$18,750
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	250	CF	$275	$68,750	$1,100	$275,000	$1,150	$287,500	$2,525	$631,250
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	250	LF	$30	$7,500	$40	$10,000	$60	$15,000	$130	$32,500
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	1800	LF	$8	$14,400	$2	$3,600	$15	$27,000	$25	$45,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	5000	SF	$40	$200,000	$5	$25,000	$60	$300,000	$105	$525,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	400	SF	$70	$28,000	$55	$22,000	$90	$36,000	$215	$86,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$2,337,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2035 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$117,000
General Requirements	5.0%									$117,000
Contractor Overhead and Profit	15.0%									$351,000
Burdened Cost SUBTOTAL	**25.0%**									**$2,922,000**
Construction Design & Administration										
Field Investigations	3.0%									$88,000
Environmental Permitting	2.5%									$73,000
Design Plans & Specifications	5.0%									$146,000
Designer Construction & Bid Support	2.5%									$73,000
Special Inspections	3.0%									$88,000
Construction Administration	4.0%									$117,000
Construction Contingency	30.0%									$877,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$4,384,000**
TOTAL ESCALATED PROJECT COST IN 2035 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$6,490,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/14/2033		9/11/2033				
Design Plans & Specifications	150	DAY		9/11/2033		2/8/2034				
Environmental Permitting	420	DAY		2/8/2034		4/4/2035				
Bidding & Contracting	150	DAY		4/4/2035		9/1/2035				
Construction	210	DAY		9/1/2035		3/29/2036				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2040 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	17	EA	$5,000	$85,000	$8,000	$136,000	$13,000	$221,000	$26,000	$442,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	265	CF	$275	$72,875	$1,100	$291,500	$1,050	$278,250	$2,425	$642,625
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	160	LF	$30	$4,800	$40	$6,400	$55	$8,800	$125	$20,000
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	275	CF	$275	$75,625	$1,100	$302,500	$1,150	$316,250	$2,525	$694,375
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	300	LF	$30	$9,000	$40	$12,000	$60	$18,000	$130	$39,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2000	LF	$8	$16,000	$2	$4,000	$15	$30,000	$25	$50,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	6000	SF	$40	$240,000	$5	$30,000	$60	$360,000	$105	$630,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	500	SF	$70	$35,000	$55	$27,500	$90	$45,000	$215	$107,500
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	1	EA	$50,000	$50,000	$30,000	$30,000	$95,000	$95,000	$175,000	$175,000
Raw Construction Cost Subtotal										**$2,801,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2040 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$140,000
General Requirements	5.0%									$140,000
Contractor Overhead and Profit	15.0%									$420,000
Burdened Cost SUBTOTAL	**25.0%**									**$3,501,000**
Construction Design & Administration										
Field Investigations	3.0%									$105,000
Environmental Permitting	2.5%									$88,000
Design Plans & Specifications	5.0%									$175,000
Designer Construction & Bid Support	2.5%									$88,000
Special Inspections	3.0%									$105,000
Construction Administration	4.0%									$140,000
Construction Contingency	30.0%									$1,050,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$5,252,000**
TOTAL ESCALATED PROJECT COST IN 2040 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$9,459,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/15/2038		9/12/2038				
Design Plans & Specifications	150	DAY		9/12/2038		2/9/2039				
Environmental Permitting	420	DAY		2/9/2039		4/4/2040				
Bidding & Contracting	150	DAY		4/4/2040		9/1/2040				
Construction	210	DAY		9/1/2040		3/30/2041				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2045 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	18	EA	$5,000	$90,000	$8,000	$144,000	$13,000	$234,000	$26,000	$468,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	295	CF	$275	$81,125	$1,100	$324,500	$1,050	$309,750	$2,425	$715,375
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	175	LF	$30	$5,250	$40	$7,000	$55	$9,625	$125	$21,875
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	300	CF	$275	$82,500	$1,100	$330,000	$1,150	$345,000	$2,525	$757,500
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	400	LF	$30	$12,000	$40	$16,000	$60	$24,000	$130	$52,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2200	LF	$8	$17,600	$2	$4,400	$15	$33,000	$25	$55,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	6700	SF	$40	$268,000	$5	$33,500	$60	$402,000	$105	$703,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	600	SF	$70	$42,000	$55	$33,000	$90	$54,000	$215	$129,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	1	EA	$50,000	$50,000	$30,000	$30,000	$95,000	$95,000	$175,000	$175,000
Raw Construction Cost Subtotal										**$3,077,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2045 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$154,000
General Requirements	5.0%									$154,000
Contractor Overhead and Profit	15.0%									$462,000
Burdened Cost SUBTOTAL	**25.0%**									**$3,847,000**
Construction Design & Administration										
Field Investigations	3.0%									$115,000
Environmental Permitting	2.5%									$96,000
Design Plans & Specifications	5.0%									$192,000
Designer Construction & Bid Support	2.5%									$96,000
Special Inspections	3.0%									$115,000
Construction Administration	4.0%									$154,000
Construction Contingency	30.0%									$1,154,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$5,769,000**
TOTAL ESCALATED PROJECT COST IN	***2045***	***DOLLARS ASSUMING ANNUAL INFLATION OF***					***4.0%***			**$12,641,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/15/2043		9/12/2043				
Design Plans & Specifications	150	DAY		9/12/2043		2/9/2044				
Environmental Permitting	420	DAY		2/9/2044		4/4/2045				
Bidding & Contracting	150	DAY		4/4/2045		9/1/2045				
Construction	210	DAY		9/1/2045		3/30/2046				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2050 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	19	EA	$5,000	$95,000	$8,000	$152,000	$13,000	$247,000	$26,000	$494,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	325	CF	$275	$89,375	$1,100	$357,500	$1,050	$341,250	$2,425	$788,125
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	190	LF	$30	$5,700	$40	$7,600	$55	$10,450	$125	$23,750
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	330	CF	$275	$90,750	$1,100	$363,000	$1,150	$379,500	$2,525	$833,250
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	500	LF	$30	$15,000	$40	$20,000	$60	$30,000	$130	$65,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2400	LF	$8	$19,200	$2	$4,800	$15	$36,000	$25	$60,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	7300	SF	$40	$292,000	$5	$36,500	$60	$438,000	$105	$766,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	700	SF	$70	$49,000	$55	$38,500	$90	$63,000	$215	$150,500
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	2	EA	$50,000	$100,000	$30,000	$60,000	$95,000	$190,000	$175,000	$350,000
Raw Construction Cost Subtotal										**$3,531,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2050 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$177,000
General Requirements	5.0%									$177,000
Contractor Overhead and Profit	15.0%									$530,000
Burdened Cost SUBTOTAL	**25.0%**									**$4,415,000**
Construction Design & Administration										
Field Investigations	3.0%									$132,000
Environmental Permitting	2.5%									$110,000
Design Plans & Specifications	5.0%									$221,000
Designer Construction & Bid Support	2.5%									$110,000
Special Inspections	3.0%									$132,000
Construction Administration	4.0%									$177,000
Construction Contingency	30.0%									$1,325,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$6,622,000**
TOTAL ESCALATED PROJECT COST IN 2050 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$17,654,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/14/2048		9/11/2048				
Design Plans & Specifications	150	DAY		9/11/2048		2/8/2049				
Environmental Permitting	420	DAY		2/8/2049		4/4/2050				
Bidding & Contracting	150	DAY		4/4/2050		9/1/2050				
Construction	210	DAY		9/1/2050		3/30/2051				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2055 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	20	EA	$5,000	$100,000	$8,000	$160,000	$13,000	$260,000	$26,000	$520,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	355	CF	$275	$97,625	$1,100	$390,500	$1,050	$372,750	$2,425	$860,875
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	210	LF	$30	$6,300	$40	$8,400	$55	$11,550	$125	$26,250
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	390	CF	$275	$107,250	$1,100	$429,000	$1,150	$448,500	$2,525	$984,750
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	600	LF	$30	$18,000	$40	$24,000	$60	$36,000	$130	$78,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2600	LF	$8	$20,800	$2	$5,200	$15	$39,000	$25	$65,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	8000	SF	$40	$320,000	$5	$40,000	$60	$480,000	$105	$840,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	800	SF	$70	$56,000	$55	$44,000	$90	$72,000	$215	$172,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	2	EA	$50,000	$100,000	$30,000	$60,000	$95,000	$190,000	$175,000	$350,000
Raw Construction Cost Subtotal										**$3,897,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2055 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$195,000
General Requirements	5.0%									$195,000
Contractor Overhead and Profit	15.0%									$585,000
Burdened Cost SUBTOTAL	**25.0%**									**$4,872,000**
Construction Design & Administration										
Field Investigations	3.0%									$146,000
Environmental Permitting	2.5%									$122,000
Design Plans & Specifications	5.0%									$244,000
Designer Construction & Bid Support	2.5%									$122,000
Special Inspections	3.0%									$146,000
Construction Administration	4.0%									$195,000
Construction Contingency	30.0%									$1,462,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$7,309,000**
TOTAL ESCALATED PROJECT COST IN 2055 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$23,706,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/14/2053		9/11/2053				
Design Plans & Specifications	150	DAY		9/11/2053		2/8/2054				
Environmental Permitting	420	DAY		2/8/2054		4/4/2055				
Bidding & Contracting	150	DAY		4/4/2055		9/1/2055				
Construction	210	DAY		9/1/2055		3/29/2056				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2060 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	21	EA	$5,000	$105,000	$8,000	$168,000	$13,000	$273,000	$26,000	$546,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	390	CF	$275	$107,250	$1,100	$429,000	$1,050	$409,500	$2,425	$945,750
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	230	LF	$30	$6,900	$40	$9,200	$55	$12,650	$125	$28,750
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	440	CF	$275	$121,000	$1,100	$484,000	$1,150	$506,000	$2,525	$1,111,000
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	750	LF	$30	$22,500	$40	$30,000	$60	$45,000	$130	$97,500
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2900	LF	$8	$23,200	$2	$5,800	$15	$43,500	$25	$72,500
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	8900	SF	$40	$356,000	$5	$44,500	$60	$534,000	$105	$934,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	900	SF	$70	$63,000	$55	$49,500	$90	$81,000	$215	$193,500
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	2	EA	$50,000	$100,000	$30,000	$60,000	$95,000	$190,000	$175,000	$350,000
Raw Construction Cost Subtotal										**$4,280,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2060 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$214,000
General Requirements	5.0%									$214,000
Contractor Overhead and Profit	15.0%									$642,000
Burdened Cost SUBTOTAL	**25.0%**									**$5,350,000**
Construction Design & Administration										
Field Investigations	3.0%									$161,000
Environmental Permitting	2.5%									$134,000
Design Plans & Specifications	5.0%									$268,000
Designer Construction & Bid Support	2.5%									$134,000
Special Inspections	3.0%									$161,000
Construction Administration	4.0%									$214,000
Construction Contingency	30.0%									$1,605,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$8,027,000**
TOTAL ESCALATED PROJECT COST IN 2060 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$31,676,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/15/2058		9/12/2058				
Design Plans & Specifications	150	DAY		9/12/2058		2/9/2059				
Environmental Permitting	420	DAY		2/9/2059		4/4/2060				
Bidding & Contracting	150	DAY		4/4/2060		9/1/2060				
Construction	210	DAY		9/1/2060		3/30/2061				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2065 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	22	EA	$5,000	$110,000	$8,000	$176,000	$13,000	$286,000	$26,000	$572,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	430	CF	$275	$118,250	$1,100	$473,000	$1,050	$451,500	$2,425	$1,042,750
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	255	LF	$30	$7,650	$40	$10,200	$55	$14,025	$125	$31,875
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	490	CF	$275	$134,750	$1,100	$539,000	$1,150	$563,500	$2,525	$1,237,250
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	850	LF	$30	$25,500	$40	$34,000	$60	$51,000	$130	$110,500
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	3200	LF	$8	$25,600	$2	$6,400	$15	$48,000	$25	$80,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	9700	SF	$40	$388,000	$5	$48,500	$60	$582,000	$105	$1,018,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	1000	SF	$70	$70,000	$55	$55,000	$90	$90,000	$215	$215,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	3	EA	$50,000	$150,000	$30,000	$90,000	$95,000	$285,000	$175,000	$525,000
Raw Construction Cost Subtotal										**$4,833,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2065 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$242,000
General Requirements	5.0%									$242,000
Contractor Overhead and Profit	15.0%									$725,000
Burdened Cost SUBTOTAL	**25.0%**									**$6,042,000**
Construction Design & Administration										
Field Investigations	3.0%									$181,000
Environmental Permitting	2.5%									$151,000
Design Plans & Specifications	5.0%									$302,000
Designer Construction & Bid Support	2.5%									$151,000
Special Inspections	3.0%									$181,000
Construction Administration	4.0%									$242,000
Construction Contingency	30.0%									$1,813,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$9,063,000**
TOTAL ESCALATED PROJECT COST IN 2065 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$43,512,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/15/2063		9/12/2063				
Design Plans & Specifications	150	DAY		9/12/2063		2/9/2064				
Environmental Permitting	420	DAY		2/9/2064		4/4/2065				
Bidding & Contracting	150	DAY		4/4/2065		9/1/2065				
Construction	210	DAY		9/1/2065		3/30/2066				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2070 PIER ANTICIPATED MAINTENANCE COSTS										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	23	EA	$5,000	$115,000	$8,000	$184,000	$13,000	$299,000	$26,000	$598,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	475	CF	$275	$130,625	$1,100	$522,500	$1,050	$498,750	$2,425	$1,151,875
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	280	LF	$30	$8,400	$40	$11,200	$55	$15,400	$125	$35,000
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	540	CF	$275	$148,500	$1,100	$594,000	$1,150	$621,000	$2,525	$1,363,500
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	950	LF	$30	$28,500	$40	$38,000	$60	$57,000	$130	$123,500
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	3500	LF	$8	$28,000	$2	$7,000	$15	$52,500	$25	$87,500
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	10700	SF	$40	$428,000	$5	$53,500	$60	$642,000	$105	$1,123,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	1200	SF	$70	$84,000	$55	$66,000	$90	$108,000	$215	$258,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place	3	EA	$50,000	$150,000	$30,000	$90,000	$95,000	$285,000	$175,000	$525,000
Raw Construction Cost Subtotal										**$5,266,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
2070 PIER ANTICIPATED MAINTENANCE COSTS										
Construction General Requirements										
Mobilization	5.0%									$263,000
General Requirements	5.0%									$263,000
Contractor Overhead and Profit	15.0%									$790,000
Burdened Cost SUBTOTAL	**25.0%**									**$6,582,000**
Construction Design & Administration										
Field Investigations	3.0%									$197,000
Environmental Permitting	2.5%									$165,000
Design Plans & Specifications	5.0%									$329,000
Designer Construction & Bid Support	2.5%									$165,000
Special Inspections	3.0%									$197,000
Construction Administration	4.0%									$263,000
Construction Contingency	30.0%									$1,975,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$9,873,000**
TOTAL ESCALATED PROJECT COST IN 2070 DOLLARS ASSUMING ANNUAL INFLATION OF 4.0%										**$57,670,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Field Investigations	120	DAY		5/14/2068		9/11/2068				
Design Plans & Specifications	150	DAY		9/11/2068		2/8/2069				
Environmental Permitting	420	DAY		2/8/2069		4/4/2070				
Bidding & Contracting	150	DAY		4/4/2070		9/1/2070				
Construction	210	DAY		9/1/2070		3/30/2071				

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Replacement Planning Cost Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
REPLACE MUNICIPAL PIER										
A) Demolish Existing Pier	*$157*	*/ SF*								
Cutoff Concrete Piles at Mudline & Dispose	135	EA	$10	$1,350	$260	$35,100	$295	$39,825	$565	$76,275
Remove & Dispose Concrete Pile Caps	36	EA	$170	$6,120	$8,950	$322,200	$9,460	$340,560	$18,580	$668,880
Remove & Dispose Concrete Deck Panels	24840	SF	$2	$49,680	$50	$1,242,000	$60	$1,490,400	$112	$2,782,080
Remove & Dispose Metal Railing	2360	LF	$2	$4,720	$15	$35,400	$30	$70,800	$47	$110,920
Remove & Dispose Utilities	24840	SF	$1	$24,840	$5	$124,200	$5	$124,200	$11	$273,240
Relocate / Salvage Surface Amenities	85	EA	$1	$85	$25	$2,125	$100	$8,500	$126	$10,710
(~60 Surfer Plaques, ~25 Benches, ~10 Trash Cans)										
B) Build New Pier Structure	*$589*	*/ SF*								
Build New Concrete Pier Structure	25000	SF	$165	$4,125,000	$135	$3,375,000	$270	$6,750,000	$570	$14,250,000
Install New Metal Guardrailing	2500	LF	$75	$187,500	$25	$62,500	$75	$187,500	$175	$437,500
Install New Metal Gate	1	EA	$15,000	$15,000	$5,000	$5,000	$10,000	$10,000	$30,000	$30,000
C) Pier Utilities & Amenities	*$103*	*/ SF*								
Electrical, Lighting, Water, Sewer, Telecomm	25000	SF	$25	$625,000	$15	$375,000	$40	$1,000,000	$80	$2,000,000
Benches, Trash Cans, Bait Stations, Fog Horn	25000	SF	$8	$200,000	$3	$75,000	$8	$200,000	$19	$475,000
Utility Realignment at New Pierhead	1	LS	$35,000	$35,000	$30,000	$30,000	$35,000	$35,000	$100,000	$100,000
D) Pier Construction Phasing										
Staging, Temporary Conditions, Traffic Controls	18	MO	$400	$7,200	$5,000	$90,000	$30,000	$540,000	$35,400	$637,200
Phasing / Temporary Structure for Pier Access	18	MO	$30,000	$540,000	$25,000	$450,000	$50,000	$900,000	$105,000	$1,890,000
Raw Construction Cost Subtotal	*$950*	*/ SF*								**$23,742,000**
Construction General Requirements										
Mobilization	5.0%									$1,187,000
General Requirements	5.0%									$1,187,000
Contractor Overhead and Profit	15.0%									$3,561,000

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Replacement Planning Cost Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
REPLACE MUNICIPAL PIER										
Burdened Cost SUBTOTAL	**25.0%**									**$29,677,000**
Construction Design & Administration										
Planning Studies	1.0%									$297,000
Public Outreach	1.0%									$297,000
Environmental Assessment & Permitting	4.0%									$1,187,000
Grant Funding Applications - Consultant Assistance	0.5%									$148,000
Field Investigations	1.0%									$297,000
Topographic & Hydrographic Surveys	0.5%									$148,000
Geotechnical Investigations	1.0%									$297,000
Design Plans & Specifications	5.0%									$1,484,000
Designer Construction & Bid Support	1.0%									$297,000
Special Inspections	2.0%									$594,000
Construction Administration	3.0%									$890,000
Construction Contingency	30.0%									$8,903,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**		*$1,781 / SF*							**$44,516,000**
TOTAL ESCALATED PROJECT COST IN	***2032***	***DOLLARS ASSUMING ANNUAL INFLATION OF***					***4.0%***			**$58,580,000**
ANTICIPATED PROJECT SCHEDULE				***Start***		***Finish***				
Planning Studies & Public Outreach	540	DAY		12/7/2025		5/31/2027			*18*	*months*
Environmental Assessment	1020	DAY		5/31/2027		3/16/2030			*34*	*months*
Field Investigations	180	DAY		3/16/2030		9/12/2030			*6*	*months*
Design Plans & Specifications	180	DAY		9/12/2030		3/11/2031			*6*	*months*
Environmental Permitting	420	DAY		3/11/2031		5/4/2032			*14*	*months*
Bidding & Contracting	150	DAY		5/4/2032		10/1/2032			*5*	*months*
Construction	540	DAY		10/1/2032		3/25/2034			*18*	*months*
									8.3	***years***

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 15 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket		EA	$5,000		$8,000		$13,000		$26,000	
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	35	CF	$275	$9,625	$1,100	$38,500	$1,050	$36,750	$2,425	$84,875
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	50	LF	$30	$1,500	$40	$2,000	$55	$2,750	$125	$6,250
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish		CF	$275		$1,100		$1,150		$2,525	
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit		LF	$30		$40		$60		$130	
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	400	LF	$8	$3,200	$2	$800	$15	$6,000	$25	$10,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	350	SF	$40	$14,000	$5	$1,750	$60	$21,000	$105	$36,750
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates		SF	$70		$55		$90		$215	
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$138,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 15 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$7,000
General Requirements	15.0%									$21,000
Contractor Overhead and Profit	15.0%									$21,000
Burdened Cost SUBTOTAL	**35.0%**									**$187,000**
Construction Design & Administration										
Field Investigations	8.0%									$15,000
Environmental Permitting	7.0%									$13,000
Design Plans & Specifications	9.0%									$17,000
Designer Construction & Bid Support	3.0%									$6,000
Special Inspections	3.0%									$6,000
Construction Administration	4.0%									$7,000
Construction Contingency	30.0%									$56,000
TOTAL PROJECT COST IN 2025 DOLLARS	**64.0%**									**$307,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 20 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	4	EA	$5,000	$20,000	$8,000	$32,000	$13,000	$52,000	$26,000	$104,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	50	CF	$275	$13,750	$1,100	$55,000	$1,050	$52,500	$2,425	$121,250
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	60	LF	$30	$1,800	$40	$2,400	$55	$3,300	$125	$7,500
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	25	CF	$275	$6,875	$1,100	$27,500	$1,150	$28,750	$2,525	$63,125
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	50	LF	$30	$1,500	$40	$2,000	$60	$3,000	$130	$6,500
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	600	LF	$8	$4,800	$2	$1,200	$15	$9,000	$25	$15,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	600	SF	$40	$24,000	$5	$3,000	$60	$36,000	$105	$63,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates		SF	$70		$55		$90		$215	
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$380,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	EQUIPMENT COST UNIT COST	EQUIPMENT COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 20 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$19,000
General Requirements	10.0%									$38,000
Contractor Overhead and Profit	15.0%									$57,000
Burdened Cost SUBTOTAL	**30.0%**									**$494,000**
Construction Design & Administration										
Field Investigations	9.0%									$44,000
Environmental Permitting	6.0%									$30,000
Design Plans & Specifications	7.0%									$35,000
Designer Construction & Bid Support	3.0%									$15,000
Special Inspections	3.0%									$15,000
Construction Administration	4.0%									$20,000
Construction Contingency	30.0%									$148,000
TOTAL PROJECT COST IN 2025 DOLLARS	**62.0%**									**$801,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 25 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	5	EA	$5,000	$25,000	$8,000	$40,000	$13,000	$65,000	$26,000	$130,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	100	CF	$275	$27,500	$1,100	$110,000	$1,050	$105,000	$2,425	$242,500
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	70	LF	$30	$2,100	$40	$2,800	$55	$3,850	$125	$8,750
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	50	CF	$275	$13,750	$1,100	$55,000	$1,150	$57,500	$2,525	$126,250
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	100	LF	$30	$3,000	$40	$4,000	$60	$6,000	$130	$13,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	800	LF	$8	$6,400	$2	$1,600	$15	$12,000	$25	$20,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	1100	SF	$40	$44,000	$5	$5,500	$60	$66,000	$105	$115,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates		SF	$70		$55		$90		$215	
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$656,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 25 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$33,000
General Requirements	8.0%									$52,000
Contractor Overhead and Profit	15.0%									$98,000
Burdened Cost SUBTOTAL	**28.0%**									**$839,000**
Construction Design & Administration										
Field Investigations	6.0%									$50,000
Environmental Permitting	3.5%									$29,000
Design Plans & Specifications	6.0%									$50,000
Designer Construction & Bid Support	2.5%									$21,000
Special Inspections	3.0%									$25,000
Construction Administration	4.0%									$34,000
Construction Contingency	30.0%									$252,000
TOTAL PROJECT COST IN 2025 DOLLARS	**55.0%**									**$1,300,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 30 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	6	EA	$5,000	$30,000	$8,000	$48,000	$13,000	$78,000	$26,000	$156,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	125	CF	$275	$34,375	$1,100	$137,500	$1,050	$131,250	$2,425	$303,125
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	80	LF	$30	$2,400	$40	$3,200	$55	$4,400	$125	$10,000
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	100	CF	$275	$27,500	$1,100	$110,000	$1,150	$115,000	$2,525	$252,500
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	200	LF	$30	$6,000	$40	$8,000	$60	$12,000	$130	$26,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	1100	LF	$8	$8,800	$2	$2,200	$15	$16,500	$25	$27,500
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	1900	SF	$40	$76,000	$5	$9,500	$60	$114,000	$105	$199,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates		SF	$70		$55		$90		$215	
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$975,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 30 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$49,000
General Requirements	6.0%									$59,000
Contractor Overhead and Profit	15.0%									$146,000
Burdened Cost SUBTOTAL	**26.0%**									**$1,229,000**
Construction Design & Administration										
Field Investigations	4.5%									$55,000
Environmental Permitting	2.5%									$31,000
Design Plans & Specifications	5.0%									$61,000
Designer Construction & Bid Support	2.5%									$31,000
Special Inspections	3.0%									$37,000
Construction Administration	4.0%									$49,000
Construction Contingency	30.0%									$369,000
TOTAL PROJECT COST IN 2025 DOLLARS	**51.5%**									**$1,862,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 35 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	7	EA	$5,000	$35,000	$8,000	$56,000	$13,000	$91,000	$26,000	$182,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	150	CF	$275	$41,250	$1,100	$165,000	$1,050	$157,500	$2,425	$363,750
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	90	LF	$30	$2,700	$40	$3,600	$55	$4,950	$125	$11,250
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	150	CF	$275	$41,250	$1,100	$165,000	$1,150	$172,500	$2,525	$378,750
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	300	LF	$30	$9,000	$40	$12,000	$60	$18,000	$130	$39,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	1600	LF	$8	$12,800	$2	$3,200	$15	$24,000	$25	$40,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	3200	SF	$40	$128,000	$5	$16,000	$60	$192,000	$105	$336,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates		SF	$70		$55		$90		$215	
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$1,351,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 35 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$68,000
General Requirements	5.0%									$68,000
Contractor Overhead and Profit	15.0%									$203,000
Burdened Cost SUBTOTAL	**25.0%**									**$1,690,000**
Construction Design & Administration										
Field Investigations	3.0%									$51,000
Environmental Permitting	2.5%									$42,000
Design Plans & Specifications	5.0%									$85,000
Designer Construction & Bid Support	2.5%									$42,000
Special Inspections	3.0%									$51,000
Construction Administration	4.0%									$68,000
Construction Contingency	30.0%									$507,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$2,536,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 40 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	8	EA	$5,000	$40,000	$8,000	$64,000	$13,000	$104,000	$26,000	$208,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	200	CF	$275	$55,000	$1,100	$220,000	$1,050	$210,000	$2,425	$485,000
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	100	LF	$30	$3,000	$40	$4,000	$55	$5,500	$125	$12,500
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	200	CF	$275	$55,000	$1,100	$220,000	$1,150	$230,000	$2,525	$505,000
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	400	LF	$30	$12,000	$40	$16,000	$60	$24,000	$130	$52,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2100	LF	$8	$16,800	$2	$4,200	$15	$31,500	$25	$52,500
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	6000	SF	$40	$240,000	$5	$30,000	$60	$360,000	$105	$630,000
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	300	SF	$70	$21,000	$55	$16,500	$90	$27,000	$215	$64,500
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$2,010,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 40 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$101,000
General Requirements	5.0%									$101,000
Contractor Overhead and Profit	15.0%									$302,000
Burdened Cost SUBTOTAL	**25.0%**									**$2,514,000**
Construction Design & Administration										
Field Investigations	3.0%									$75,000
Environmental Permitting	2.5%									$63,000
Design Plans & Specifications	5.0%									$126,000
Designer Construction & Bid Support	2.5%									$63,000
Special Inspections	3.0%									$75,000
Construction Administration	4.0%									$101,000
Construction Contingency	30.0%									$754,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$3,771,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 1 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 45 YEARS AFTER CONSTRUCTED										
A) Pile Jacket Repair										
Install Fiberglass Grouted Pile Jacket	9	EA	$5,000	$45,000	$8,000	$72,000	$13,000	$117,000	$26,000	$234,000
B) Pile Cap Spall Repair										
Spall Repairs - Demo, Rebar, Prep, Patch, Finish	250	CF	$275	$68,750	$1,100	$275,000	$1,050	$262,500	$2,425	$606,250
C) Pile Cap Crack Repair										
Epoxy Crack Injection - Pile Caps	110	LF	$30	$3,300	$40	$4,400	$55	$6,050	$125	$13,750
D) Deck Panel Soffit Spall Repair										
Soffit Spalls - Demo, Rebar, Prep, Patch, Finish	250	CF	$275	$68,750	$1,100	$275,000	$1,150	$287,500	$2,525	$631,250
E) Deck Panel Soffit Crack Repair										
Epoxy Crack Injection - Deck Soffit	500	LF	$30	$15,000	$40	$20,000	$60	$30,000	$130	$65,000
F) Deck Panel Top Crack Repair										
Epoxy Crack Injection - Deck Top Surface	2600	LF	$8	$20,800	$2	$5,200	$15	$39,000	$25	$65,000
G) Deck Panel Top Spall Repair										
Top Surface Spalls - Demo, Prep, Patch, Finish	6500	SF	$40	$260,000	$5	$32,500	$60	$390,000	$105	$682,500
H) Deck Panel FRP Strengthening										
Panel Soffit - FRP Laminates	400	SF	$70	$28,000	$55	$22,000	$90	$36,000	$215	$86,000
J) Deck Panel Replacement in-kind										
Deck Panels - Remove, Cast-in-Place		EA	$50,000		$30,000		$95,000		$175,000	
Raw Construction Cost Subtotal										**$2,384,000**

PLANNING BUDGETARY COST ESTIMATE (2025 Dollars)	PRELIMINARY	DATE PREPARED: 11/13/2025	SHEET: 2 OF 2
ACTIVITY AND LOCATION: Hermosa Beach Pier Capital Planning Hermosa Beach, CA	A/E CONTRACT NUMBER:		A/E PROJECT NUMBER:
PROJECT TITLE: **Municipal Pier Cost / Benefit Analysis** **Hermosa Beach, California**	ESTIMATED BY: **ESN ENGINEERING, PLLC** STATUS OF DESIGN: Capital Improvement Planning		TASK NUMBER: PHASE NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		EQUIPMENT COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
NEW PIER ANTICIPATED MAINTENANCE COSTS - 45 YEARS AFTER CONSTRUCTED										
Construction General Requirements										
Mobilization	5.0%									$119,000
General Requirements	5.0%									$119,000
Contractor Overhead and Profit	15.0%									$358,000
Burdened Cost SUBTOTAL	**25.0%**									**$2,980,000**
Construction Design & Administration										
Field Investigations	3.0%									$89,000
Environmental Permitting	2.5%									$75,000
Design Plans & Specifications	5.0%									$149,000
Designer Construction & Bid Support	2.5%									$75,000
Special Inspections	3.0%									$89,000
Construction Administration	4.0%									$119,000
Construction Contingency	30.0%									$894,000
TOTAL PROJECT COST IN 2025 DOLLARS	**50.0%**									**$4,470,000**

Total Pier Costs (2025 - 2070) Based on Year that Pier is Replaced

Cost by Year

Total Costs:		$ 108,130,694	$ 106,957,513	$ 106,615,124	$ 106,229,554	$ 106,117,090	$ 105,599,978	$ 103,898,975	$ 104,542,547	$ 105,211,863	$ 105,659,695	$ 107,625,922	$ 109,670,798	$ 111,797,469
Year		1	2	3	4	5	6	7	8	9	10	11	12	13
		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
1	2026	$ 17,120,133	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920
2	2027	$ 16,049,502	$ 16,049,502	$ 877,718	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437
3	2028	$ 16,691,482	$ 16,691,482	$ 16,691,482	$ 5,624	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979
4	2029	$ 11,699	$ 17,359,141	$ 17,359,141	$ 17,359,141	$ 5,849	$ 5,849	$ 5,849	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258
5	2030	$ 12,167	$ 12,167	$ 18,053,507	$ 18,053,507	$ 18,053,507	$ 6,083	$ 6,083	$ 6,083	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469
6	2031	$ 12,653	$ 12,653	$ 12,653	$ 18,775,647	$ 18,775,647	$ 18,775,647	$ 14,081,735	$ 6,327	$ 6,327	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432
7	2032	$ 13,159	$ 13,159	$ 13,159	$ 13,159	$ 19,526,673	$ 19,526,673	$ 14,645,005	$ 14,645,005	$ 6,580	$ 6,580	$ 1,153,809	$ 1,153,809	$ 1,153,809
8	2033	$ 13,686	$ 13,686	$ 13,686	$ 13,686	$ 13,686	$ 20,307,740	$ 15,230,805	$ 15,230,805	$ 15,230,805	$ 6,843	$ 6,843	$ 1,199,961	$ 1,199,961
9	2034	$ 14,233	$ 14,233	$ 14,233	$ 14,233	$ 14,233	$ 14,233	$ 15,840,037	$ 15,840,037	$ 15,840,037	$ 15,840,037	$ 7,117	$ 7,117	$ 1,247,960
10	2035	$ 14,802	$ 14,802	$ 14,802	$ 14,802	$ 14,802	$ 14,802	$ 14,802	$ 16,473,639	$ 16,473,639	$ 16,473,639	$ 16,473,639	$ 7,401	$ 7,401
11	2036	$ 15,395	$ 15,395	$ 15,395	$ 15,395	$ 15,395	$ 15,395	$ 15,395	$ 15,395	$ 17,132,584	$ 17,132,584	$ 17,132,584	$ 17,132,584	$ 7,697
12	2037	$ 98,303	$ 16,010	$ 16,010	$ 16,010	$ 16,010	$ 16,010	$ 16,010	$ 16,010	$ 16,010	$ 17,817,888	$ 17,817,888	$ 17,817,888	$ 17,817,888
13	2038	$ 102,236	$ 102,236	$ 16,651	$ 16,651	$ 16,651	$ 16,651	$ 16,651	$ 16,651	$ 16,651	$ 16,651	$ 18,530,603	$ 18,530,603	$ 18,530,603
14	2039	$ 106,325	$ 106,325	$ 106,325	$ 17,317	$ 17,317	$ 17,317	$ 17,317	$ 17,317	$ 17,317	$ 17,317	$ 17,317	$ 19,271,827	$ 19,271,827
15	2040	$ 110,578	$ 110,578	$ 110,578	$ 110,578	$ 18,009	$ 18,009	$ 18,009	$ 18,009	$ 18,009	$ 18,009	$ 18,009	$ 18,009	$ 20,042,700
16	2041	$ 115,001	$ 115,001	$ 115,001	$ 115,001	$ 115,001	$ 18,730	$ 18,730	$ 18,730	$ 18,730	$ 18,730	$ 18,730	$ 18,730	$ 18,730
17	2042	$ 312,054	$ 119,601	$ 119,601	$ 119,601	$ 119,601	$ 119,601	$ 19,479	$ 19,479	$ 19,479	$ 19,479	$ 19,479	$ 19,479	$ 19,479
18	2043	$ 324,536	$ 324,536	$ 124,385	$ 124,385	$ 124,385	$ 124,385	$ 124,385	$ 20,258	$ 20,258	$ 20,258	$ 20,258	$ 20,258	$ 20,258
19	2044	$ 337,517	$ 337,517	$ 337,517	$ 129,361	$ 129,361	$ 129,361	$ 129,361	$ 129,361	$ 21,068	$ 21,068	$ 21,068	$ 21,068	$ 21,068
20	2045	$ 351,018	$ 351,018	$ 351,018	$ 351,018	$ 134,535	$ 134,535	$ 134,535	$ 134,535	$ 134,535	$ 21,911	$ 21,911	$ 21,911	$ 21,911
21	2046	$ 365,059	$ 365,059	$ 365,059	$ 365,059	$ 365,059	$ 139,916	$ 139,916	$ 139,916	$ 139,916	$ 139,916	$ 22,788	$ 22,788	$ 22,788
22	2047	$ 616,179	$ 379,661	$ 379,661	$ 379,661	$ 379,661	$ 379,661	$ 145,513	$ 145,513	$ 145,513	$ 145,513	$ 145,513	$ 23,699	$ 23,699
23	2048	$ 640,826	$ 640,826	$ 394,847	$ 394,847	$ 394,847	$ 394,847	$ 394,847	$ 151,334	$ 151,334	$ 151,334	$ 151,334	$ 151,334	$ 24,647
24	2049	$ 666,459	$ 666,459	$ 666,459	$ 410,641	$ 410,641	$ 410,641	$ 410,641	$ 410,641	$ 157,387	$ 157,387	$ 157,387	$ 157,387	$ 157,387
25	2050	$ 693,117	$ 693,117	$ 693,117	$ 693,117	$ 427,067	$ 427,067	$ 427,067	$ 427,067	$ 427,067	$ 163,682	$ 163,682	$ 163,682	$ 163,682
26	2051	$ 720,842	$ 720,842	$ 720,842	$ 720,842	$ 720,842	$ 444,150	$ 444,150	$ 444,150	$ 444,150	$ 444,150	$ 170,230	$ 170,230	$ 170,230
27	2052	$ 1,073,766	$ 749,676	$ 749,676	$ 749,676	$ 749,676	$ 749,676	$ 461,916	$ 461,916	$ 461,916	$ 461,916	$ 461,916	$ 177,039	$ 177,039
28	2053	$ 1,116,717	$ 1,116,717	$ 779,663	$ 779,663	$ 779,663	$ 779,663	$ 779,663	$ 480,392	$ 480,392	$ 480,392	$ 480,392	$ 480,392	$ 184,120
29	2054	$ 1,161,386	$ 1,161,386	$ 1,161,386	$ 810,849	$ 810,849	$ 810,849	$ 810,849	$ 810,849	$ 499,608	$ 499,608	$ 499,608	$ 499,608	$ 499,608
30	2055	$ 1,207,841	$ 1,207,841	$ 1,207,841	$ 1,207,841	$ 843,283	$ 843,283	$ 843,283	$ 843,283	$ 843,283	$ 519,592	$ 519,592	$ 519,592	$ 519,592
31	2056	$ 1,256,155	$ 1,256,155	$ 1,256,155	$ 1,256,155	$ 1,256,155	$ 877,015	$ 877,015	$ 877,015	$ 877,015	$ 877,015	$ 540,376	$ 540,376	$ 540,376
32	2057	$ 1,779,287	$ 1,306,401	$ 1,306,401	$ 1,306,401	$ 1,306,401	$ 1,306,401	$ 912,095	$ 912,095	$ 912,095	$ 912,095	$ 912,095	$ 561,991	$ 561,991
33	2058	$ 1,850,459	$ 1,850,459	$ 1,358,657	$ 1,358,657	$ 1,358,657	$ 1,358,657	$ 1,358,657	$ 948,579	$ 948,579	$ 948,579	$ 948,579	$ 948,579	$ 584,471
34	2059	$ 1,924,477	$ 1,924,477	$ 1,924,477	$ 1,413,003	$ 1,413,003	$ 1,413,003	$ 1,413,003	$ 1,413,003	$ 986,522	$ 986,522	$ 986,522	$ 986,522	$ 986,522
35	2060	$ 2,001,456	$ 2,001,456	$ 2,001,456	$ 2,001,456	$ 1,469,524	$ 1,469,524	$ 1,469,524	$ 1,469,524	$ 1,469,524	$ 1,025,983	$ 1,025,983	$ 1,025,983	$ 1,025,983
36	2061	$ 2,081,515	$ 2,081,515	$ 2,081,515	$ 2,081,515	$ 2,081,515	$ 1,528,304	$ 1,528,304	$ 1,528,304	$ 1,528,304	$ 1,528,304	$ 1,067,022	$ 1,067,022	$ 1,067,022
37	2062	$ 3,218,993	$ 2,164,775	$ 2,164,775	$ 2,164,775	$ 2,164,775	$ 2,164,775	$ 1,589,437	$ 1,589,437	$ 1,589,437	$ 1,589,437	$ 1,589,437	$ 1,109,703	$ 1,109,703
38	2063	$ 3,347,753	$ 3,347,753	$ 2,251,366	$ 2,251,366	$ 2,251,366	$ 2,251,366	$ 2,251,366	$ 1,653,014	$ 1,653,014	$ 1,653,014	$ 1,653,014	$ 1,653,014	$ 1,154,091
39	2064	$ 3,481,663	$ 3,481,663	$ 3,481,663	$ 2,341,421	$ 2,341,421	$ 2,341,421	$ 2,341,421	$ 2,341,421	$ 1,719,135	$ 1,719,135	$ 1,719,135	$ 1,719,135	$ 1,719,135
40	2065	$ 3,620,930	$ 3,620,930	$ 3,620,930	$ 3,620,930	$ 2,435,078	$ 2,435,078	$ 2,435,078	$ 2,435,078	$ 2,435,078	$ 1,787,900	$ 1,787,900	$ 1,787,900	$ 1,787,900
41	2066	$ 3,765,767	$ 3,765,767	$ 3,765,767	$ 3,765,767	$ 3,765,767	$ 2,532,481	$ 2,532,481	$ 2,532,481	$ 2,532,481	$ 2,532,481	$ 1,859,416	$ 1,859,416	$ 1,859,416
42	2067	$ 4,642,349	$ 3,916,398	$ 3,916,398	$ 3,916,398	$ 3,916,398	$ 3,916,398	$ 2,633,780	$ 2,633,780	$ 2,633,780	$ 2,633,780	$ 2,633,780	$ 1,933,793	$ 1,933,793
43	2068	$ 4,828,043	$ 4,828,043	$ 4,073,054	$ 4,073,054	$ 4,073,054	$ 4,073,054	$ 4,073,054	$ 2,739,131	$ 2,739,131	$ 2,739,131	$ 2,739,131	$ 2,739,131	$ 2,011,144
44	2069	$ 5,021,164	$ 5,021,164	$ 5,021,164	$ 4,235,976	$ 4,235,976	$ 4,235,976	$ 4,235,976	$ 4,235,976	$ 2,848,696	$ 2,848,696	$ 2,848,696	$ 2,848,696	$ 2,848,696
45	2070	$ 5,222,011	$ 5,222,011	$ 5,222,011	$ 5,222,011	$ 4,405,415	$ 4,405,415	$ 4,405,415	$ 4,405,415	$ 4,405,415	$ 2,962,644	$ 2,962,644	$ 2,962,644	$ 2,962,644

Total Pier Costs (2025 - 2070) Based on Year that Pier is Replaced

Cost by Year

Total Costs:		$ 114,009,207	$ 116,576,664	$ 120,065,705	$ 123,694,307	$ 127,468,054	$ 131,392,751	$ 135,668,102	$ 140,797,276	$ 146,131,618	$ 151,679,334	$ 157,448,958	$ 163,838,125	$ 171,089,126
Year		14	15	16	17	18	19	20	21	22	23	24	25	26
		2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
1	2026	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920
2	2027	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437
3	2028	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979
4	2029	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258
5	2030	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469
6	2031	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432
7	2032	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809
8	2033	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961
9	2034	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960
10	2035	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878
11	2036	$ 7,697	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043
12	2037	$ 8,005	$ 8,005	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724
13	2038	$ 18,530,603	$ 8,325	$ 8,325	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993
14	2039	$ 19,271,827	$ 19,271,827	$ 8,658	$ 8,658	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953
15	2040	$ 20,042,700	$ 20,042,700	$ 20,042,700	$ 9,005	$ 9,005	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711
16	2041	$ 20,844,408	$ 20,844,408	$ 20,844,408	$ 20,844,408	$ 9,365	$ 9,365	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046
17	2042	$ 19,479	$ 21,678,185	$ 21,678,185	$ 21,678,185	$ 21,678,185	$ 9,740	$ 9,740	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488
18	2043	$ 20,258	$ 20,258	$ 22,545,312	$ 22,545,312	$ 22,545,312	$ 22,545,312	$ 10,129	$ 10,129	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387
19	2044	$ 21,068	$ 21,068	$ 21,068	$ 23,447,124	$ 23,447,124	$ 23,447,124	$ 23,447,124	$ 10,534	$ 10,534	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883
20	2045	$ 21,911	$ 21,911	$ 21,911	$ 21,911	$ 24,385,009	$ 24,385,009	$ 24,385,009	$ 24,385,009	$ 10,956	$ 10,956	$ 2,528,118	$ 2,528,118	$ 2,528,118
21	2046	$ 22,788	$ 22,788	$ 22,788	$ 22,788	$ 22,788	$ 25,360,410	$ 25,360,410	$ 25,360,410	$ 25,360,410	$ 11,394	$ 11,394	$ 3,018,000	$ 3,018,000
22	2047	$ 23,699	$ 23,699	$ 23,699	$ 23,699	$ 23,699	$ 23,699	$ 26,374,826	$ 26,374,826	$ 26,374,826	$ 26,374,826	$ 11,850	$ 11,850	$ 3,138,720
23	2048	$ 24,647	$ 24,647	$ 24,647	$ 24,647	$ 24,647	$ 24,647	$ 24,647	$ 27,429,819	$ 27,429,819	$ 27,429,819	$ 27,429,819	$ 12,324	$ 12,324
24	2049	$ 25,633	$ 25,633	$ 25,633	$ 25,633	$ 25,633	$ 25,633	$ 25,633	$ 25,633	$ 28,527,012	$ 28,527,012	$ 28,527,012	$ 28,527,012	$ 12,817
25	2050	$ 163,682	$ 26,658	$ 26,658	$ 26,658	$ 26,658	$ 26,658	$ 26,658	$ 26,658	$ 26,658	$ 29,668,093	$ 29,668,093	$ 29,668,093	$ 29,668,093
26	2051	$ 170,230	$ 170,230	$ 27,725	$ 27,725	$ 27,725	$ 27,725	$ 27,725	$ 27,725	$ 27,725	$ 27,725	$ 30,854,816	$ 30,854,816	$ 30,854,816
27	2052	$ 177,039	$ 177,039	$ 177,039	$ 28,834	$ 28,834	$ 28,834	$ 28,834	$ 28,834	$ 28,834	$ 28,834	$ 28,834	$ 32,089,009	$ 32,089,009
28	2053	$ 184,120	$ 184,120	$ 184,120	$ 184,120	$ 29,987	$ 29,987	$ 29,987	$ 29,987	$ 29,987	$ 29,987	$ 29,987	$ 29,987	$ 33,372,569
29	2054	$ 191,485	$ 191,485	$ 191,485	$ 191,485	$ 191,485	$ 31,187	$ 31,187	$ 31,187	$ 31,187	$ 31,187	$ 31,187	$ 31,187	$ 31,187
30	2055	$ 519,592	$ 199,145	$ 199,145	$ 199,145	$ 199,145	$ 199,145	$ 32,434	$ 32,434	$ 32,434	$ 32,434	$ 32,434	$ 32,434	$ 32,434
31	2056	$ 540,376	$ 540,376	$ 207,110	$ 207,110	$ 207,110	$ 207,110	$ 207,110	$ 33,731	$ 33,731	$ 33,731	$ 33,731	$ 33,731	$ 33,731
32	2057	$ 561,991	$ 561,991	$ 561,991	$ 215,395	$ 215,395	$ 215,395	$ 215,395	$ 215,395	$ 35,081	$ 35,081	$ 35,081	$ 35,081	$ 35,081
33	2058	$ 584,471	$ 584,471	$ 584,471	$ 584,471	$ 224,011	$ 224,011	$ 224,011	$ 224,011	$ 224,011	$ 36,484	$ 36,484	$ 36,484	$ 36,484
34	2059	$ 607,849	$ 607,849	$ 607,849	$ 607,849	$ 607,849	$ 232,971	$ 232,971	$ 232,971	$ 232,971	$ 232,971	$ 37,943	$ 37,943	$ 37,943
35	2060	$ 1,025,983	$ 632,163	$ 632,163	$ 632,163	$ 632,163	$ 632,163	$ 242,290	$ 242,290	$ 242,290	$ 242,290	$ 242,290	$ 39,461	$ 39,461
36	2061	$ 1,067,022	$ 1,067,022	$ 657,450	$ 657,450	$ 657,450	$ 657,450	$ 657,450	$ 251,981	$ 251,981	$ 251,981	$ 251,981	$ 251,981	$ 41,039
37	2062	$ 1,109,703	$ 1,109,703	$ 1,109,703	$ 683,748	$ 683,748	$ 683,748	$ 683,748	$ 683,748	$ 262,061	$ 262,061	$ 262,061	$ 262,061	$ 262,061
38	2063	$ 1,154,091	$ 1,154,091	$ 1,154,091	$ 1,154,091	$ 711,098	$ 711,098	$ 711,098	$ 711,098	$ 711,098	$ 272,543	$ 272,543	$ 272,543	$ 272,543
39	2064	$ 1,200,255	$ 1,200,255	$ 1,200,255	$ 1,200,255	$ 1,200,255	$ 739,542	$ 739,542	$ 739,542	$ 739,542	$ 739,542	$ 283,445	$ 283,445	$ 283,445
40	2065	$ 1,787,900	$ 1,248,265	$ 1,248,265	$ 1,248,265	$ 1,248,265	$ 1,248,265	$ 769,124	$ 769,124	$ 769,124	$ 769,124	$ 769,124	$ 294,783	$ 294,783
41	2066	$ 1,859,416	$ 1,859,416	$ 1,298,196	$ 1,298,196	$ 1,298,196	$ 1,298,196	$ 1,298,196	$ 799,888	$ 799,888	$ 799,888	$ 799,888	$ 799,888	$ 306,574
42	2067	$ 1,933,793	$ 1,933,793	$ 1,933,793	$ 1,350,124	$ 1,350,124	$ 1,350,124	$ 1,350,124	$ 1,350,124	$ 831,884	$ 831,884	$ 831,884	$ 831,884	$ 831,884
43	2068	$ 2,011,144	$ 2,011,144	$ 2,011,144	$ 2,011,144	$ 1,404,129	$ 1,404,129	$ 1,404,129	$ 1,404,129	$ 1,404,129	$ 865,159	$ 865,159	$ 865,159	$ 865,159
44	2069	$ 2,091,590	$ 2,091,590	$ 2,091,590	$ 2,091,590	$ 2,091,590	$ 1,460,294	$ 1,460,294	$ 1,460,294	$ 1,460,294	$ 1,460,294	$ 899,766	$ 899,766	$ 899,766
45	2070	$ 2,962,644	$ 2,175,254	$ 2,175,254	$ 2,175,254	$ 2,175,254	$ 2,175,254	$ 1,518,706	$ 1,518,706	$ 1,518,706	$ 1,518,706	$ 1,518,706	$ 935,756	$ 935,756

Total Pier Costs (2025 - 2070) Based on Year that Pier is Replaced

Cost by Year

Total Costs:		$ 178,630,167	$ 186,472,849	$ 194,629,239	$ 203,492,822	$ 213,311,141	$ 223,522,192	$ 234,141,686	$ 245,185,959	$ 257,156,385	$ 269,917,874	$ 283,189,822	$ 296,992,649	$ 311,347,589
Year		27	28	29	30	31	32	33	34	35	36	37	38	39
		2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064
1	2026	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920
2	2027	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437
3	2028	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979
4	2029	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258
5	2030	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469
6	2031	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432
7	2032	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809
8	2033	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961
9	2034	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960
10	2035	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878
11	2036	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043
12	2037	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724
13	2038	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993
14	2039	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953
15	2040	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711
16	2041	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046
17	2042	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488
18	2043	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387
19	2044	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883
20	2045	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118
21	2046	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000
22	2047	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720
23	2048	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269
24	2049	$ 12,817	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840
25	2050	$ 13,329	$ 13,329	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634
26	2051	$ 30,854,816	$ 13,862	$ 13,862	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796
27	2052	$ 32,089,009	$ 32,089,009	$ 14,417	$ 14,417	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908
28	2053	$ 33,372,569	$ 33,372,569	$ 33,372,569	$ 14,994	$ 14,994	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505
29	2054	$ 34,707,472	$ 34,707,472	$ 34,707,472	$ 34,707,472	$ 15,593	$ 15,593	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845
30	2055	$ 32,434	$ 36,095,771	$ 36,095,771	$ 36,095,771	$ 36,095,771	$ 16,217	$ 16,217	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198
31	2056	$ 33,731	$ 33,731	$ 37,539,602	$ 37,539,602	$ 37,539,602	$ 37,539,602	$ 16,866	$ 16,866	$ 5,415,228	$ 5,415,228	$ 5,415,228	$ 5,415,228	$ 5,415,228
32	2057	$ 35,081	$ 35,081	$ 35,081	$ 39,041,186	$ 39,041,186	$ 39,041,186	$ 39,041,186	$ 17,540	$ 17,540	$ 5,631,838	$ 5,631,838	$ 5,631,838	$ 5,631,838
33	2058	$ 36,484	$ 36,484	$ 36,484	$ 36,484	$ 40,602,833	$ 40,602,833	$ 40,602,833	$ 40,602,833	$ 18,242	$ 18,242	$ 5,857,111	$ 5,857,111	$ 5,857,111
34	2059	$ 37,943	$ 37,943	$ 37,943	$ 37,943	$ 37,943	$ 42,226,947	$ 42,226,947	$ 42,226,947	$ 42,226,947	$ 18,972	$ 18,972	$ 6,091,395	$ 6,091,395
35	2060	$ 39,461	$ 39,461	$ 39,461	$ 39,461	$ 39,461	$ 39,461	$ 43,916,024	$ 43,916,024	$ 43,916,024	$ 43,916,024	$ 19,730	$ 19,730	$ 6,335,051
36	2061	$ 41,039	$ 41,039	$ 41,039	$ 41,039	$ 41,039	$ 41,039	$ 41,039	$ 45,672,665	$ 45,672,665	$ 45,672,665	$ 45,672,665	$ 20,520	$ 20,520
37	2062	$ 42,681	$ 42,681	$ 42,681	$ 42,681	$ 42,681	$ 42,681	$ 42,681	$ 42,681	$ 47,499,572	$ 47,499,572	$ 47,499,572	$ 47,499,572	$ 21,340
38	2063	$ 272,543	$ 44,388	$ 44,388	$ 44,388	$ 44,388	$ 44,388	$ 44,388	$ 44,388	$ 44,388	$ 49,399,555	$ 49,399,555	$ 49,399,555	$ 49,399,555
39	2064	$ 283,445	$ 283,445	$ 46,164	$ 46,164	$ 46,164	$ 46,164	$ 46,164	$ 46,164	$ 46,164	$ 46,164	$ 51,375,537	$ 51,375,537	$ 51,375,537
40	2065	$ 294,783	$ 294,783	$ 294,783	$ 48,010	$ 48,010	$ 48,010	$ 48,010	$ 48,010	$ 48,010	$ 48,010	$ 48,010	$ 53,430,559	$ 53,430,559
41	2066	$ 306,574	$ 306,574	$ 306,574	$ 306,574	$ 49,931	$ 49,931	$ 49,931	$ 49,931	$ 49,931	$ 49,931	$ 49,931	$ 49,931	$ 55,567,781
42	2067	$ 318,837	$ 318,837	$ 318,837	$ 318,837	$ 318,837	$ 51,928	$ 51,928	$ 51,928	$ 51,928	$ 51,928	$ 51,928	$ 51,928	$ 51,928
43	2068	$ 865,159	$ 331,590	$ 331,590	$ 331,590	$ 331,590	$ 331,590	$ 54,005	$ 54,005	$ 54,005	$ 54,005	$ 54,005	$ 54,005	$ 54,005
44	2069	$ 899,766	$ 899,766	$ 344,854	$ 344,854	$ 344,854	$ 344,854	$ 344,854	$ 56,165	$ 56,165	$ 56,165	$ 56,165	$ 56,165	$ 56,165
45	2070	$ 935,756	$ 935,756	$ 935,756	$ 358,648	$ 358,648	$ 358,648	$ 358,648	$ 358,648	$ 58,412	$ 58,412	$ 58,412	$ 58,412	$ 58,412

Total Pier Costs (2025 - 2070) Based on Year that Pier is Replaced

Cost by Year

Total Costs:		$ 327,127,060	$ 343,537,711	$ 360,604,788	$ 378,354,548	$ 394,274,789	$ 408,207,042
Year		40	41	42	43	44	45
		2065	2066	2067	2068	2069	2070
1	2026	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920	$ 1,687,920
2	2027	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437	$ 1,755,437
3	2028	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979	$ 1,206,979
4	2029	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258	$ 1,255,258
5	2030	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469	$ 1,305,469
6	2031	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432	$ 1,109,432
7	2032	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809	$ 1,153,809
8	2033	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961	$ 1,199,961
9	2034	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960	$ 1,247,960
10	2035	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878	$ 1,297,878
11	2036	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043	$ 1,617,043
12	2037	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724	$ 1,681,724
13	2038	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993	$ 1,748,993
14	2039	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953	$ 1,818,953
15	2040	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711	$ 1,891,711
16	2041	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046	$ 2,161,046
17	2042	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488	$ 2,247,488
18	2043	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387	$ 2,337,387
19	2044	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883	$ 2,430,883
20	2045	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118	$ 2,528,118
21	2046	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000	$ 3,018,000
22	2047	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720	$ 3,138,720
23	2048	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269	$ 3,264,269
24	2049	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840	$ 3,394,840
25	2050	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634	$ 3,530,634
26	2051	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796	$ 4,052,796
27	2052	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908	$ 4,214,908
28	2053	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505	$ 4,383,505
29	2054	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845	$ 4,558,845
30	2055	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198	$ 4,741,198
31	2056	$ 5,415,228	$ 5,415,228	$ 5,415,228	$ 5,415,228	$ 5,415,228	$ 5,415,228
32	2057	$ 5,631,838	$ 5,631,838	$ 5,631,838	$ 5,631,838	$ 5,631,838	$ 5,631,838
33	2058	$ 5,857,111	$ 5,857,111	$ 5,857,111	$ 5,857,111	$ 5,857,111	$ 5,857,111
34	2059	$ 6,091,395	$ 6,091,395	$ 6,091,395	$ 6,091,395	$ 6,091,395	$ 6,091,395
35	2060	$ 6,335,051	$ 6,335,051	$ 6,335,051	$ 6,335,051	$ 6,335,051	$ 6,335,051
36	2061	$ 7,438,788	$ 7,438,788	$ 7,438,788	$ 7,438,788	$ 7,438,788	$ 7,438,788
37	2062	$ 21,340	$ 7,736,340	$ 7,736,340	$ 7,736,340	$ 7,736,340	$ 7,736,340
38	2063	$ 22,194	$ 22,194	$ 8,045,793	$ 8,045,793	$ 8,045,793	$ 8,045,793
39	2064	$ 51,375,537	$ 23,082	$ 23,082	$ 8,367,625	$ 8,367,625	$ 8,367,625
40	2065	$ 53,430,559	$ 53,430,559	$ 24,005	$ 24,005	$ 8,702,330	$ 8,702,330
41	2066	$ 55,567,781	$ 55,567,781	$ 55,567,781	$ 24,965	$ 24,965	$ 9,859,299
42	2067	$ 57,790,492	$ 57,790,492	$ 57,790,492	$ 57,790,492	$ 25,964	$ 25,964
43	2068	$ 54,005	$ 60,102,112	$ 60,102,112	$ 60,102,112	$ 60,102,112	$ 27,002
44	2069	$ 56,165	$ 56,165	$ 62,506,196	$ 62,506,196	$ 62,506,196	$ 83,341,595
45	2070	$ 58,412	$ 58,412	$ 58,412	$ 65,006,444	$ 130,012,888	$ 173,350,518

Sensequake

JMC²

CIVIL + STRUCTURAL ENGINEERING

Sensequake-based Structural Integrity Evaluation Report

Hermosa Beach Pier

September 5, 2025



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Sensequake-based Structural Integrity Evaluation Report

Hermosa Beach Pier

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I. Property and Confidentiality

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II. Executive Summary

This report presents the results of the sensing-based integrity evaluation test of the Hermosa Beach Pier using Sensequake's proprietary sensing-based structural health monitoring to evaluate its structural integrity.

The Hermosa Beach Pier is made up of 36 bays, 10 are selected to be evaluated as part of this study. The majority of the bays are constructed by four prestressed concrete panels linked by shear keys and supported by two bents, 30.5 feet in length and 20 feet wide for the span. The end bay, Bay 35-36 has 10 concrete panels linked by shear keys. The existing pier was constructed in 1965.

The following bays were selected to be tested as part of the evaluation:

Bay 10-11	Bay 15-16	Bay 27-28	Bay 35-36
Bay 12-13	Bay 18-19	Bay 30-31	
Bay 13-14	Bay 21-22	Bay 32-33	

These bays were prioritized based on visual inspection results, which highlighted advanced deterioration such as surface cracking, spalling, and suspected internal degradation.

The data collected was then analyzed in detail with a simplified 3D model of the Pier bays created in Sensequake's 3D-SAM™ software. The analysis is done without detailed structural drawings and is solely based on the measured ambient vibrations.

The following is achieved using the measured data:

- Multiple 3D mode shapes and natural frequencies (dynamic properties or stiffness baselines);
- Multiple structural integrity baselines for the individual bays of the Pier;
- [redacted]

The evaluation reveals that all tested bays exhibited varying levels of deterioration, with notable damage concentrated in specific panels and structural regions. A combination of transverse mode, vertical mode, and resonance frequency comparisons are used in combination to provide the following heat maps for each tested bay.

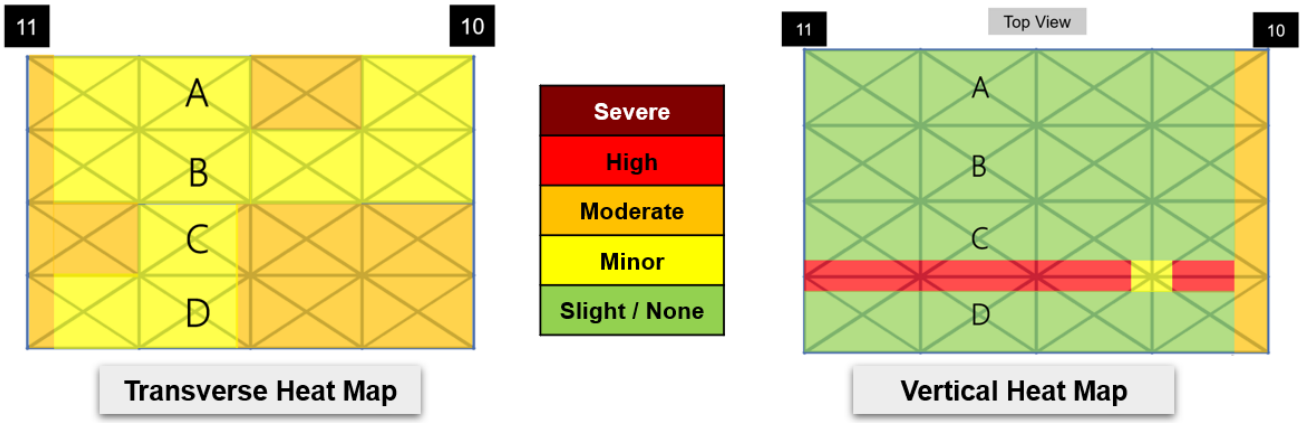


Figure II-1: Combined Heat Maps for bay 10-11

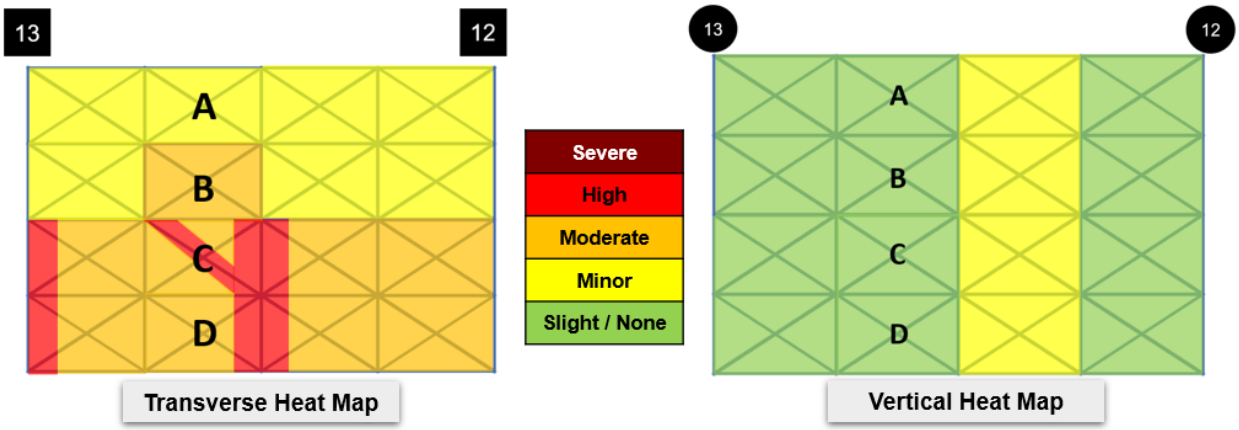


Figure II-2: Combined Heat Maps for bay 12-13

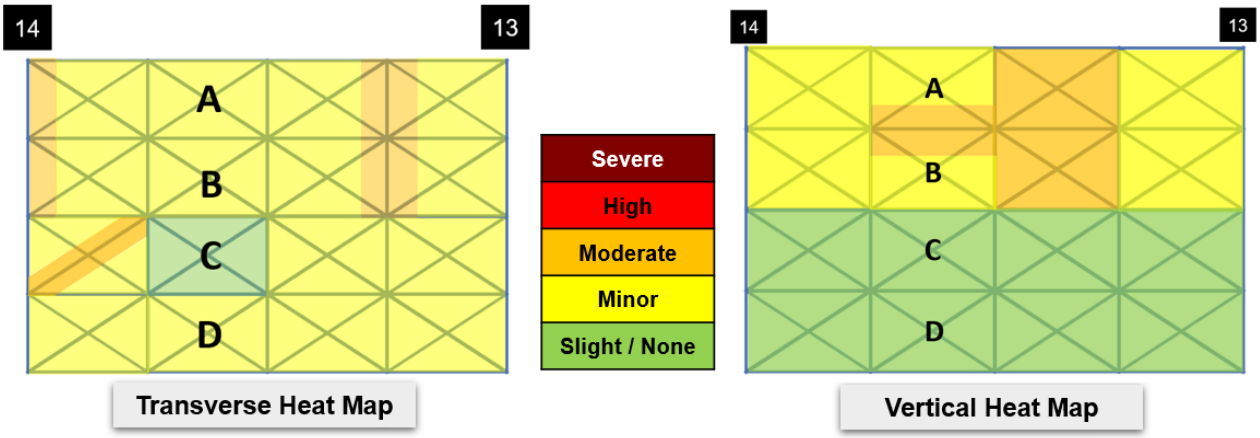


Figure II-3: Combined Heat Maps for Bay 13-14

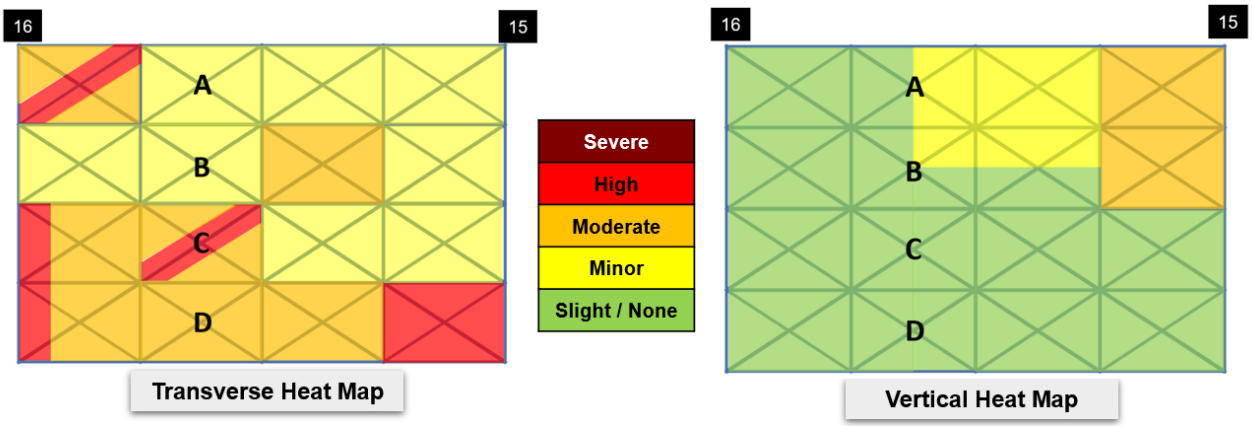


Figure II-4: Combined Heat Maps for Bay 15-16

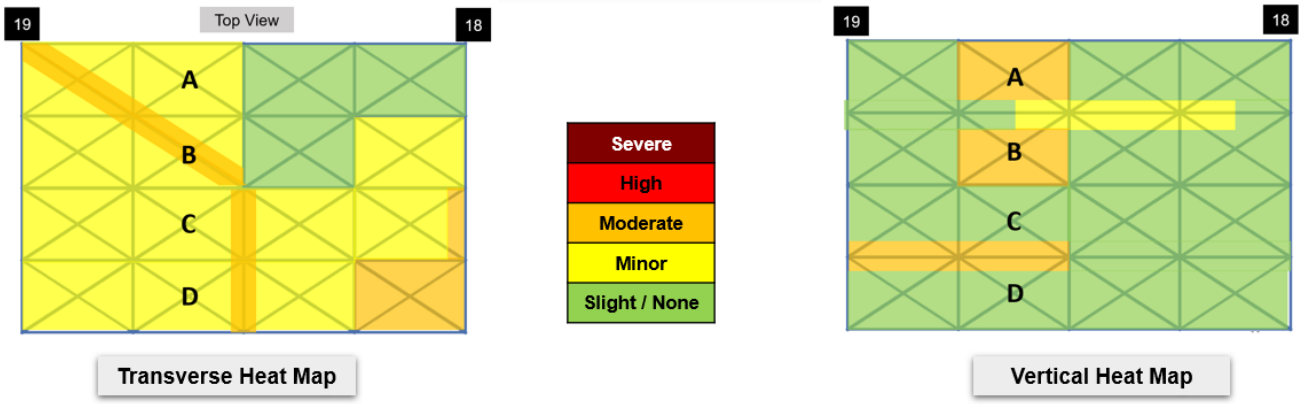


Figure II-5: Combined Heat Maps for Bay 18-19

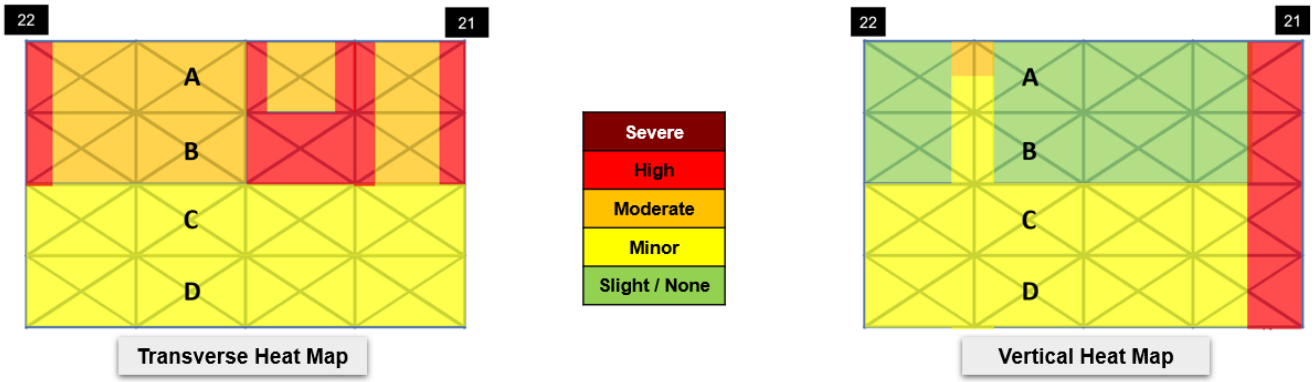


Figure II-6: Combined Heat Maps for Bay 21-22

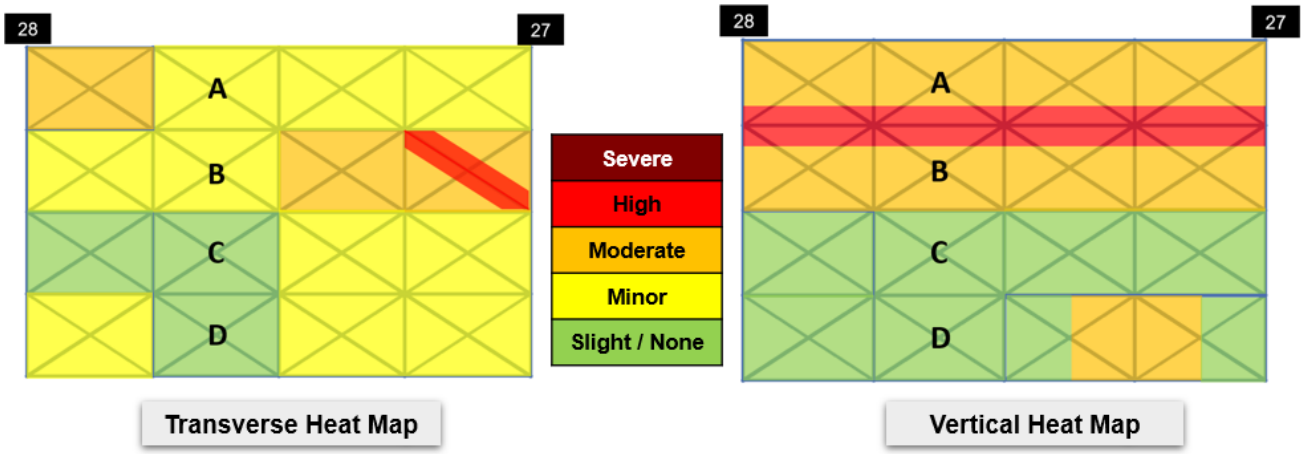


Figure II-7: Combined Heat Maps for Bay 27-28

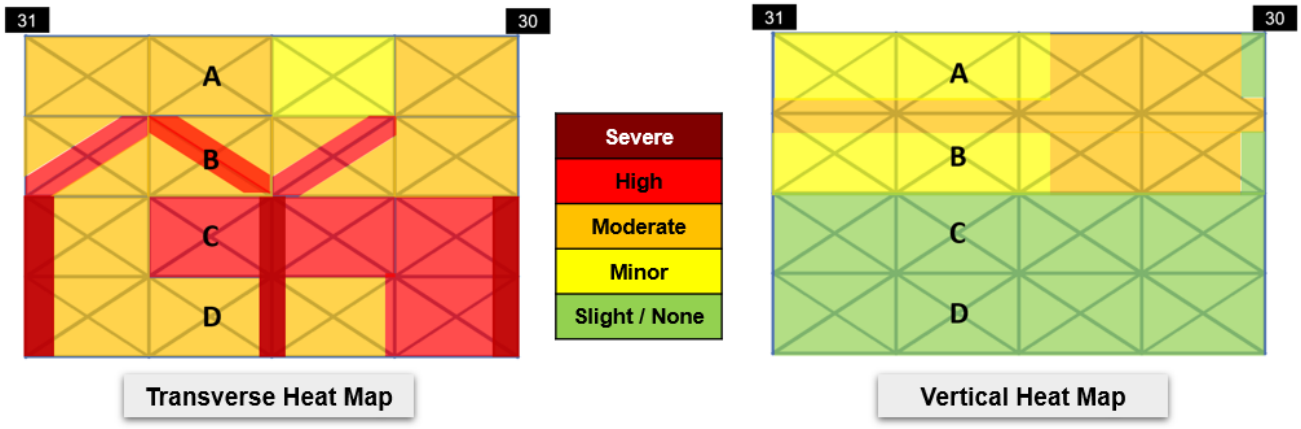


Figure II-8: Combined Heat Maps for Bay 30-31

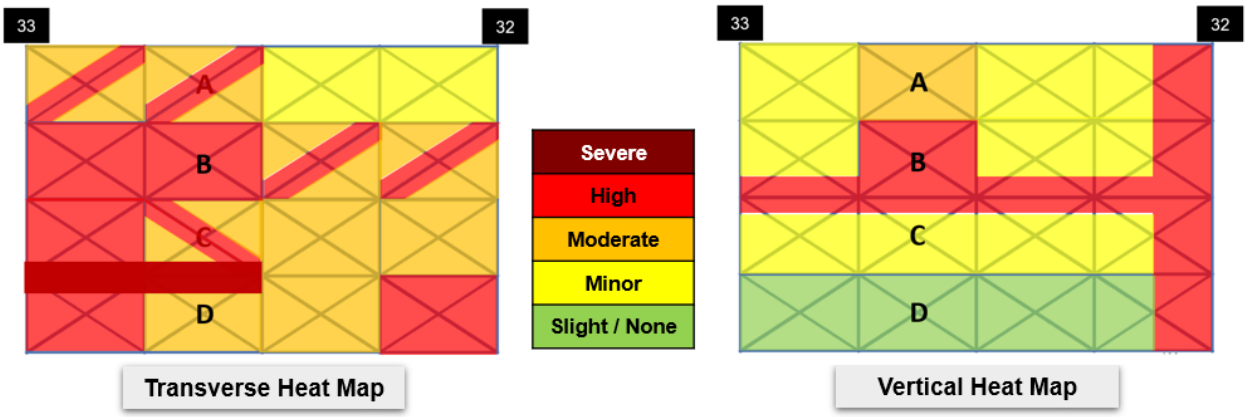


Figure II-9: Combined Heat Maps for Bay 32-33

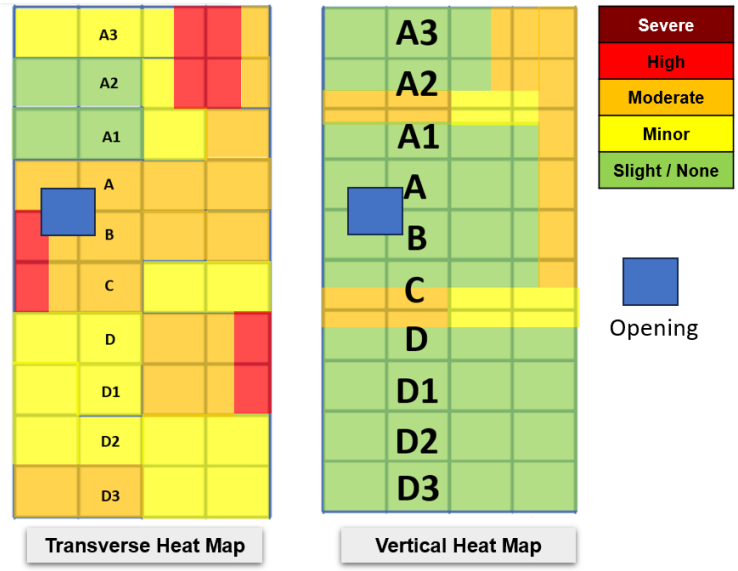


Figure II-10: Combined Heat Maps for Bay 35-36

In summary, the combination of dynamic testing, curvature quantification, vertical flexibility analysis, and visual inspection provides a detailed and reliable assessment of the Hermosa Beach Pier's structural condition. The findings confirm that multiple spans are experiencing progressive deterioration, with several regions requiring immediate attention or further investigation.

Future repetition of this same test can be used for long-term structural health management and support the development of targeted maintenance and retrofit strategies to extend the Pier’s service life.

III. Mandate

Sensequake's mandate for this project is to perform an ambient vibration-based integrity evaluation of certain bays of the Hermosa Beach Pier.

Sensequake's mandate is defined as follows:

- Review available plans for the structures and inspection reports.
- Design the sensing test of the pier including the location of the sensors, data sampling frequency, test duration, and execution plans.
- Gather ambient vibration data from the pier using sensors with six channels of data (acceleration and velocities in XYZ).
- Perform a few weeks of in-depth post-processing of the vibration data gathered to:
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]

- [redacted]
- [redacted]
- [redacted]

IV. Conditions and Restrictions

In this section, the “Client” is defined as the City of Hermosa Beach.

We draw the reader’s attention to the fact that this report does not constitute a legal opinion. The principles, procedures, and standards applied to the execution of intellectual services, including the characterization of the Hermosa Beach Pier, were carried out by recognized and compliant procedures in the art.

It is imperative to note that the methods used in the characterization and assessment of the work, although aimed at minimizing unidentified risks and problems, cannot guarantee their absence. The analysis is based on the information on the pier received by Sensequake and the sensing tests. In case of missing information, reasonable assumptions were made.

Data, information, analytical processing, comments, views, and opinions presented in this report are intended exclusively for the Client in relation to the pier. To this end, Sensequake explicitly and exclusively recognizes its professional responsibilities towards its Client and accepts no responsibility regarding the relevance and validity of the report to third parties other than its Client. After these conditions and restrictions, Sensequake states that this report must be read in its entirety since sections taken out of context can be misleading and result in deductions and/or wrong conclusions.

The modal identification algorithms of 3D-SAM^{TM} are in accordance with state-of-the-art ambient vibration sensing technologies. Readers of the report should be aware of the limitations of this technique which can be found in existing literature (Brincker and Ventura 2015).

The evaluation of structural performance is based on the analysis of structural stiffness properties, including measured frequencies, mode shapes and damping ratios. These do not entirely guarantee that all damage or failure mechanisms will be identified. Sensequake removes itself from any direct or indirect damages that could be caused due to the limitations of this approach.

1 Overview of Sensequake Technology

1.1 Sensing and Ambient Vibration Tests

Comprehensive ambient vibration sensing tests were designed and performed on select bays of the Hermosa Beach Pier so that their dynamic characteristics (natural frequencies, mode shapes, and damping ratios) could be derived. [redacted]

The competence of ambient vibration testing to derive modal properties such as the natural frequencies, mode shapes and estimates of internal equivalent modal damping ratios has been demonstrated in many studies over the past decades. Sensequake's high-resolution wireless sensors are capable of measuring the minuscule ambient accelerations and velocities of structures (Figure 1-1).

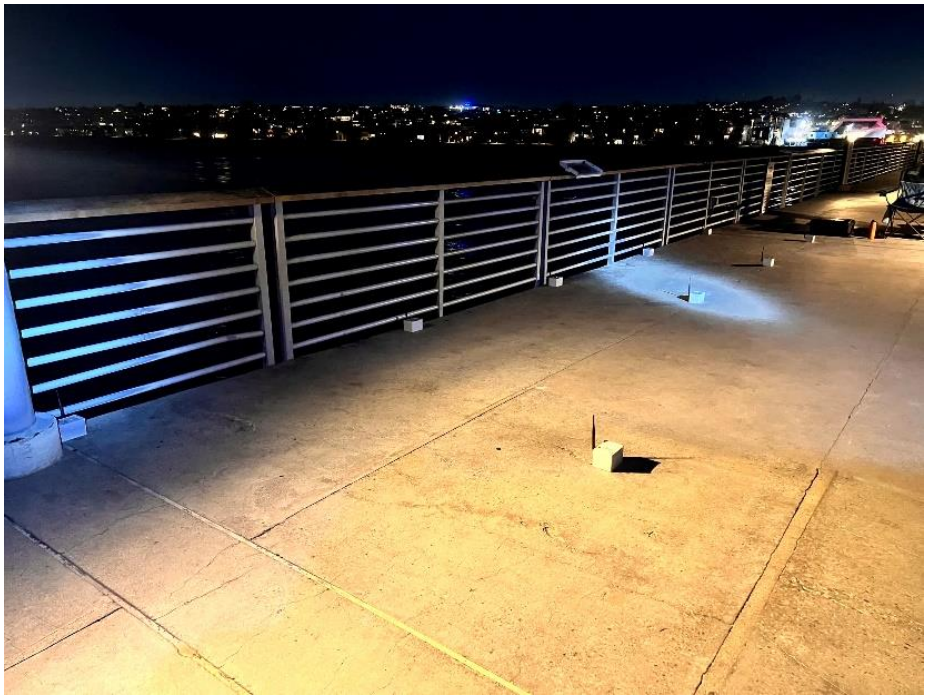


Figure 1-1: The wireless Sensequake Larzé sensors used for ambient vibration testing

Unlike forced vibration tests, the forces detected in the structure during ambient vibration tests are not controlled. The structure is assumed to be excited by wind, traffic, micro-tremors, and human activities. The measurements (velocities and accelerations) are recorded for several minutes during the regular operating conditions of the structure to ensure that all the modes of interest are sufficiently excited. In the modal identification of output-only systems, the input loads are unknown, and the modal identification has to be carried out solely based on the output responses.

Although the displacements detected in both ambient and forced vibration tests are very small, vibrator-induced motions may be several orders of magnitude greater than the ambient vibrations. It has been shown, however, that forced and ambient tests lead to a consistent agreement for modal parameters in structures. Today, ambient vibration tests are the most advanced, efficient, and reliable sensing method for capturing modal properties as well as understanding the behaviour and integrity of existing structures (Trifunac 1972; Lamarche et al. 2008; Hans et al. 2005).

[redacted]

1.2 Sensequake's 3D-SAM™ Technology

[redacted]

[redacted]



[redacted]

[redacted]



[redacted]

2 Sensing Test

2.1 Sensing Test Summary

Comprehensive ambient vibration sensing tests are designed and performed on the structure to derive its main characteristics (natural frequencies, mode shapes, and damping ratios). [redacted]

For the current test, 10 Sensequake Larzé wireless sensors were used to measure the horizontal and vertical vibrations in the pier. In addition to high-quality data collected by the sensors, one of the main features of the Larzé system is the automated synchronization achieved through a wireless mesh network. The sensors need to be within the reach of the radios for a few seconds for synchronization and then moved to their designated locations (Figure 2-1 (a)). The sensors maintain synchronization for more than 12 hours.



Figure 2-1: (a) Sensequake Larzé sensor; (b) Sensequake Larzé sensor and control application

[redacted]

The following are the specifications of the Sensequake Larzé sensors.

[redacted]

The sampling frequencies can be selected based on the type of structure. The sensor's analog-to-digital converters operate at much higher sampling rates and further decimate the data to achieve higher signal-to-noise ratios. [redacted]

3 Ambient Vibration Testing – An Overview

Modal identification of structures by evaluating their ambient vibration response through mathematical procedures has been performed since the early 1930s with major advances in Operation Modal Analysis (OMA) techniques occurring in the early 1990s. The process of OMA (Figure 3-1) involves utilizing time and frequency domain analysis techniques to isolate the response of the structure in terms of its dynamic characteristics (frequencies and mode shapes) from the measured response due to the "ambient" of excitation such as traffic, wind, etc.

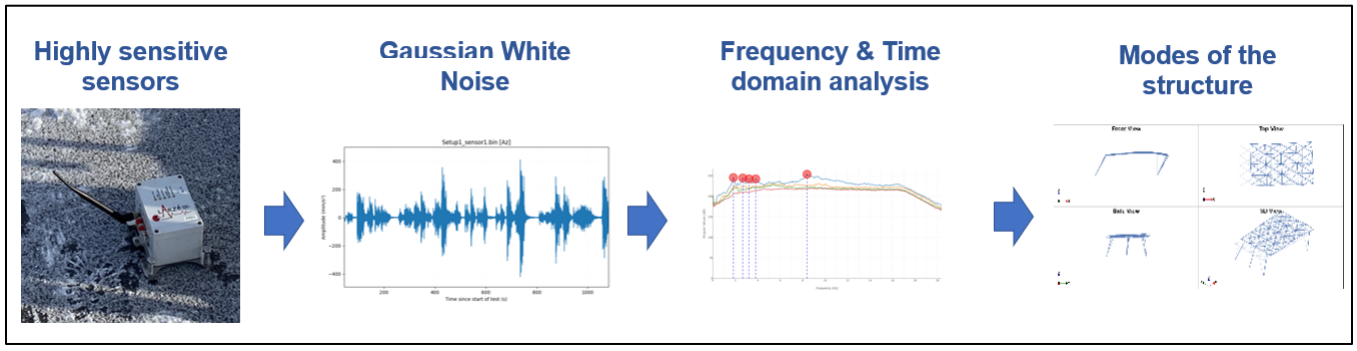


Figure 3-1: Operational Modal Analysis (OMA) process

Among the available mathematical methods (Figure 3-2) to process the measured response of a structure to ambient excitation is Frequency Domain Decomposition (commonly referred to as FDD). This is comparatively faster as it involves frequency domain analysis (peak-picking method). Time domain analysis techniques such as Enhanced Frequency Domain Decomposition (EFDD) and Stochastic Subspace Identification (SSI) are more robust as they involve performing parametric analysis of the measured responses of the structure.

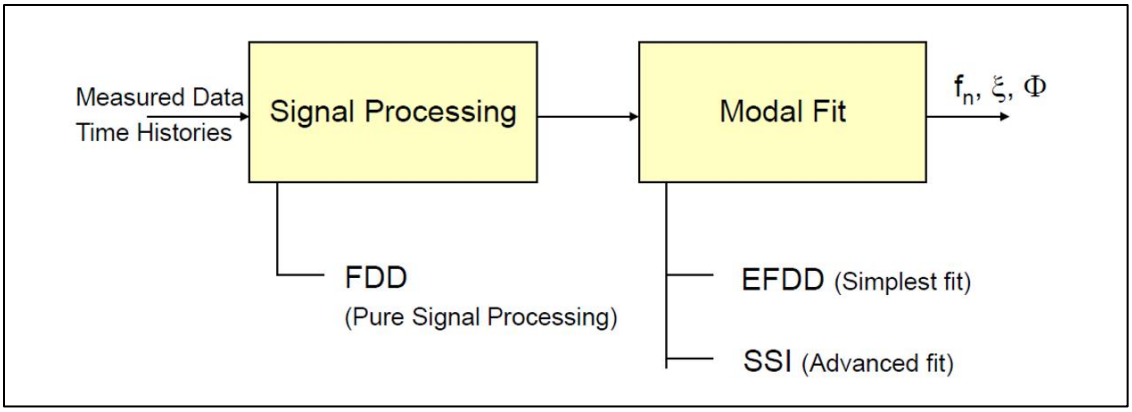


Figure 3-2: Mathematical analysis techniques for OMA.

The overview of FDD of the measured responses of the system by generating the Power Spectral Density (PSD) matrix utilizing their Fourier transformation is shown in Figure 3-3.

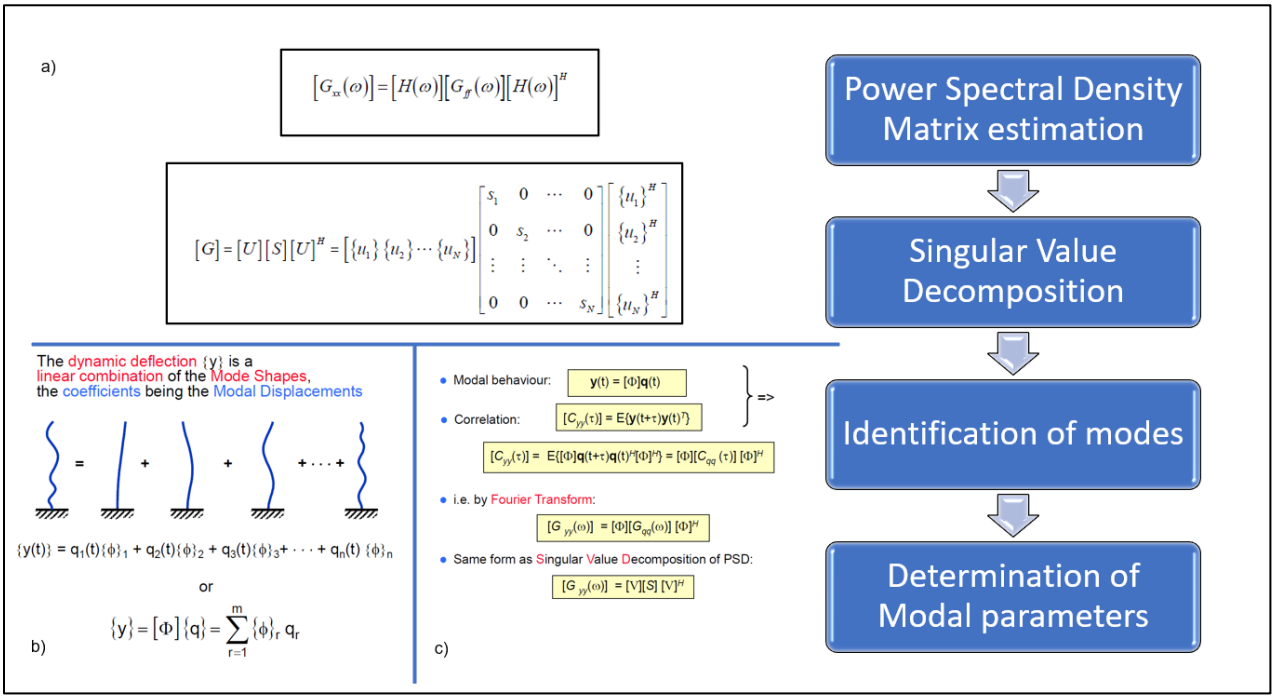


Figure 3-3: Brief overview of Frequency Domain Decomposition; a) Power Spectral Density matrix formulation followed by its Singular Value Decomposition; b) Definition of modal behavior of structure in terms of its frequency, mode shape and damping; c) Correlation of the modal response with the Singular Value Decomposition

The frequency-domain decomposition (FDD) technique is based on the singular value decomposition (SVD) of the power spectral density (PSD) matrix shown in Figure 3-3 (a). It then correlates the expected output (the measured response of the system in terms of its normal modes and modal coordinates) Figure 3-3 (b), with the singular values and their corresponding single vectors.

Sensequake utilizes SSI to determine the dynamic characteristics of a structure which is explained in detail in this section.

One of the data files from the test of the Hermosa Beach Pier and its results are used in this section as an example to better clarify the identification process. The raw output of the reference sensor (sensor 1) in the Z-direction is plotted as a function of time (Figure 3-4). The challenge is to extract the dynamic information of the structure (i.e., its modal properties) from these kinds of recordings.

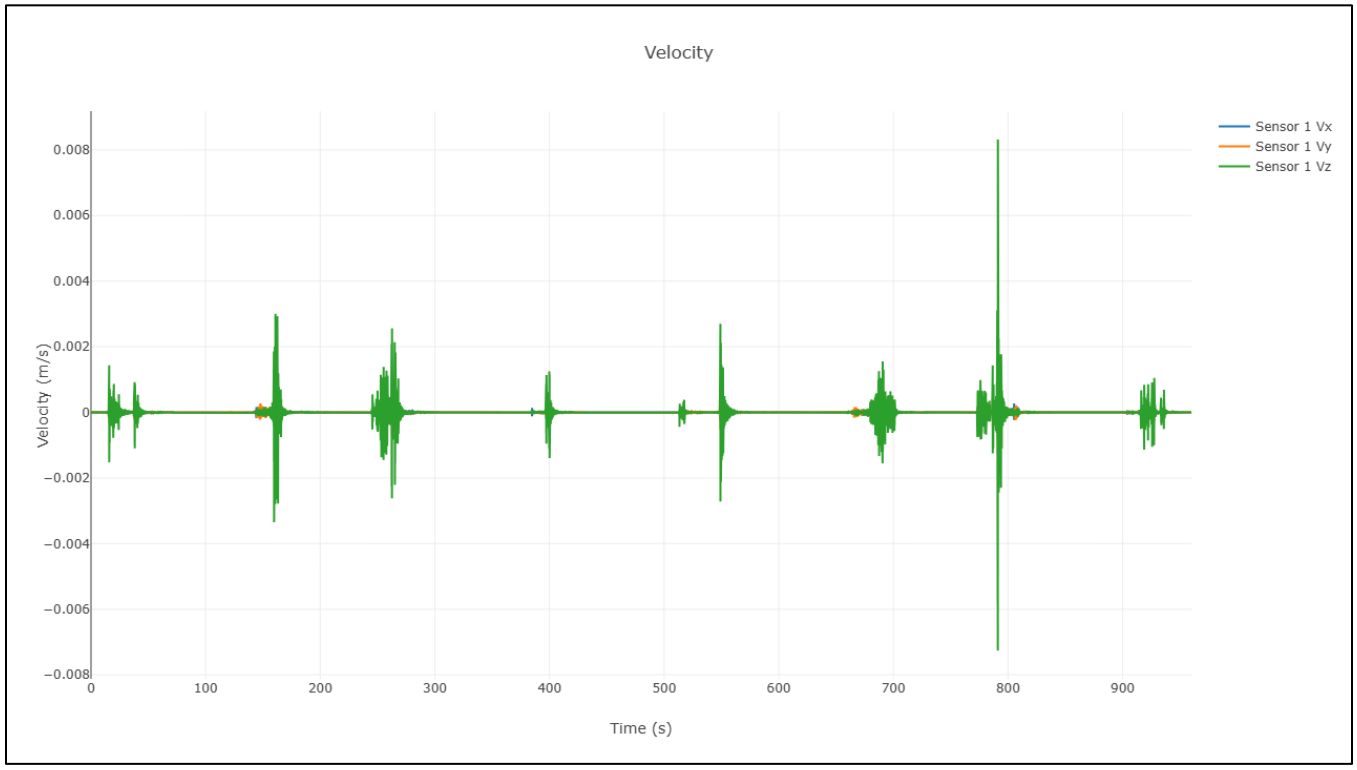


Figure 3-4: Raw output of Sensor #1, Hermosa Beach Pier

The spectrogram of the same signal is shown in Figure 3-5, representing the frequency content of the signal as a function of time. The figure shows some strong horizontal lines around certain specific values; for example, between 10.0 to 12.0 Hz. These values are therefore present throughout the entirety of the recording and are related to the natural frequencies found through the test.

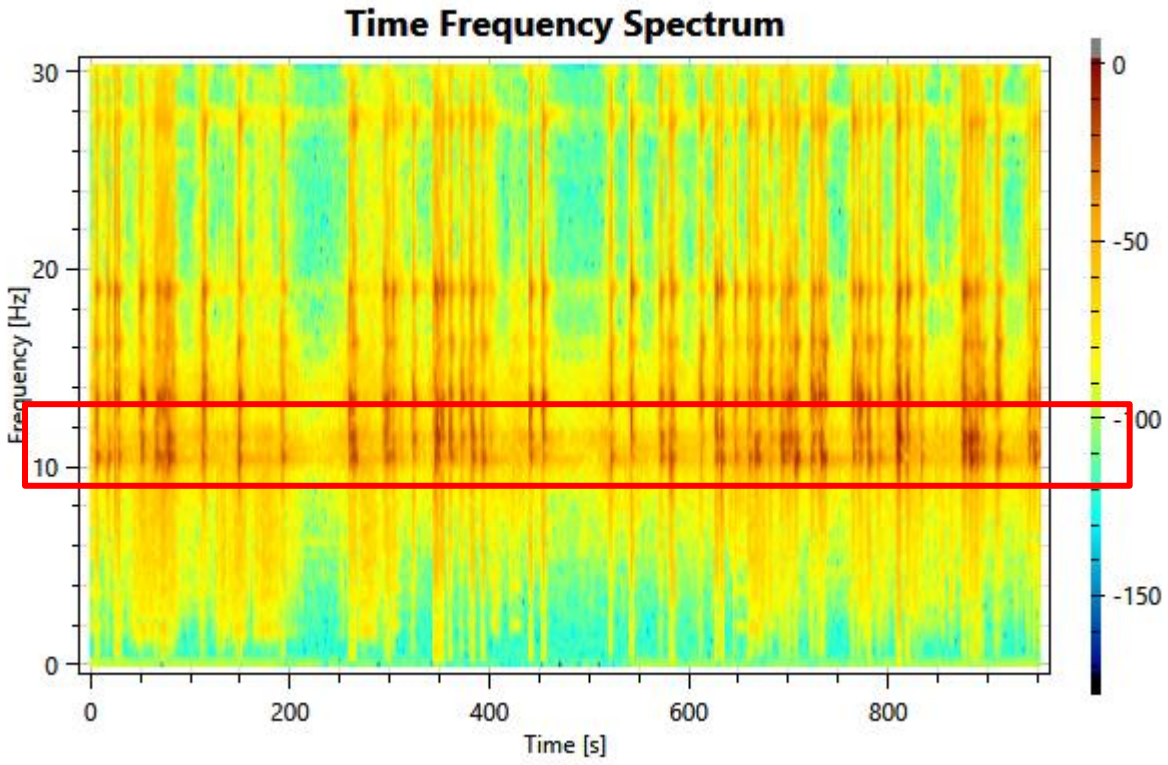


Figure 3-5: Spectrogram of measured velocity of Sensor #1, Hermosa Beach Pier

Figure 3-6 shows the power spectral density of the same signal, and also shows clear peaks around the same values, corresponding to the first vertical modal frequency of the structure.

Even though ambient vibrations due to loading such as wind and micro tremors are of low amplitude, the modal properties of the pier are embedded in the signals. These modal properties can be extracted using advanced mathematical algorithms. Appropriate pre-processing such as applying bandpass filters and decimation of the signals is required for extraction.

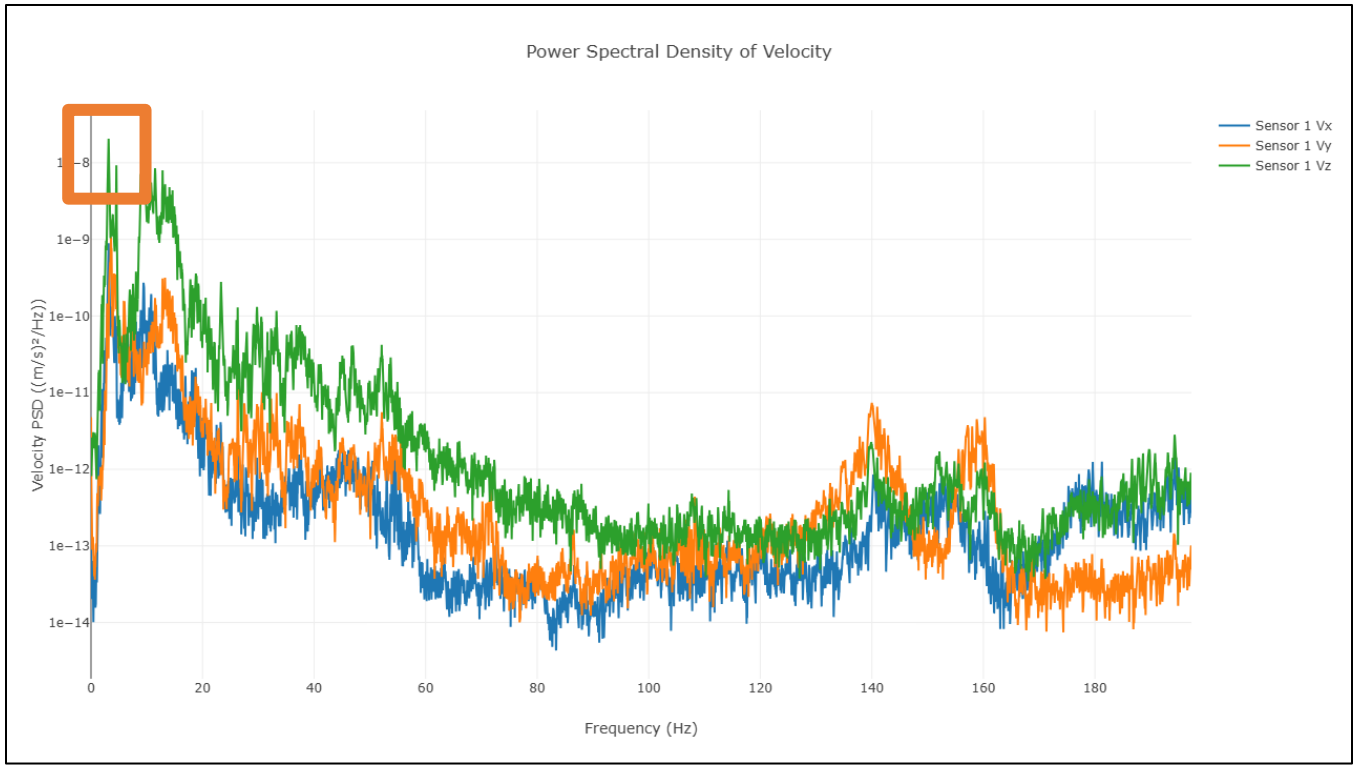


Figure 3-6: Power spectral density of Sensor #1, Hermosa Beach Pier

An important step in deriving the modal properties is calculating the singular values of all signals of each setup. The natural frequencies can be read on the singular value decomposition (SVD) of the matrices of spectral density $\boldsymbol{G}_{xy}$ defined by (Brincker and Ventura 2015):

$$G_{xy}(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{xy}(\tau)e^{-i\omega t}\,d\tau \quad (1)$$

This is also the Fourier transform of cross-correlation matrices and is defined for measurement signals *x* and *y* by:

$$R_{xy}(\tau) = E[y(t)x^{T}(t+\tau)] \quad (2)$$

The underlying principle is that every structure (imperceptibly) oscillates according to its eigenmodes under the loading of ambient vibrations and these oscillations appear as peaks in the cross-correlations.

The Stochastic Subspace Identification (SSI) algorithm is used to identify natural frequencies, damping ratios, and mode shapes. Since the range of frequencies is known, a bandpass filter is applied and the signals have been decimated to increase the signal-to-noise ratio and reduce the computation time of the algorithm. SSI algorithms, initially introduced in Van Overschee and De Moor (1996), provide the modal properties which optimally match the measurements, for a chosen number of oscillators, ***N***.

The measured time series $y_1, y_2, \ldots, y_n$, are gathered in a vector ***Y*** and the following matrix is computed:

$$H = \begin{bmatrix} Y(1) & \cdots & Y(q+1) \\ Y(2) & \cdots & Y(q+2) \\ \vdots & \ddots & \vdots \\ Y(2s) & \cdots & Y(2s+q) \end{bmatrix} \quad (3)$$

Where ***Y****(k)* corresponds to the kth measurement point and *s* and *q* are parameters chosen by the user. This matrix has the structure of a Hankel matrix, reducing computation costs. The principle of the method is to split the first *s* rows of ***H***, denoted by $\boldsymbol{H_1}$ and assumed to be given, and use it the predict the *s* last rows of $\boldsymbol{H_2}$, assumed to be stochastic. Modal properties are then deduced from the fact that $\boldsymbol{H_2}$ is known from the measurements. Concretely, the observation matrix ***O*** is defined and computed using:

$$O = H_2 {H_1}^T (H_1 {H_1}^T)^+ H_1 \quad (4)$$

Where the superscript + stands for the Moore-Penrose pseudo-inverse. The singular value decomposition of ***O*** is performed:

$$O = USV^T \quad (5)$$

from which the following matrix is computed:

$$A = U_N S_N^{1/2} \tag{6}$$

The index ***N*** stands for the truncation order, or modal order, corresponding to the number of oscillators considered for the estimation of the dynamic properties. The eigenvalues and eigenvectors of ***A*** are used to estimate the modal properties.

The actual structural properties can be identified by investigating their sensitivity to ***N***: they are the ones, which remain stable, and independent of ***N***. The other ones are artifacts, mostly related to measurement noise.

After calculation of system matrix $\boldsymbol{A}_d$ and found observation matrix ***C***, the modal properties can be extracted.

The first step is to perform an eigenvalue decomposition of the system matrix $\boldsymbol{A}_d$ as follows:

$$\hat{A}_d = \Psi[\mu_i]\Psi^{-1} \tag{7}$$

The continuous time poles are found from the discrete-time poles μ_i by the following:

$$\mu_i = \exp(\lambda_i) \tag{8}$$

Leading to the well-known formulas:

$$\lambda_i = \frac{\ln(\mu_i)}{\Delta T}$$
$$\omega_i = |\lambda_i|$$
$$f_i = \frac{\omega_i}{2\pi}$$
$$\varsigma_i = \frac{Re(\lambda_i)}{|\lambda_i|} \tag{9}$$

The mode shape matrix can be found from the following formula:

$$\Phi = C\Psi \tag{10}$$

4 Structural Health Monitoring

4.1 Structural Identification

Two phases of testing were completed on different bays of the Hermosa Beach Pier (Figure 4-1). A total of 10 bays were selected between the phases in consultation with the project stakeholders. These bays were chosen due to their elevated visual deterioration, cracking, and spalling noted in inspection reports and confirmed through preliminary structural screening. Additionally, these bays accounted for the panels that were targeted for future repairs/replacement due to their condition.

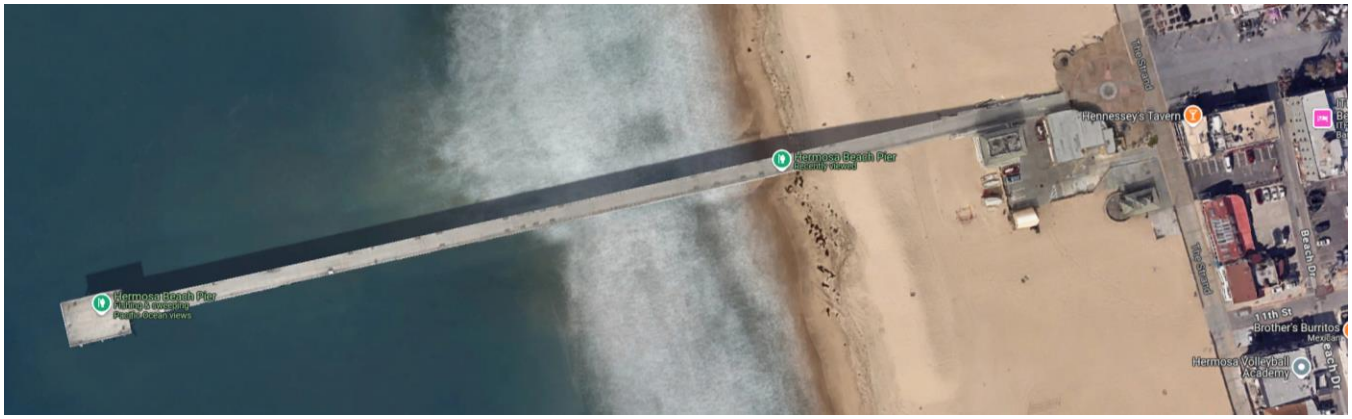


Figure 4-1: Hermosa Beach Pier (Google Maps)

The Hermosa Beach Pier has 36 Bents. The panels, bays and bents are named as illustrated in Figure 4-2 from East to West. This naming scheme is consistently followed throughout the report. The ten bays selected for testing include Bays 10–11, 12–13, 13–14, 15–16, 18–19, 21–22, 27–28, 30–31, 32–33, and 35–36. These bays were prioritized based on visual inspection results, which highlighted advanced deterioration such as surface cracking, spalling, and suspected internal degradation.

Ambient vibration tests were employed to identify modal properties (natural frequencies, damping ratios, mode shapes) across the selected bays. The testing layout and methodology were adapted to the specific geometry and structural configurations of the bays.

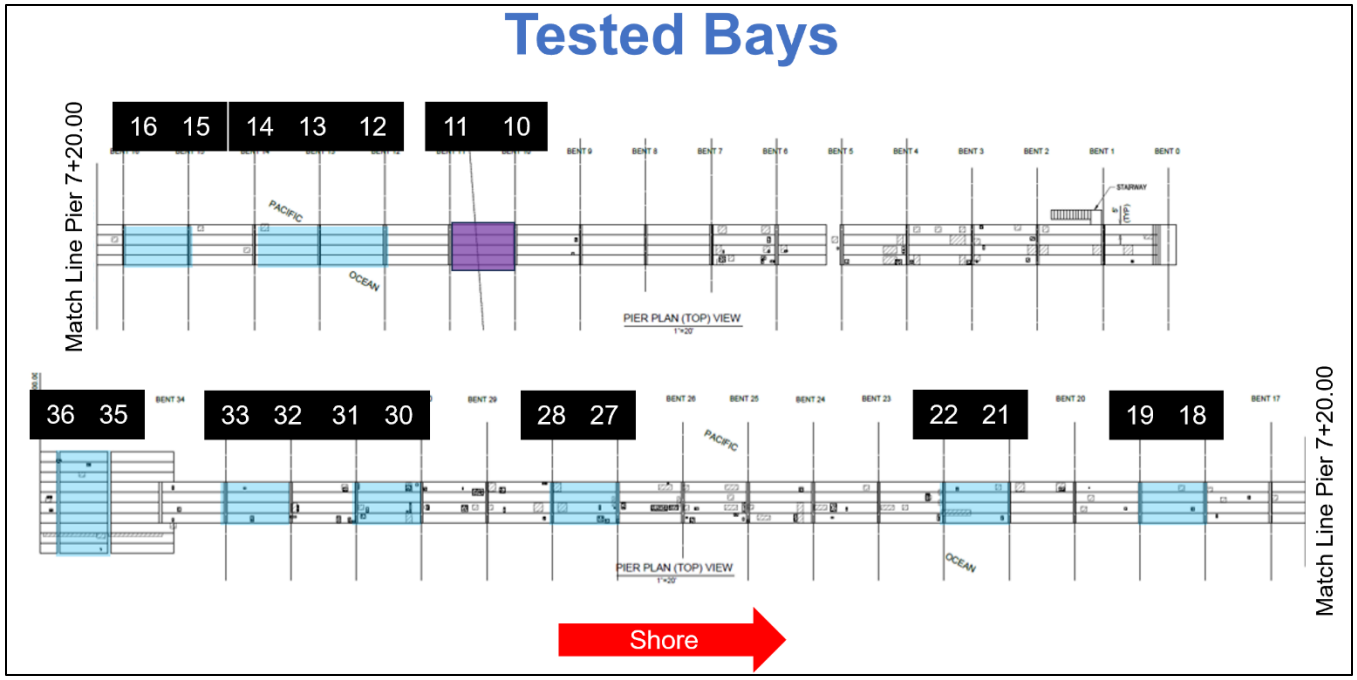


Figure 4-2 Structural numbering of the Hermosa Beach Pier

Nine of the tested bays (specifically Bays 10–11 through 32–33) share the same superstructure design. Each consists of four prestressed concrete panels interconnected by shear keys and supported by two bents. These spans measure approximately 30.5 feet in length and 20 feet in width. This structural configuration has been consistent across a significant portion of the Hermosa Beach Pier and provided a basis for comparative analysis of modal characteristics observed across the tests.

Bay 35–36 differs from the others in that it comprises ten panels rather than four. This variation in panel count results in a wider span, which may influence both the stiffness distribution and modal behavior. Consequently, special attention was given to Bay 35–36 during both test design and analysis. In all cases, the tests were conducted using the same methodology, ensuring consistency in baseline extraction. Sensor placement was carefully designed to capture the dynamic response of each bay, with attention to coverage across all panels and shear keys, especially in regions where visual inspections had noted signs of distress.

4.2 Description of the Test

The testing of the Pier was done in two phases: the first was completed on November 17, 2024, at an average temperature of 64ºF. Phase 2 was conducted over four consecutive days in mid-March, 2025, under average on-site temperature conditions of approximately 53°F. The site work was conducted by Sensequake's local partner, JMC[2].

For Bays 10–11 through 32–33, each was instrumented using ten Sensequake Larzé wireless sensors per setup using the same layout. In contrast, Bay 35–36 required a modified approach due to its expanded geometry and the presence of ten concrete panels. To accommodate this, a revised sensor configuration was implemented. The placement ensured coverage across all panels.

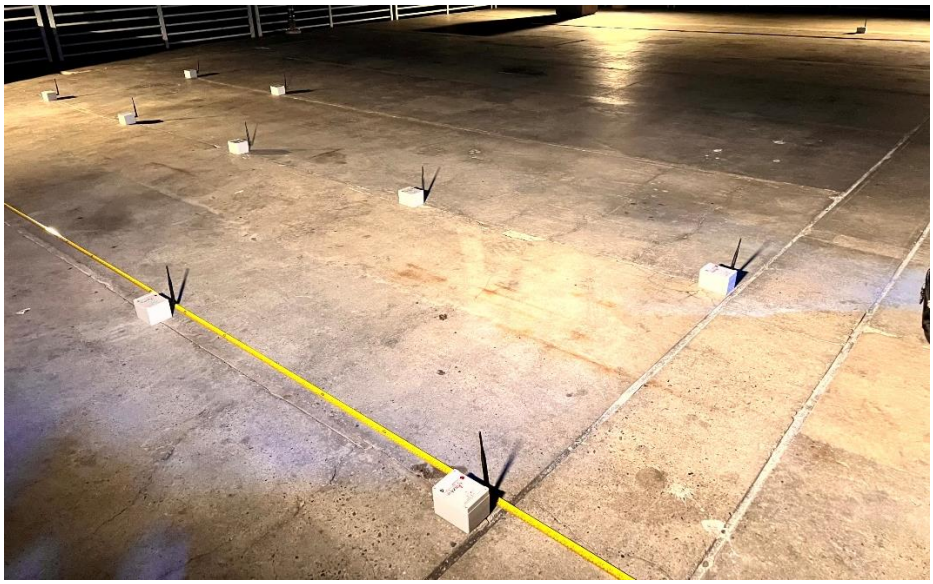


Figure 4-3: Testing of the Hermosa Beach Pier

To extract the baseline properties of the structure, 424 locations were selected to deploy sensors and collect ambient vibration data with 6 channels per sensor location resulting in 2544 vibration sensor channels. The test involved 10 Larzé Sensors over 53 setups. [redacted] The sensors were placed on the pier panels with selected locations. Data was collected for 10 minutes in each setup under operational conditions.

The sensor layout is designed considering the geometry, structural configuration, and current condition of the structure (see Appendix A for the detailed sensor layouts). The structure's dimensions, including Bay length, were measured during testing and verified against the original drawings. This data was also used to prepare 3D models of each pier bay (Figure 4-4). Sensor data is applied to the model, as shown by the red triaxial icons in the Figure.

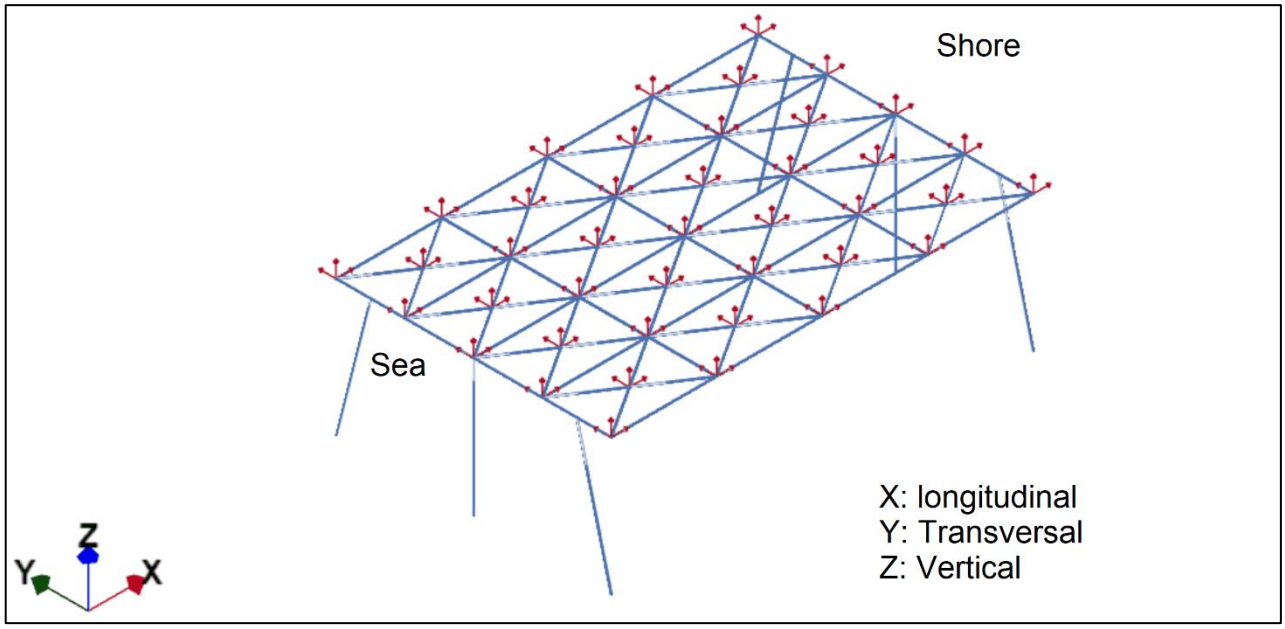


Figure 4-4: 3D Model of the Hermosa Beach Pier with sensor locations

The axis orientation for the 3D model is the same as the sensor axes on site. It should be noted that the 3D model is a simplified geometrical model to better visualize the mode shapes. The model is simplified and does not include detailed structural information, such as connections, dimensions, and material properties. Movement at the locations without sensors is assumed for better visualizations. However, all conclusions on structural integrity are based solely on the data measured by the sensors.

4.3 Dynamic Property Results (Stiffness Baselines)

Both time and frequency domain techniques were used to derive the modal properties of the sections of the Pier. The average singular values for the spans are shown in the figures in the following sub-sections. Singular Value Decomposition (SVD), employed for frequency-domain analysis, identifies peaks representing potential structural modes. These peaks correspond to the vertical lines from the stochastic subspace identification (SSI) shown in the figures, a time-domain method. It is important to note that not all peaks represent structural modes.

The associated frequencies, periods and damping ratios are summarized in the tables in each section. Finally, the mode shapes are detailed for each identified mode of the sections. The digital copies of the animations for each mode shape have been provided for better visualization.

4.3.1 Results of the Test - Bay 10-11

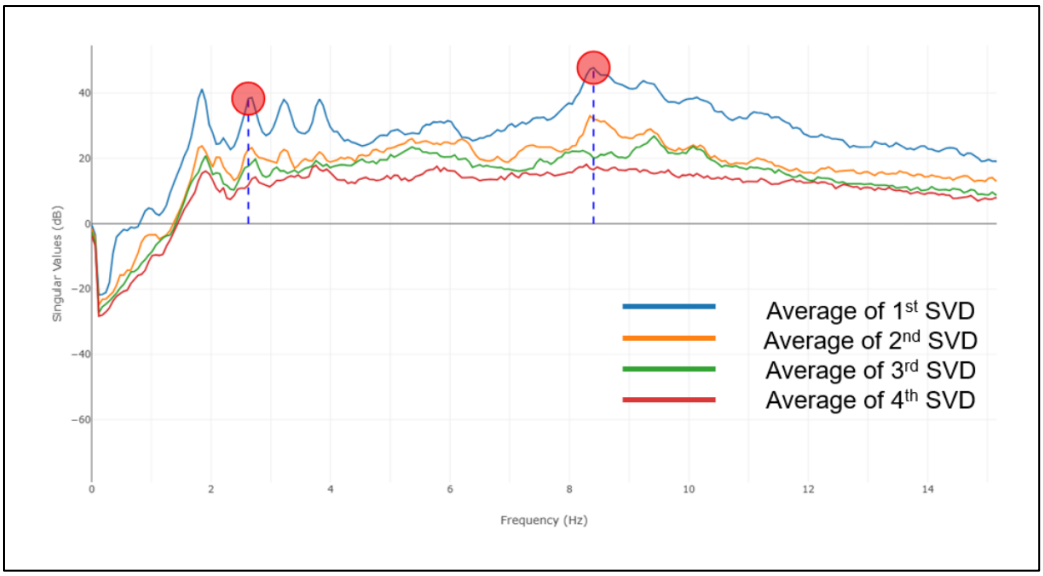


Figure 4-5: Singular value decomposition of the cross-spectral correlation, Bay 10-11, Hermosa Beach Pier

Table 4-1: Modal Properties for Bay 10-11, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	2.64	0.38	1.4
2 – 1st Vertical	8.47	0.12	2.0

Table 4-2: Mode 1, Bay 10-11, Hermosa Beach Pier

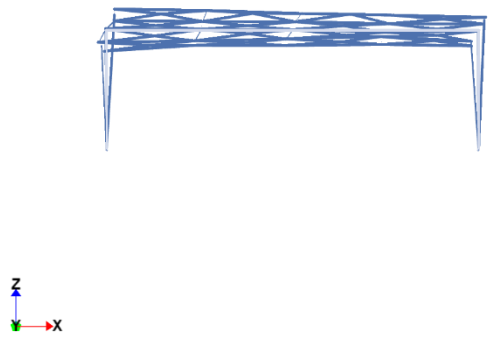
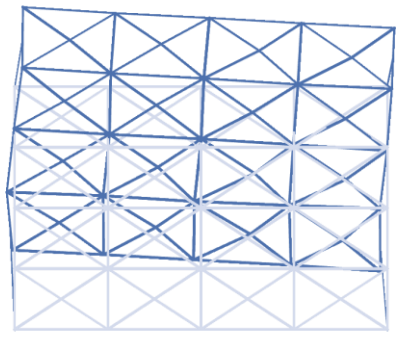
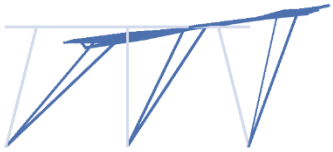
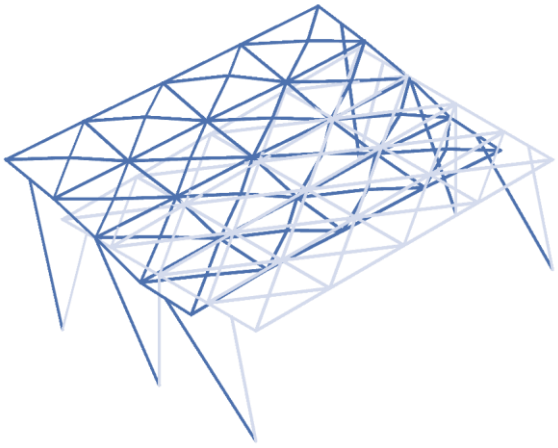
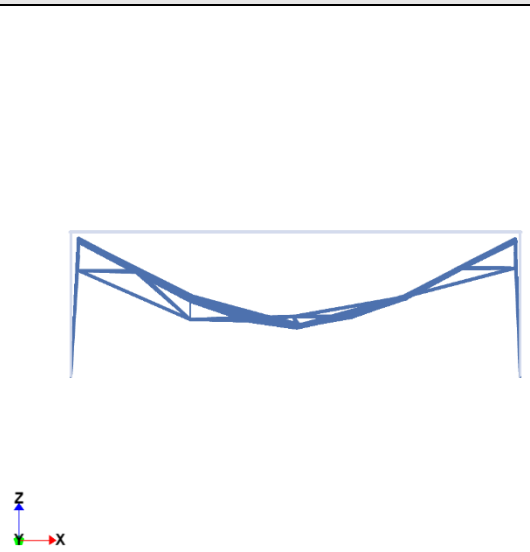
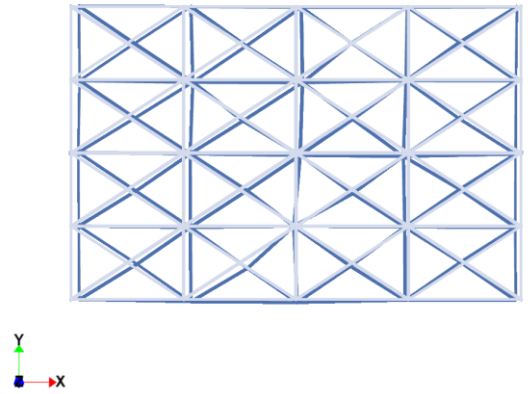
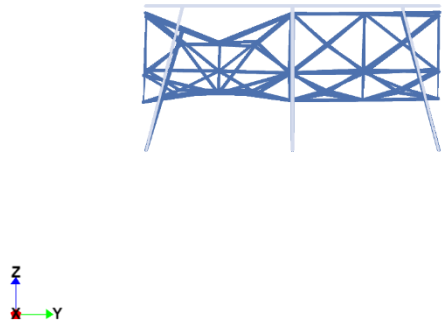
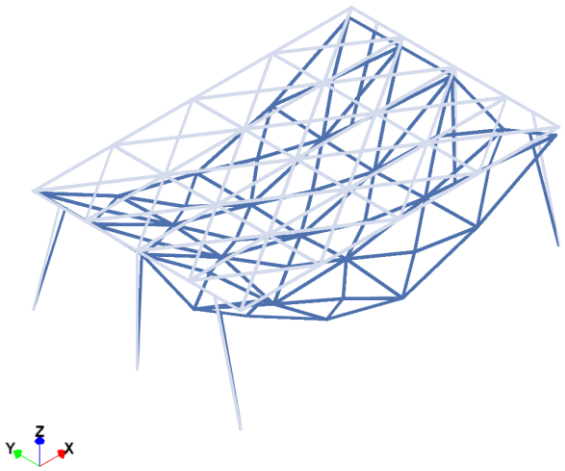
Bay 10–11			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	2.64	0.38	1.4
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-3: Mode 2, Bay 10-11, Hermosa Beach Pier

Bay 10–11			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.47	0.12	2.0
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.2 Results of the Test - Bay 12-13

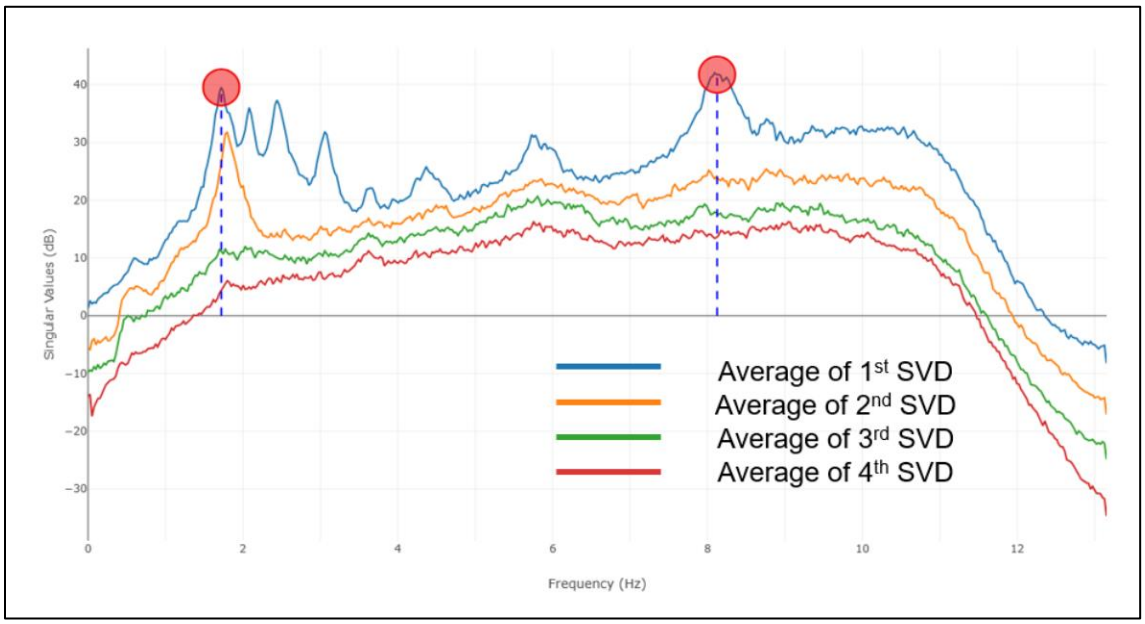


Figure 4-6: Singular value decomposition of the cross-spectral correlation, Bay 12-13, Hermosa Beach Pier

Table 4-4: Modal Properties for Bay 12-13, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.72	0.58	2.0
2 – 1st Vertical	8.13	0.12	1.7

Table 4-5: Mode 1, Bay 12-13, Hermosa Beach Pier

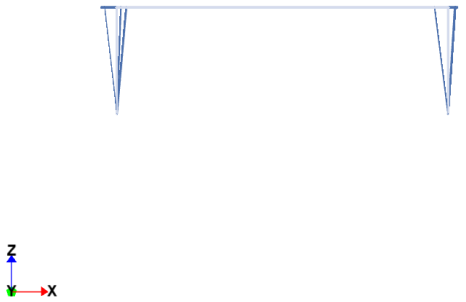
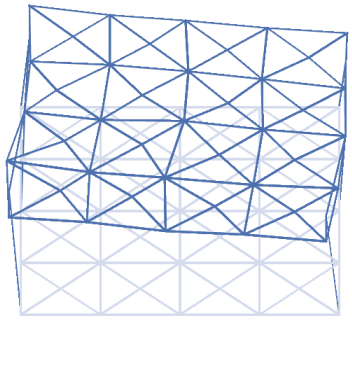
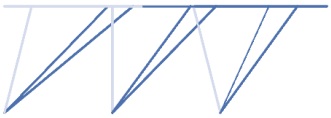
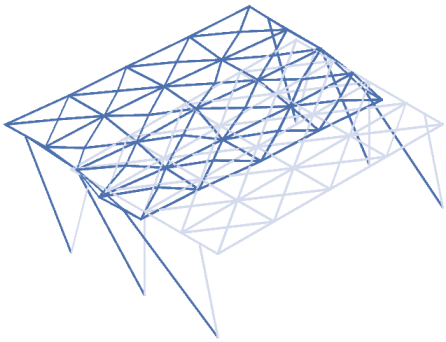
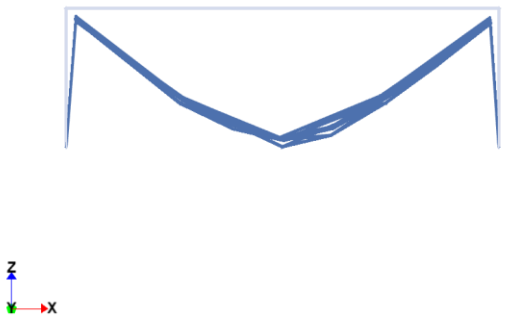
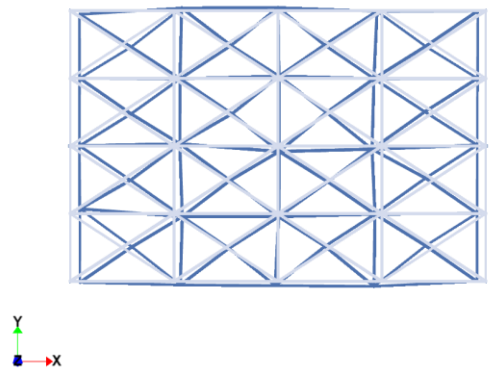
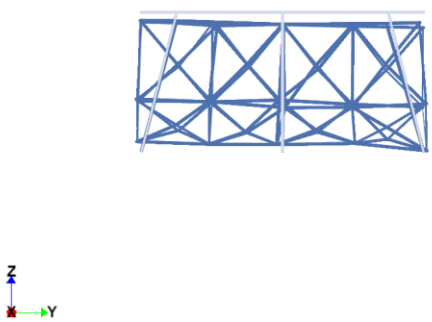
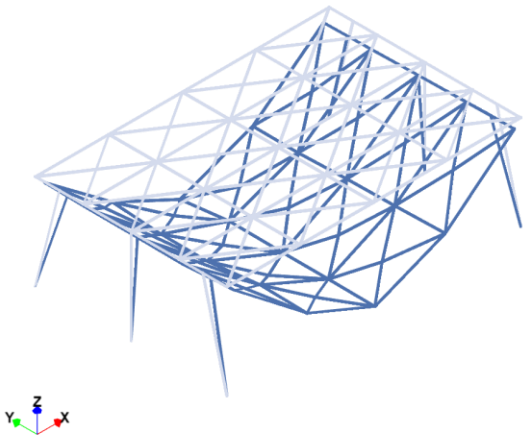
Bay 12-13			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.72	0.58	2.0
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-6: Mode 2, Bay 12-13, Hermosa Beach Pier

Bay 12-13			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.13	0.12	1.7
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.3 Results of the Test - Bay 13-14

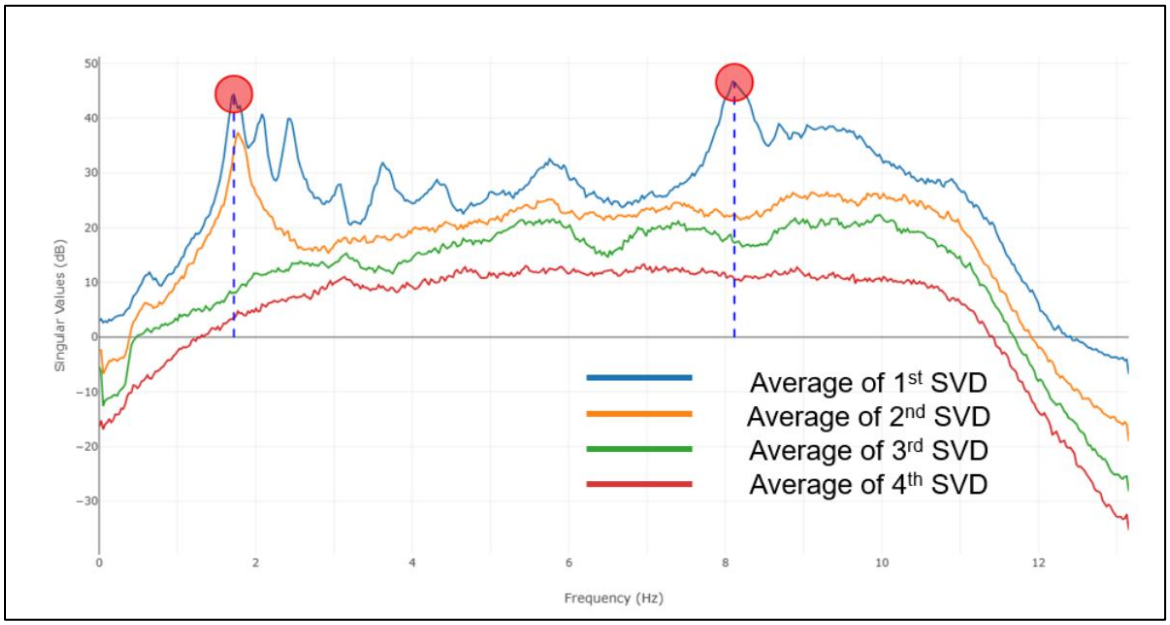


Figure 4-7: Singular value decomposition of the cross-spectral correlation, Bay 13-14, Hermosa Beach Pier

Table 4-7: Modal Properties for Bay 13-14, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.70	0.59	2.0
2 – 1st Vertical	8.11	0.12	1.3

Table 4-8: Mode 1, Bay 13-14, Hermosa Beach Pier

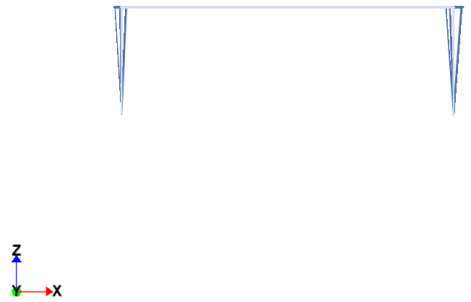
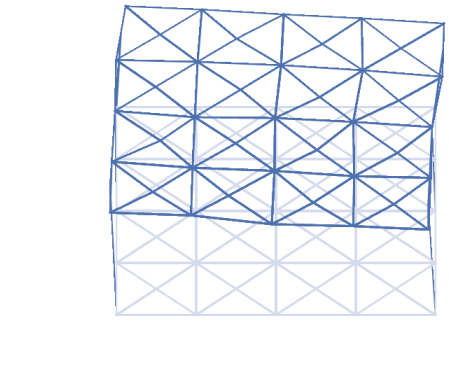
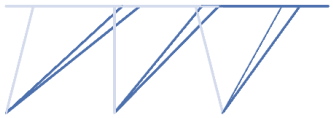
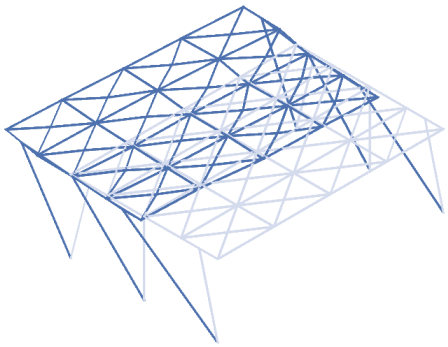
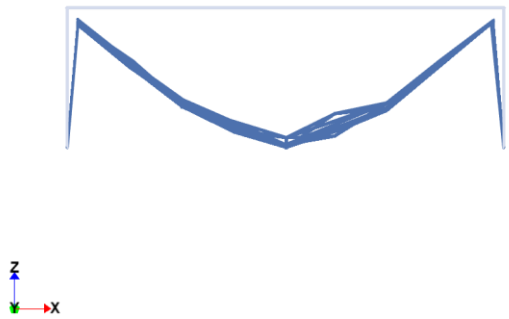
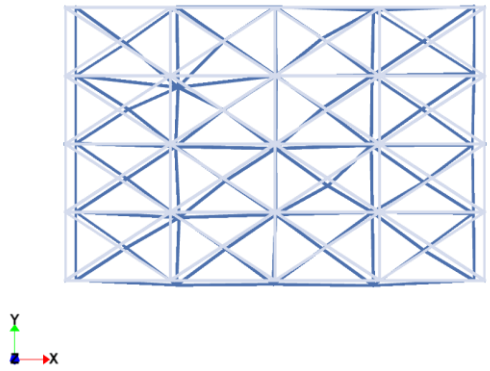
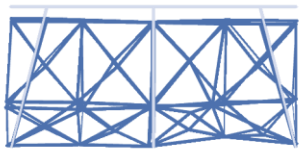
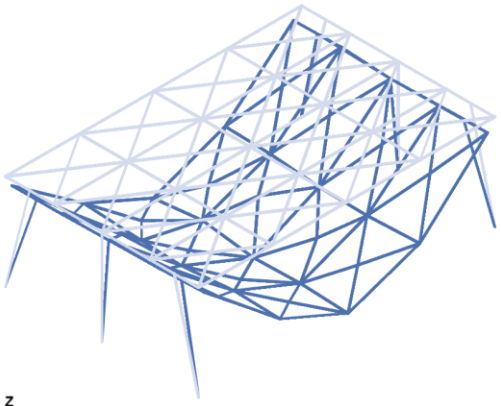
Bay 13-14			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.70	0.59	2.0
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-9: Mode 2, Bay 13-14, Hermosa Beach Pier

Bay 13-14			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.11	0.12	1.3
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.4 Results of the Test - Bay 15-16

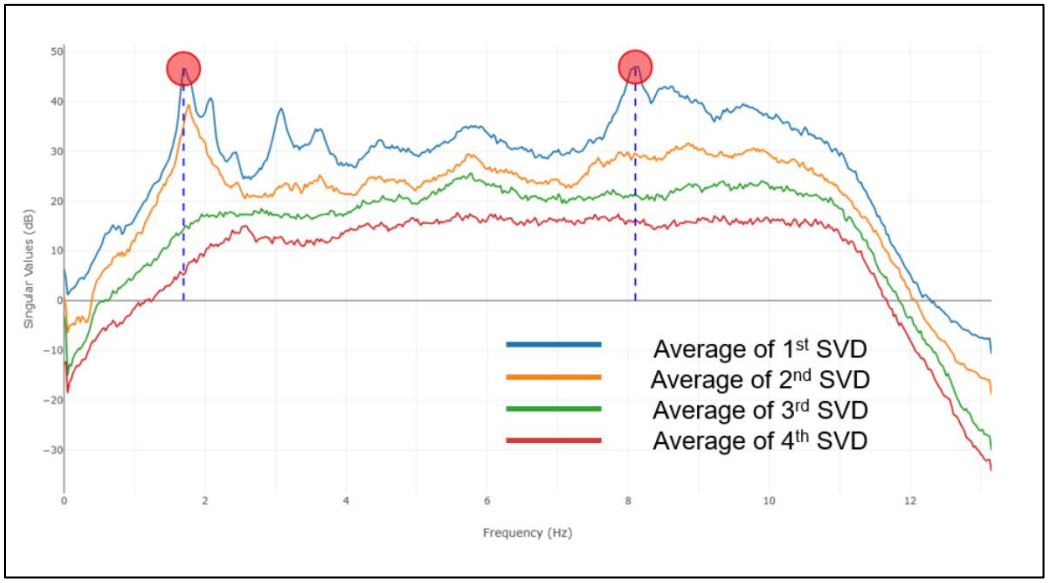


Figure 4-8: Singular value decomposition of the cross-spectral correlation, Bay 15-16, Hermosa Beach Pier

Table 4-10: Modal Properties for Bay 15-16, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.70	0.59	1.9
2 – 1st Vertical	8.04	0.12	1.5

Table 4-11: Mode 1, Bay 15-16, Hermosa Beach Pier

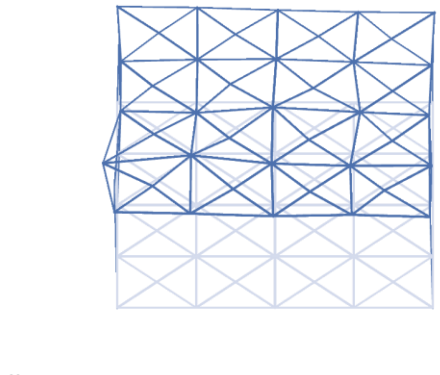
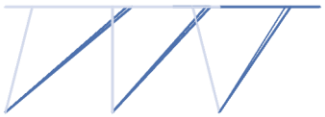
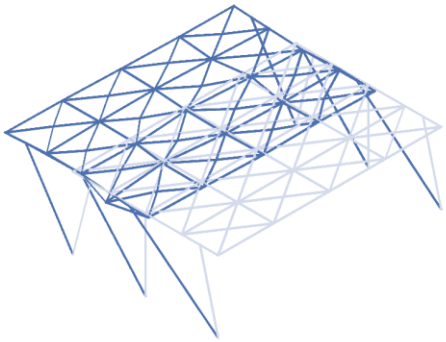
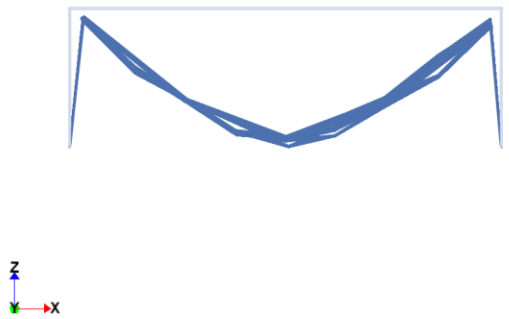
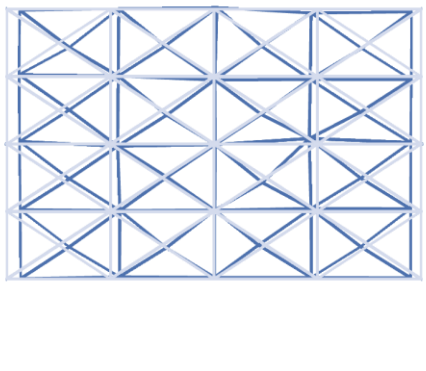
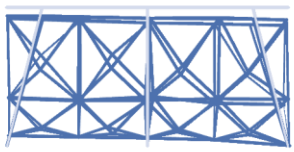
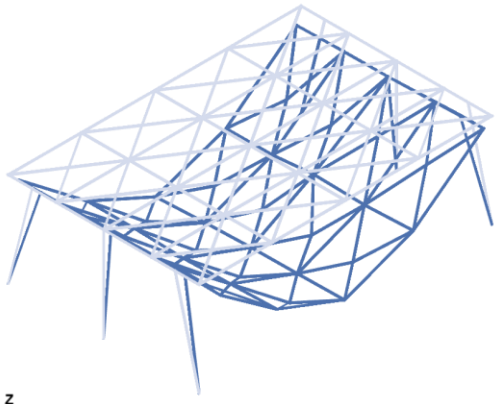
Bay 15-16			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.70	0.59	1.9
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-12: Mode 2, Bay 15-16, Hermosa Beach Pier

Bay 15-16			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.04	0.12	1.5
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.5 Results of the Test - Bay 18-19

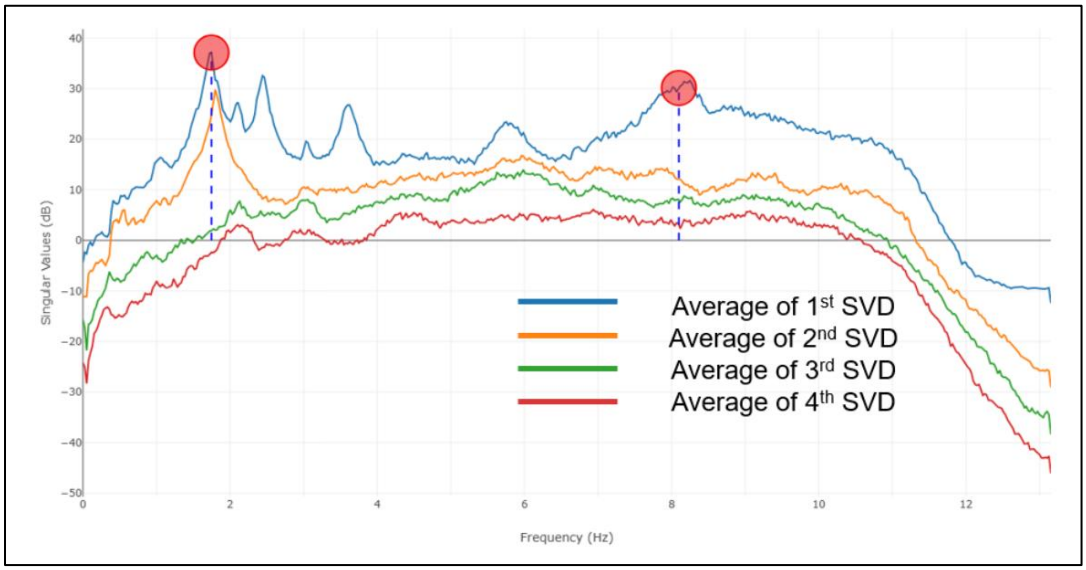


Figure 4-9: Singular value decomposition of the cross-spectral correlation, Bay 18-19, Hermosa Beach Pier

Table 4-13: Modal Properties for Bay 18-19, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.72	0.58	2.4
2 – 1st Vertical	8.06	0.12	3.4

Table 4-14: Mode 1, Bay 18-19, Hermosa Beach Pier

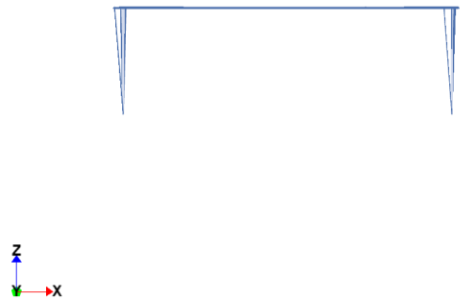
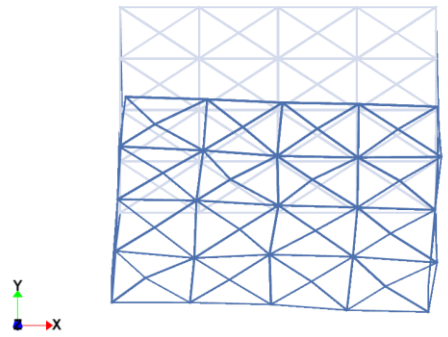
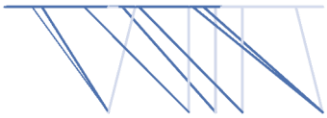
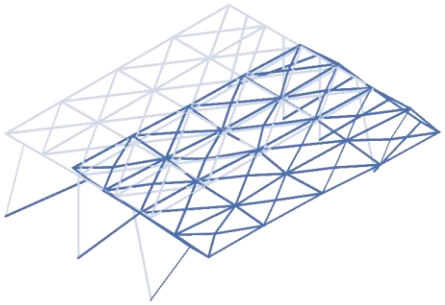
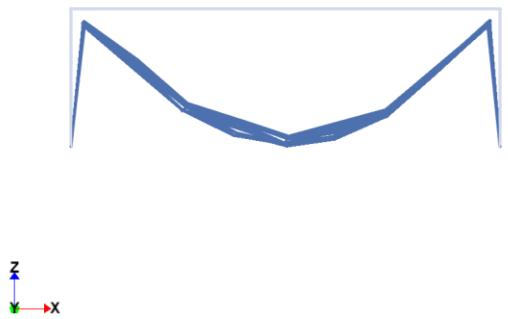
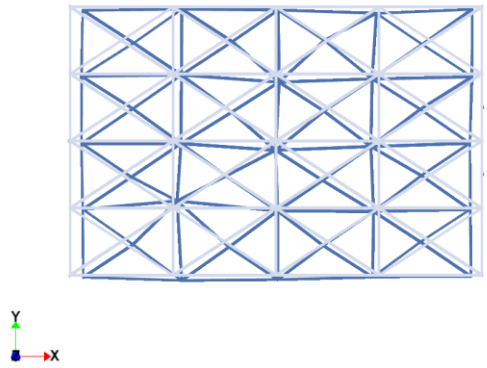
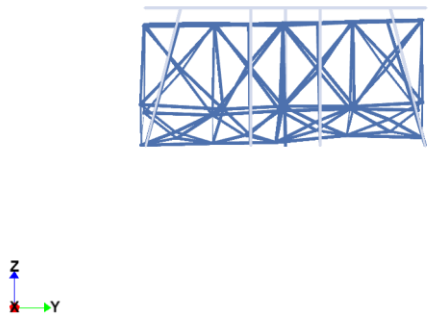
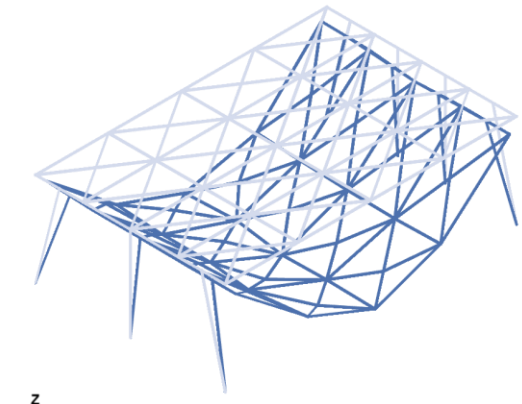
Bay 18-19			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.72	0.58	2.4
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-15: Mode 2, Bay 18-19, Hermosa Beach Pier

Bay 18-19			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.06	0.12	3.4
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.6 Results of the Test - Bay 21-22

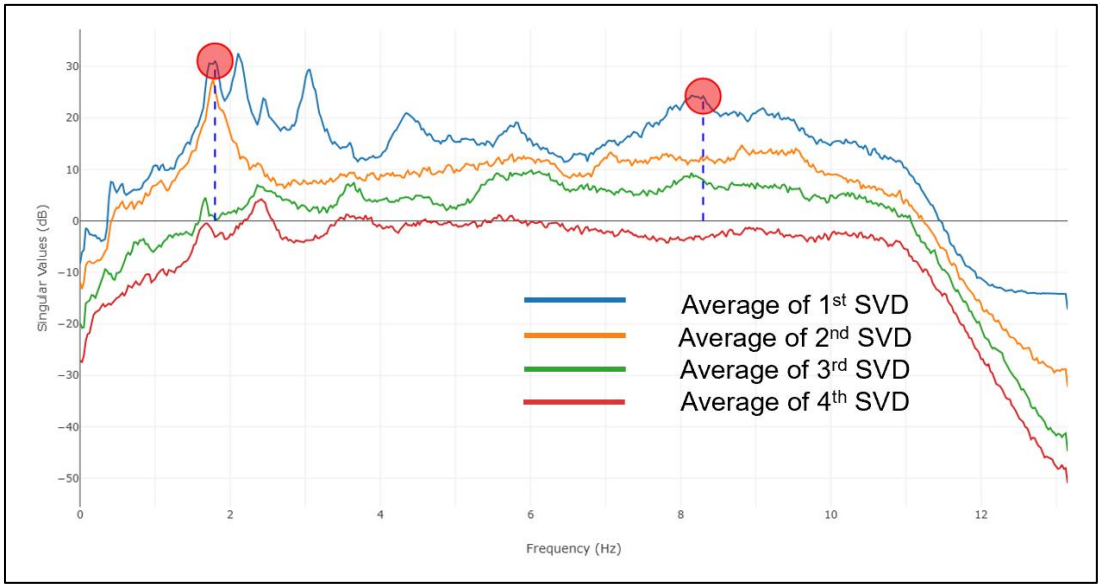


Figure 4-10: Singular value decomposition of the cross-spectral correlation, Bay 21-22, Hermosa Beach Pier

Table 4-16: Modal Properties for Bay 21-22, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.83	0.55	6.4
2 – 1st Vertical	8.24	0.12	4.7

Table 4-17: Mode 1, Bay 21-22, Hermosa Beach Pier

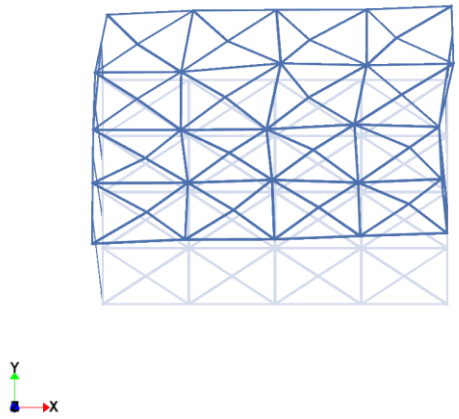
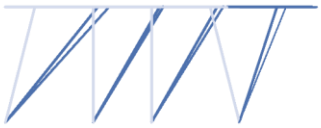
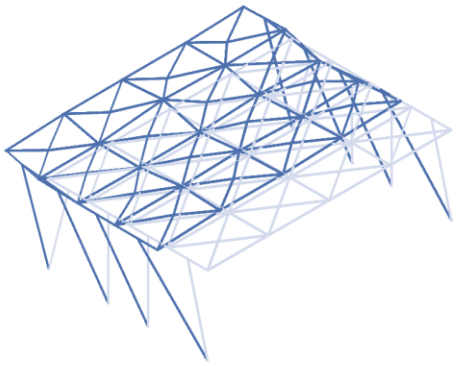
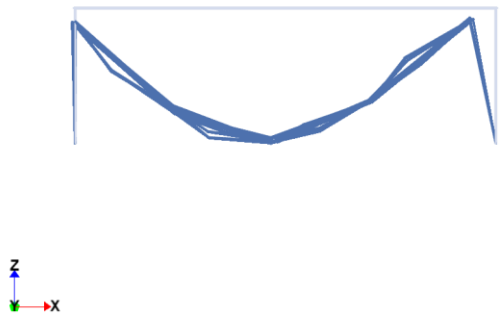
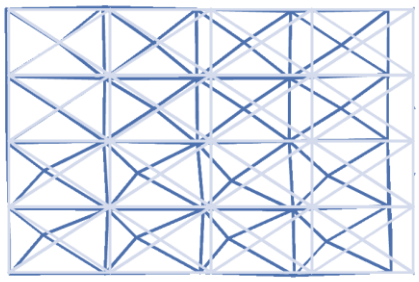
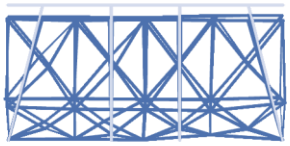
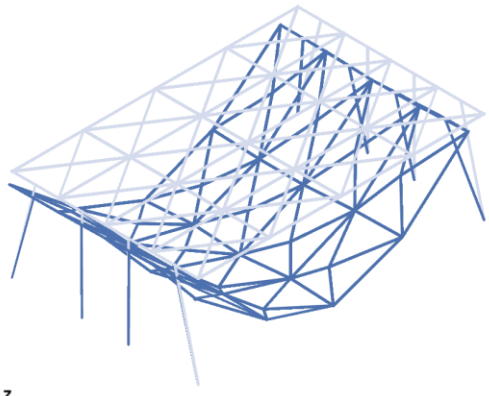
Bay 21-22			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.83	0.55	6.4
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-18: Mode 2, Bay 21-22, Hermosa Beach Pier

Bay 21-22			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	8.24	0.12	4.7
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.7 Results of the Test - Bay 27-28

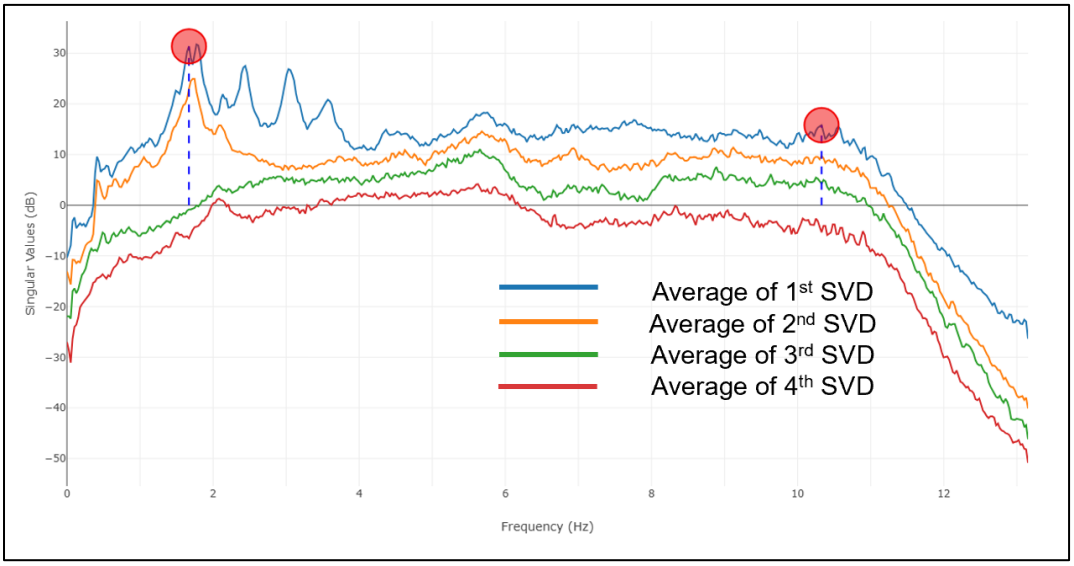


Figure 4-11: Singular value decomposition of the cross-spectral correlation, Bay 27-28, Hermosa Beach Pier

Table 4-19: Modal Properties for Bay 27-28, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.66	0.60	2.7
2 – 1st Vertical	10.34	0.10	3.7

Table 4-20: Mode 1, Bay 27-28, Hermosa Beach Pier

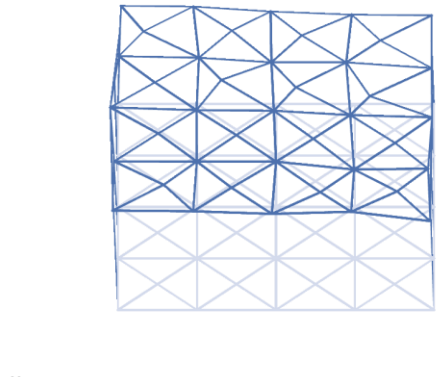
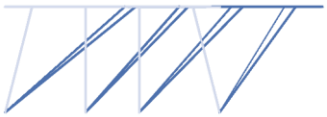
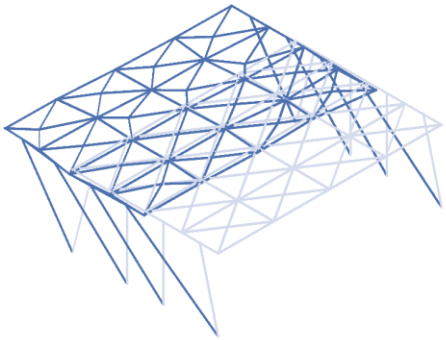
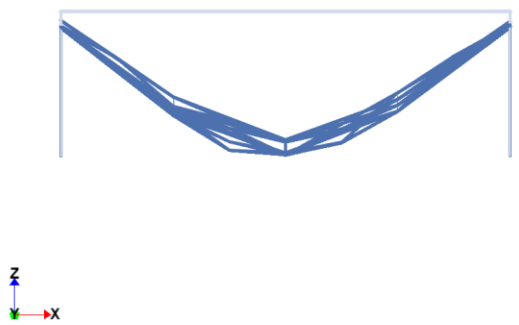
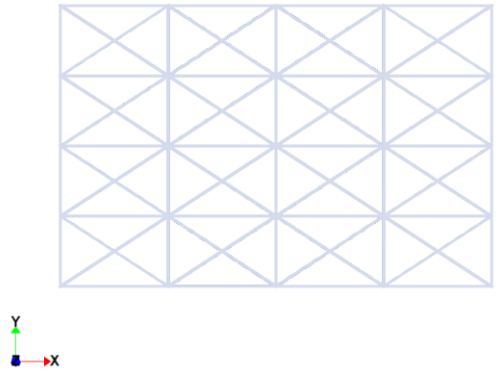
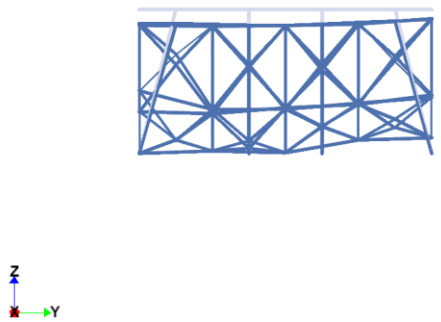
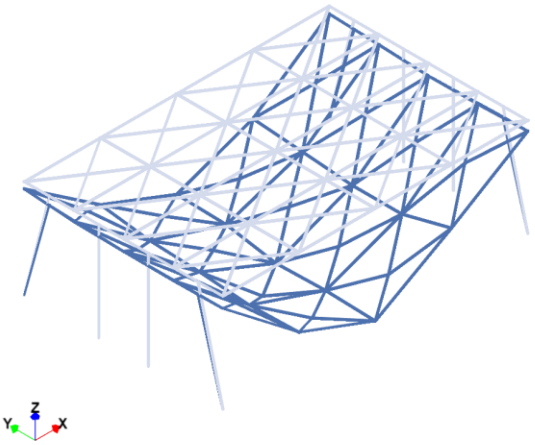
Bay 27-28			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.66	0.60	2.7
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-21: Mode 2, Bay 27-28, Hermosa Beach Pier

Bay 27-28			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	10.34	0.10	3.7
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.8 Results of the Test - Bay 30-31

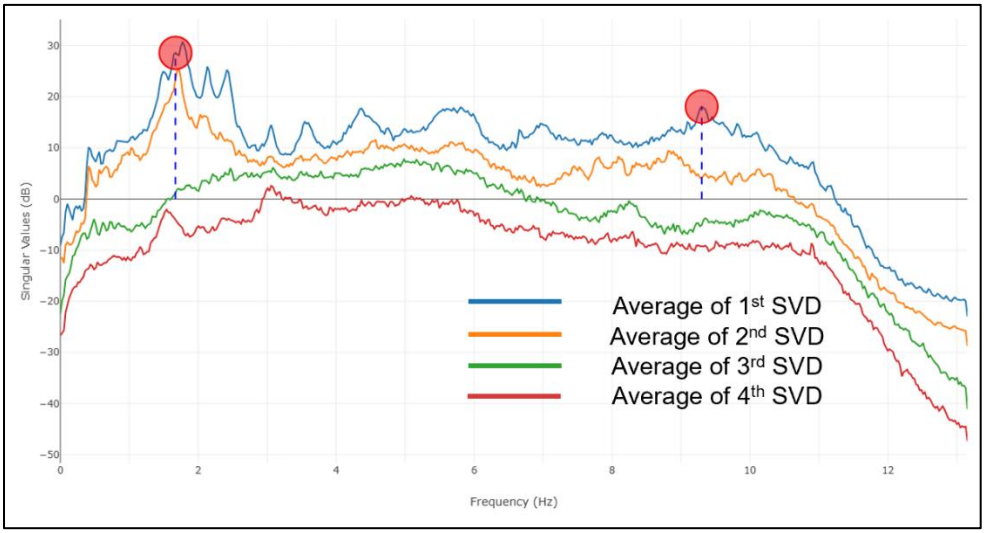


Figure 4-12: Singular value decomposition of the cross-spectral correlation, Bay 30-31, Hermosa Beach Pier

Table 4-22: Modal Properties for Bay 30-31, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.65	0.61	4.4
2 – 1st Vertical	9.38	0.11	3.5

Table 4-23: Mode 1, Bay 30-31, Hermosa Beach Pier

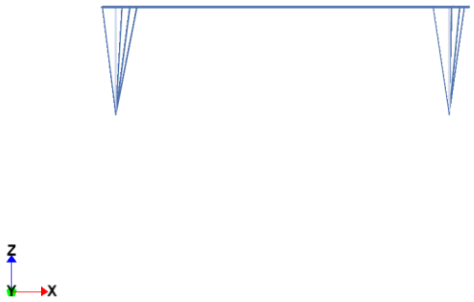
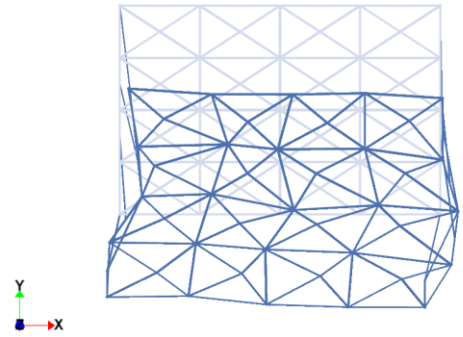
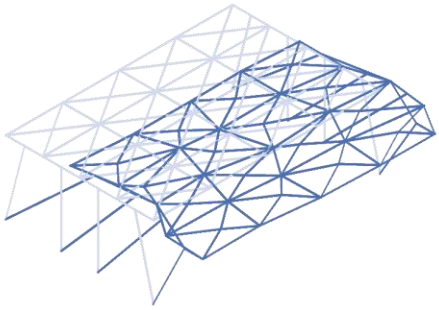
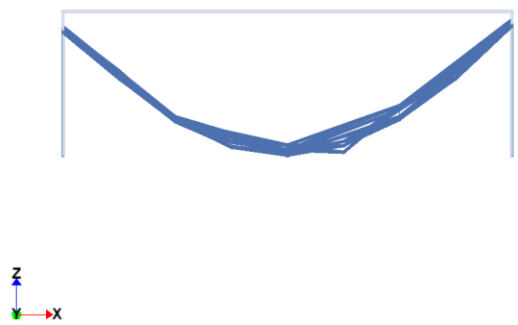
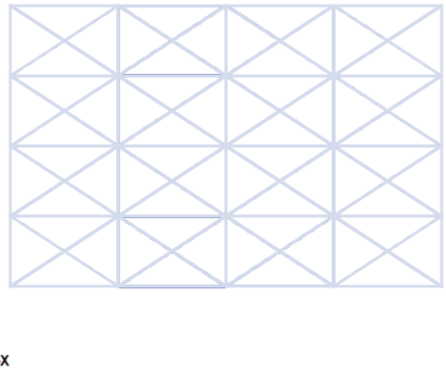
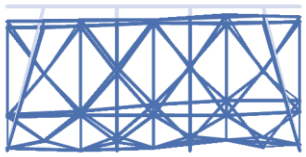
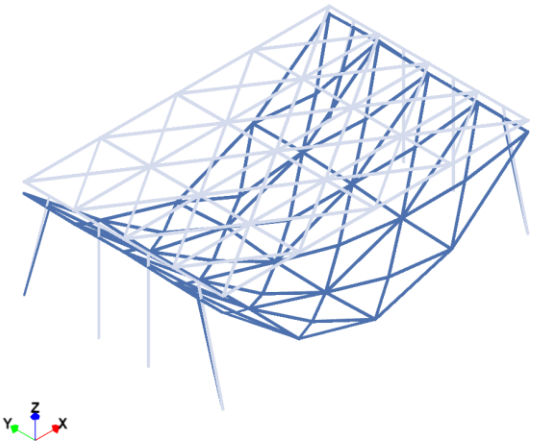
Bay 30-31			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.65	0.61	4.4
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-24: Mode 2, Bay 30-31, Hermosa Beach Pier

Bay 30-31			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	9.38	0.11	3.5
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.9 Results of the Test - Bay 32-33

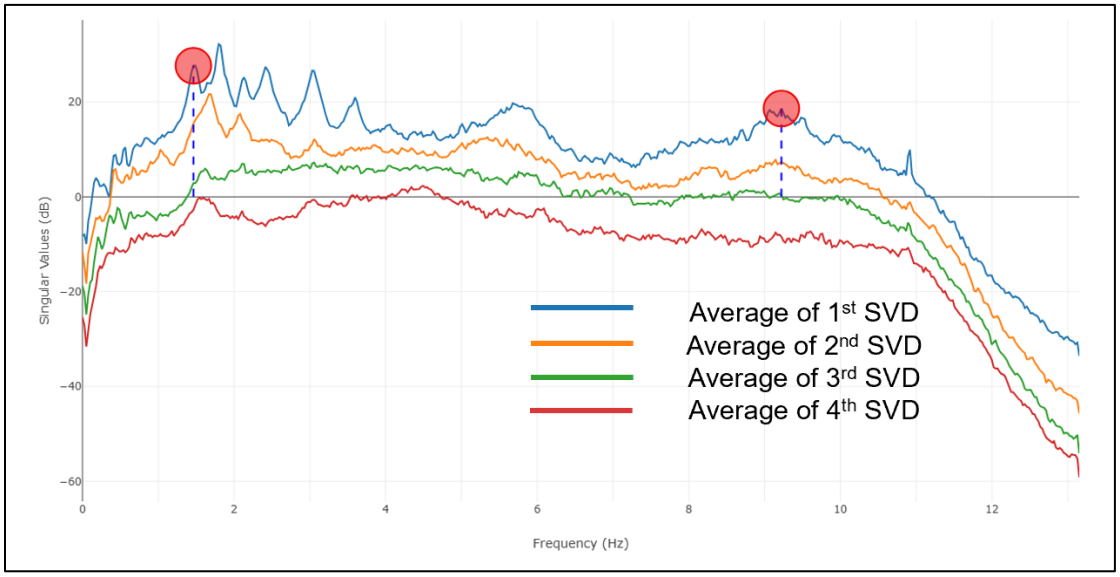


Figure 4-13: Singular value decomposition of the cross-spectral correlation, Bay 32-33, Hermosa Beach Pier

Table 4-25: Modal Properties for Bay 32-33, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.48	0.68	4.5
2 – 1st Vertical	9.20	0.11	4.7

Table 4-26: Mode 1, Bay 32-33, Hermosa Beach Pier

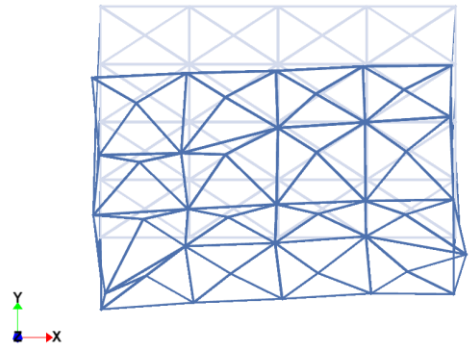
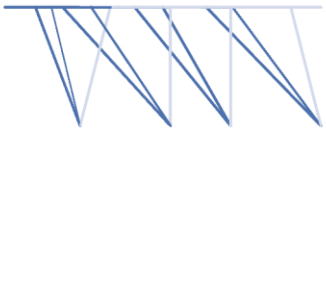
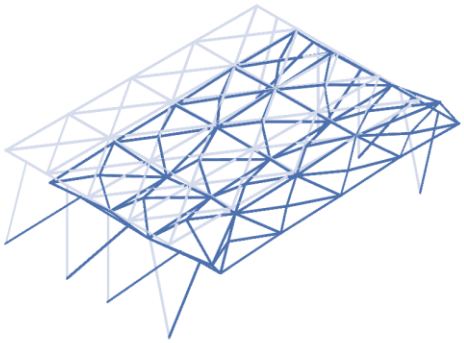
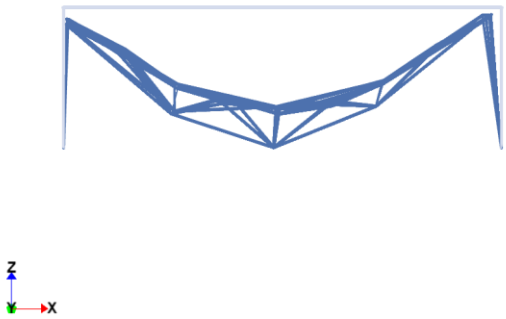
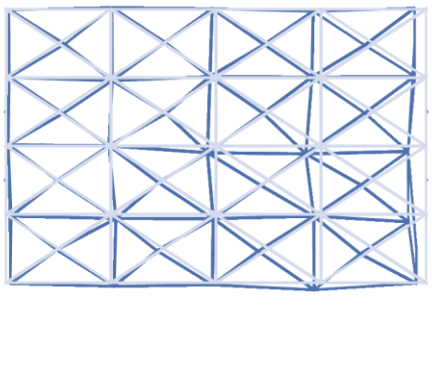
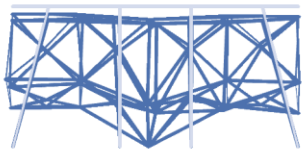
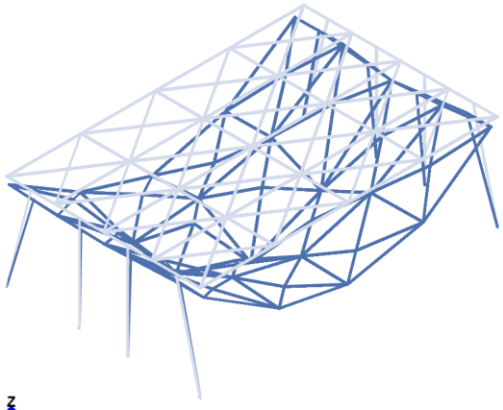
Bay 32-33			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.48	0.68	4.5
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-27: Mode 2, Bay 32-33, Hermosa Beach Pier

Bay 32-33			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	9.20	0.11	4.7
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

4.3.10 Results of the Test - Bay 35-36

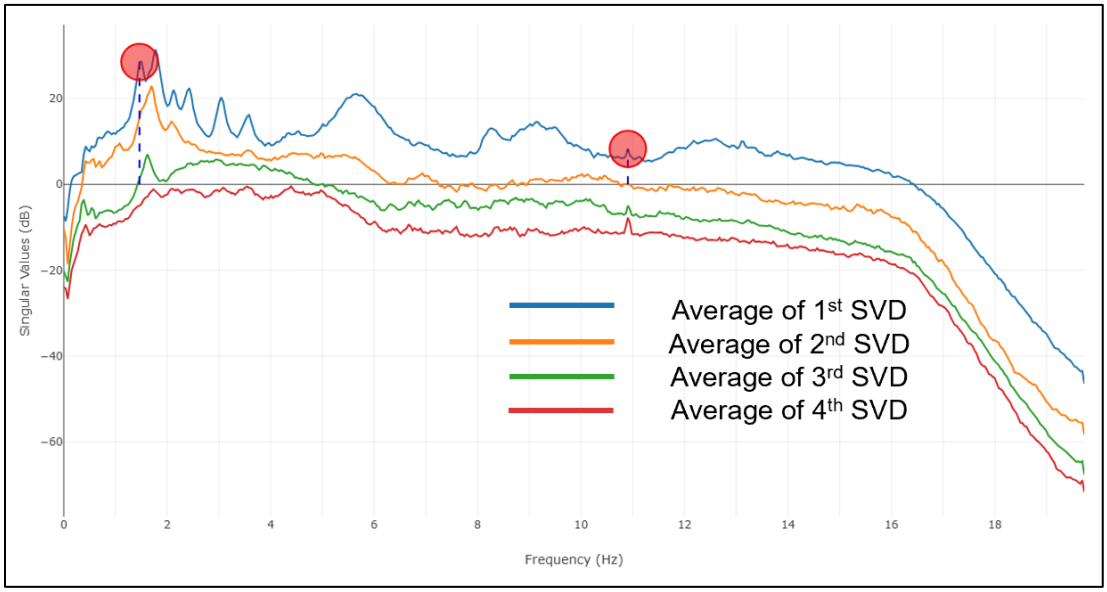


Figure 4-14: Singular value decomposition of the cross-spectral correlation, Bay 35-36, Hermosa Beach Pier

Table 4-28: Modal Properties for Bay 35-36, Hermosa Beach Pier

Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1 – 1st Transverse	1.49	0.67	5.3
2 – 1st Vertical	10.80	0.09	0.5

Table 4-29: Mode 1, Bay 35-36, Hermosa Beach Pier

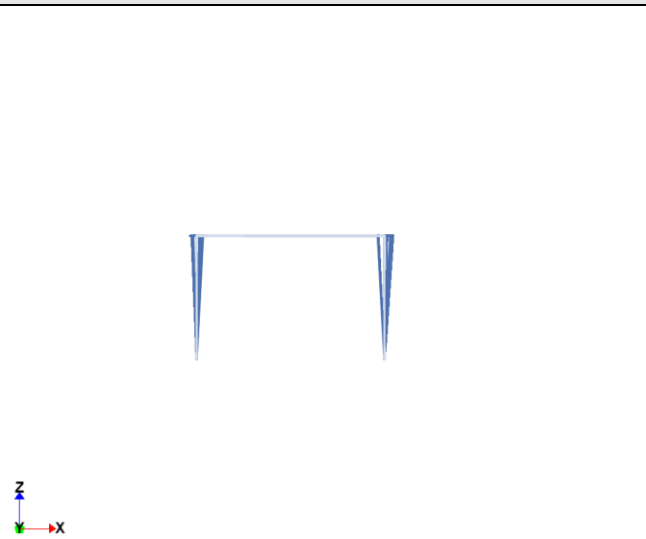
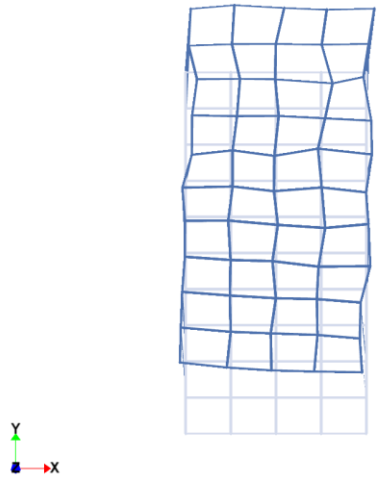
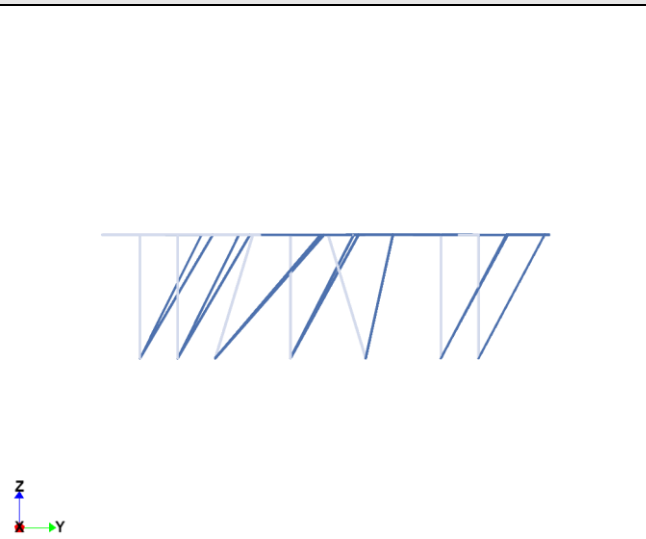
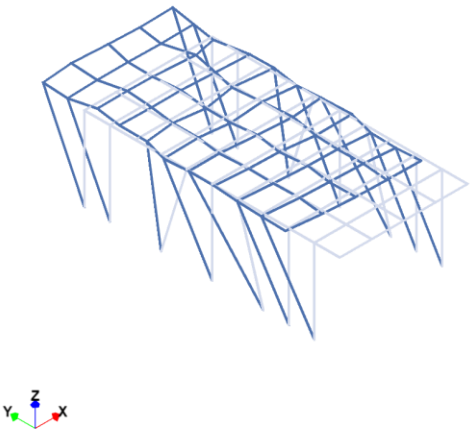
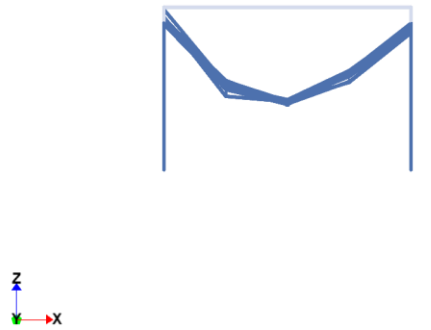
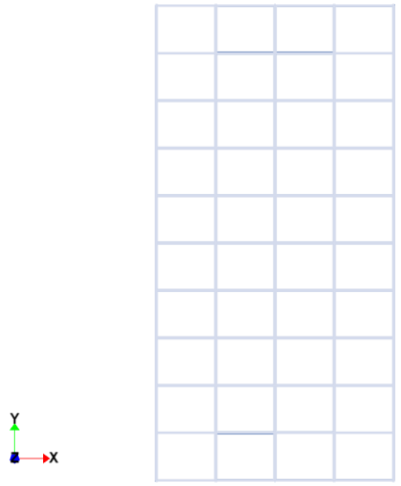
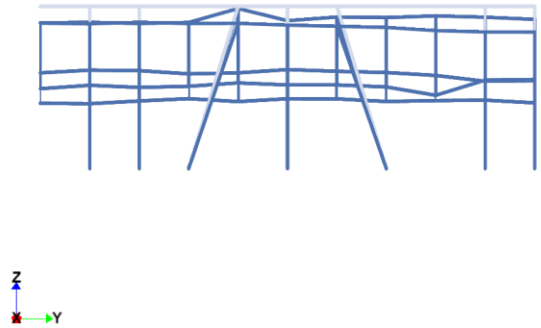
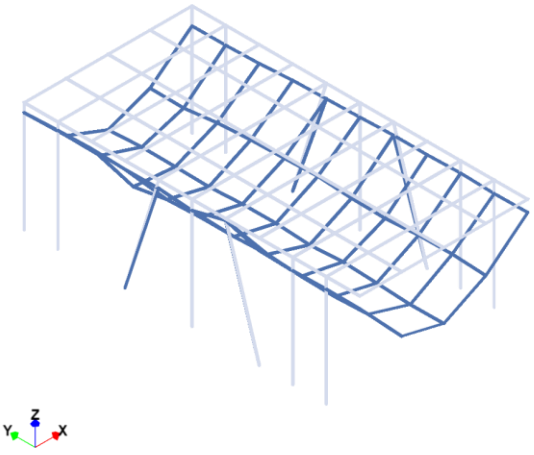
Bay 35-36			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
1	1.49	0.67	5.3
Mode 1 - 1st Transverse			
Front-view		Top-view	
			
Side-view		3D-view	
			

Table 4-30: Mode 2, Bay 35-36, Hermosa Beach Pier

Bay 35-36			
Modal Parameters			
Mode	Natural Frequency (Hz)	Natural Period (s)	Damping Ratio (%)
2	10.80	0.09	0.5
Mode 2 - 1st Vertical			
Front-view		Top-view	
			
Side-view		3D-view	
			

5 Discussions: Integrity Evaluation

[redacted]

Through the in-depth analysis of the ambient vibration data of the Pier, the natural frequencies, mode shapes, and damping ratios are identified. [redacted]

The degradation of a structure alters the overall stiffness of the pier and thus its modal properties. Structural degradation can be classified into two categories: symmetrical and asymmetrical degradation. Symmetrical degradation refers to a uniform reduction in the strength of the structural components, leading to a decrease in natural frequency that may preserve the symmetrical shape of the mode shape of vibration. Conversely, asymmetrical degradation can result in an alteration of the mode shape geometry, rendering it asymmetrical.

It is important to mention that even though the sensors were located on the deck level, the extracted dynamic properties are sensitive to stiffness changes coming from all structural components including the deck, panels, bents and foundations. Changes in the stiffness of each element impact the mode shapes differently. Using Sensequake's unique database of healthy and unhealthy mode shapes, the cause of that anomaly in the mode shape can be identified. Moreover, the distortion in the mode shapes can be quantified to determine the severity of the damage as needed

[redacted]

[redacted]



[redacted]

[redacted]



[redacted] This approach allows for precise localization and severity classification of structural anomalies. The curvature value categories are used to assess the severity of structural anomalies based on the degree of distortion in the mode shape. They are classified as follows:

- Curvature < 1% – Slight / None: Indicates a symmetric and healthy mode shape, with no significant structural concerns.
- 1% ⩽ Curvature < 3% – Minor: indicates mild irregularities, possibly early signs of localized flexibility or minor deterioration.

- 3% ⩽ Curvature < 6% – Moderate: Reflects noticeable asymmetry in the mode shape, often associated with moderate structural issues or degradation.
- 6% ⩽ Curvature < 12% – High: Denotes substantial distortion, indicating pronounced damage or localized structural weakness.
- Curvature > 12% – Severe: Represents critical structural concern, typically due to major cracks or significant loss of stiffness in a localized area.

Based on these categories, Figure 5-3 provides the color coding, which helps illustrate different levels of structural deterioration and prioritize the areas in need of monitoring, maintenance, or immediate intervention. After computing the curvature values and classifying them according to severity, each line segment was categorized and color-coded accordingly. These categorized lines formed the basis for generating the transverse mode heat map, visually illustrating areas of structural concern. This quantification method is consistently applied to all transverse modes throughout the report for each Bay evaluated.

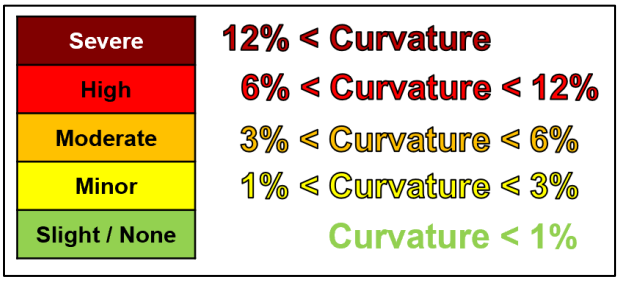


Figure 5-3 Curvature categorization and color coding

[redacted]



[redacted]

[redacted]

[redacted]

[redacted]

The following subsections discuss the observations made in the Pier's stiffness properties.

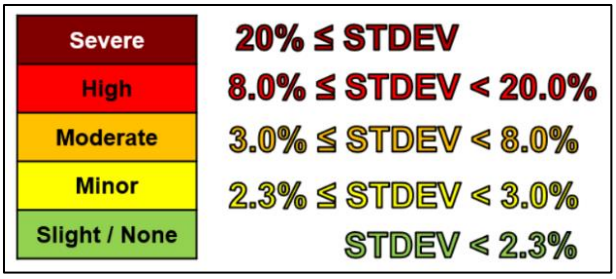


Figure 5-5: Structural condition based on quantified vertical curvature change

5.1 Mode Shape Evaluation – Bay 10-11

Based on the described evaluation integrity strategy, the transverse heat map for Bay 10-11 is shown in Figure 5-6.

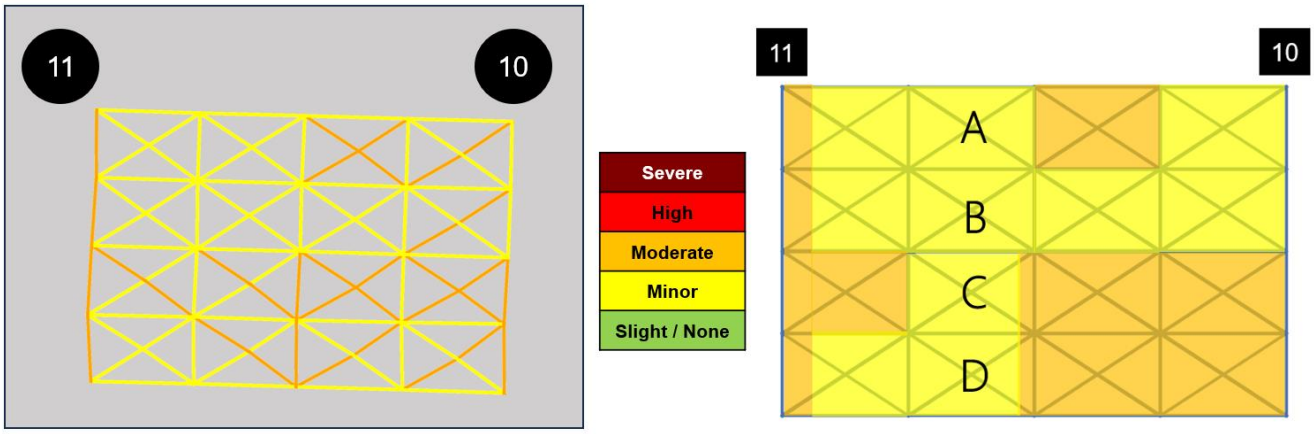


Figure 5-6: Transverse Heat Map generation Bay 10-11

Bay 10–11 overall shows significant inconsistency in vertical mode shapes, with the shear key C–D and surrounding nodes exhibiting the highest STDEV values in the region. Notably, the West-Mid and East-Joint nodes displayed strong deviations in magnitude (Table 5-1 and 5-2), resulting in a “High” classification. In contrast, in-panel nodes remained stable and consistent, indicating that the vertical flexibility anomalies were localized to the shear key line and external

nodes. These findings suggest potential localized degradation concentrated along the transverse shear key and joints, while the internal deck behavior remains relatively unaffected.

Table 5-1 Node Vertical Magnitude Comparison for the edge nodes Bay 10-11

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.11	0.72	1.00	0.67	0.07	0.51
SK C-D	0.40	0.91	0.88	0.68	0.38	0.65
SK B-C	0.08	0.70	0.98	0.70	0.08	0.51
SK A-B	0.08	0.67	0.98	0.70	0.09	0.5
NORTH EDGE	0.07	0.69	0.97	0.66	0.10	0.5
AVG	0.15	0.74	0.96	0.68	0.14	
STDEV	12.7%	8.9%	4.2%	1.5%	11.8%	

Table 5-2 Node Vertical Magnitude Comparison for the in-plane nodes Bay 10-11

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.40	0.93	0.88	0.38	0.64
PANEL C	0.42	0.92	0.89	0.37	0.65
PANEL B	0.41	0.92	0.88	0.39	0.65
PANEL A	0.38	0.90	0.85	0.40	0.63
AVG	0.40	0.92	0.87	0.39	
STDEV	1.4%	0.9%	1.2%	1.0%	

After calculating the STDEV values and classifying each line accordingly, a heat map for the vertical mode is generated to visually represent the performance and consistency of vertical flexibilities. This heat map highlights areas of potential concern, where elevated STDEV values indicate irregularities in mode shape amplitudes and suggest localized structural anomalies.

The vertical heat map is generated based on the tables above for Bay 10-11 (Figure 5-7).

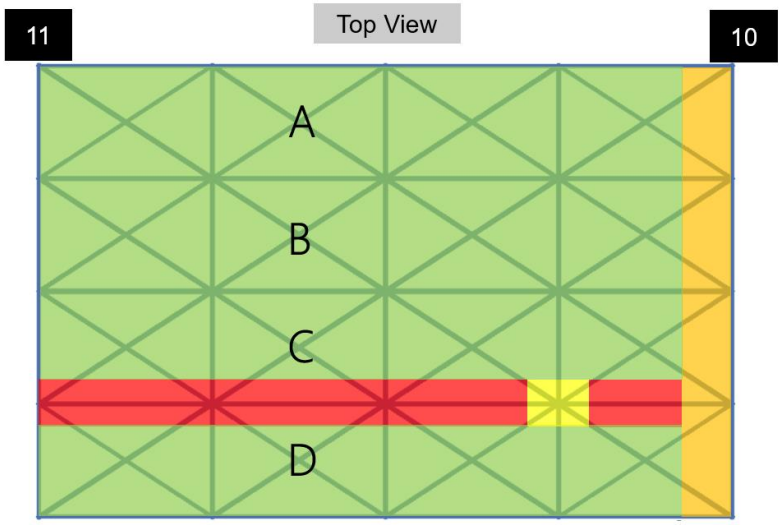


Figure 5-7 Vertical Heat map for Bay 10-11

Overall, Bay 10–11 exhibits moderate deterioration in the transverse direction across all panels, with no severe anomalies detected. However, the vertical heat map reveals a concentrated high deterioration zone along the shear key between Panels C and D, aligning with the horizontal axis. The anomaly is consistently reflected in the combined heat map, emphasizing a localized stiffness degradation in that region. The overall behavior suggests that while the superstructure remains generally stable, the shear key line is a critical zone requiring attention due to potential vertical flexibility irregularities (Figure 5-8).

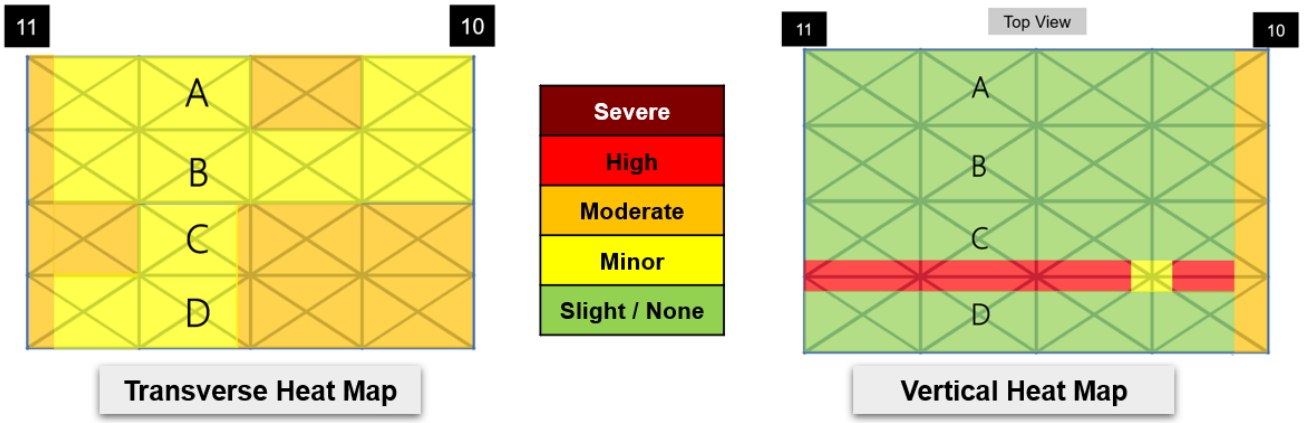


Figure 5-8 Combined heat maps comparison for Bay 10-11

5.2 Mode Shape Evaluation - Bay 12-13

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 12-13 (Figure 5-9). From the heat map, Panels C and D exhibited signs of high deterioration based on the curvature distribution. The observed vertical displacement in the inspection photos aligns with the localized mode shape distortion on the western side of Panel C, further validating the findings (Figure 5-10).

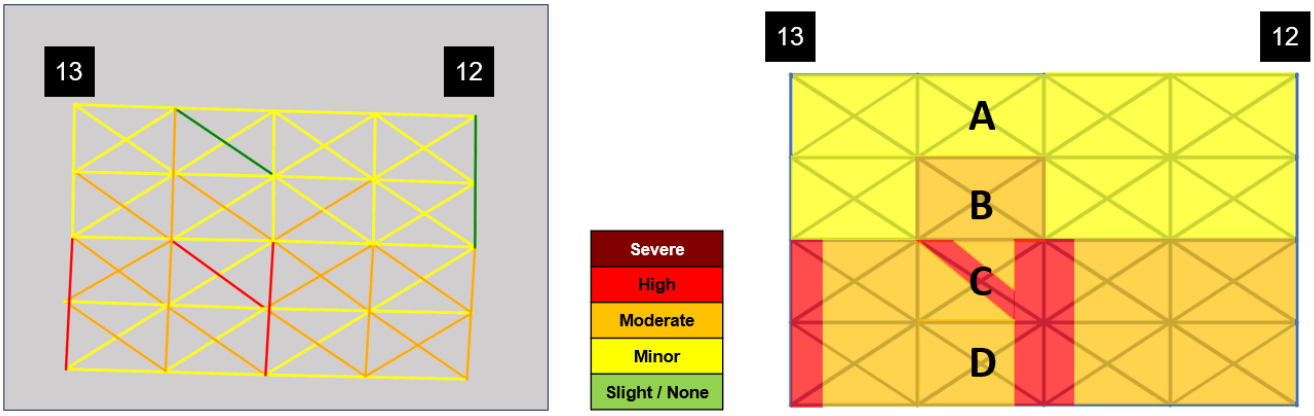


Figure 5-9 Transverse Heat Map generation Bay 12-13

For the vertical mode, the in-plane sensor nodes along the “Mid-East” line exhibit higher standard deviation values and were therefore classified as “Minor.” While Panels B, C, and D generally

demonstrate consistent behavior, a comparison with adjacent nodes along the “Mid-West” line revealed noticeable inconsistencies and elevated average magnitudes. To ensure a more conservative and precautionary evaluation, the entire “Mid-East” line was rated as exhibiting minor anomalies.



Figure 5-10 Vertical displacement on Bay 12-13 Panel C

Table 5-3 Node Vertical Magnitude Comparison for the edge nodes Bay 12-13

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.06	0.64	0.93	0.63	0.07	0.47
Shear Key C-D	0.10	0.64	0.95	0.65	0.08	0.48
Shear Key B-C	0.09	0.69	0.96	0.63	0.09	0.49
Shear Key A-B	0.09	0.69	0.95	0.67	0.10	0.50
NORTH EDGE	0.08	0.66	1.00	0.68	0.11	0.51
AVG	0.08	0.66	0.96	0.65	0.09	
STDEV	1.2%	2.0%	2.2%	2.1%	1.4%	

Table 5-4 Node Vertical Magnitude Comparison for the in-plane nodes Bay 12-13

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.38	0.81	0.86	0.39	0.61
PANEL C	0.38	0.87	0.86	0.39	0.63
PANEL B	0.38	0.85	0.87	0.41	0.63
PANEL A	0.38	0.83	0.92	0.42	0.64
AVG	0.38	0.84	0.88	0.40	
STDEV	0.3%	2.1%	2.4%	1.2%	

The vertical heat map is generated based on the Tables above for Bay 12-13 (Figure 5-11).

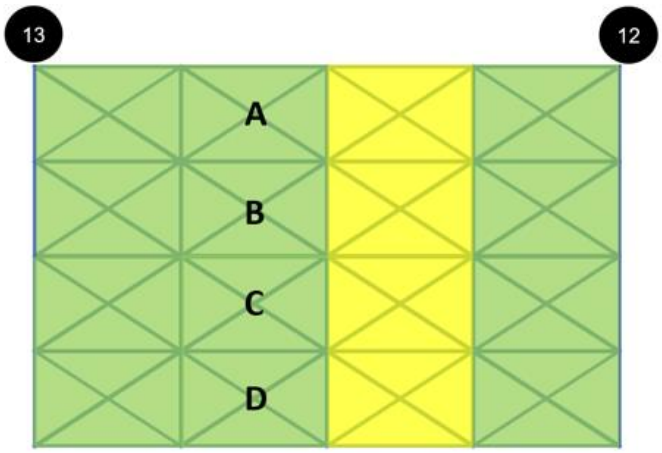


Figure 5-11 Vertical Heat Map for Bay 12-13

Overall, Bay 12-13 exhibits moderate to high deterioration in the transverse mode, particularly in Panels C and D. In contrast, the vertical mode shows only slight to minor anomalies, indicating relatively consistent vertical flexibility. The transverse heat map highlights significant localized curvature changes along the western side of Panel C, correlating with the large visible crack observed during visual inspection. This crack is likely the primary cause of the structural anomaly

in this bay. Panels A and B display comparatively better performance, reinforcing the localized nature of the deterioration (Figure 5-12).

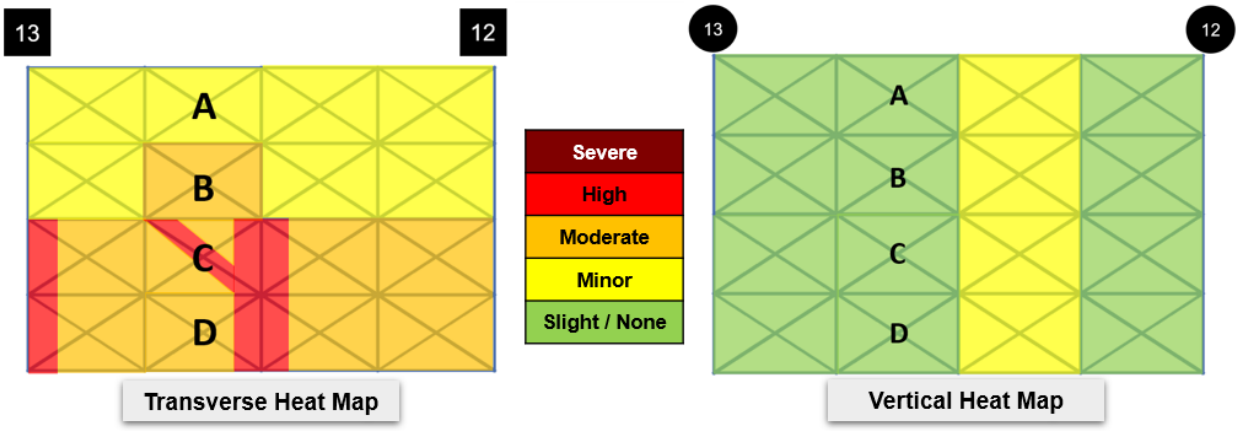


Figure 5-12 Combined Heat Maps for Bay 12-13

5.3 Mode Shape Evaluation - Bay 13-14

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 13-14 (Figure 5-13).

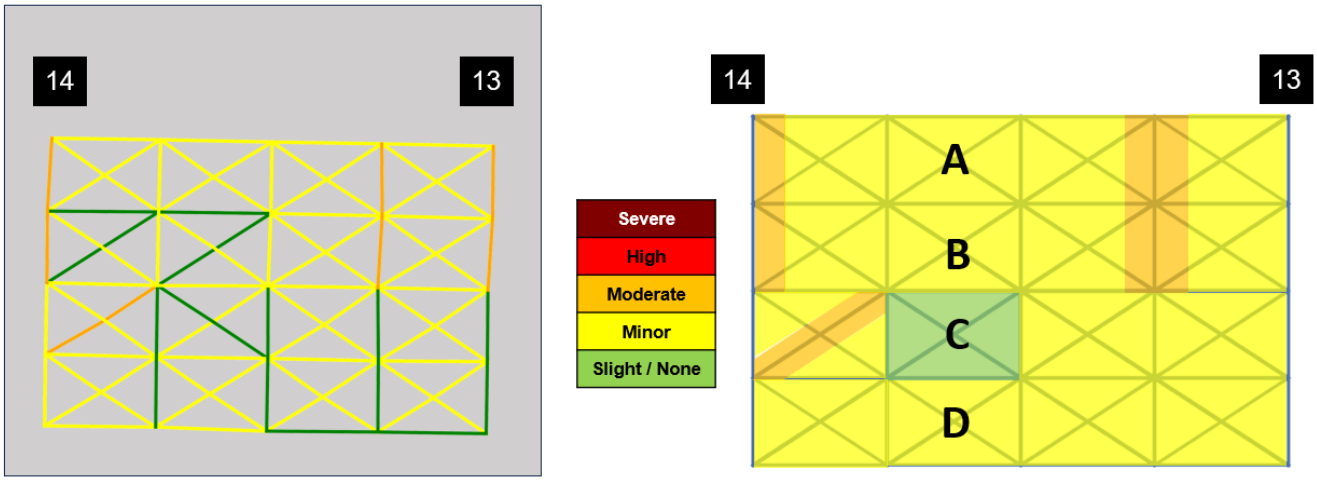


Figure 5-13 Transverse Heat Map generation Bay 13-14

For the vertical mode, Table 5-5 and Table 5-6 show the magnitude for the vertical modes. After comparison and calculation of the standard deviation, for Bay 13-14, the vertical mode analysis reveals generally consistent behavior, with most nodes falling within the healthy STDEV range. However, moderate inconsistencies are observed at the Mid Node along the shear key A-B and at the East Mid position within the in-panel evaluation, particularly affecting Panels B and A. These localized irregularities suggest minor to moderate vertical flexibility issues in those areas.

Table 5-5 Node Vertical Magnitude Comparison for the edge nodes Bay 13-14

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.09	0.68	0.99	0.72	0.11	0.52
Shear Key C-D	0.11	0.69	0.99	0.74	0.11	0.52
Shear Key B-C	0.11	0.71	1.00	0.72	0.11	0.53
Shear Key A-B	0.12	0.71	0.93	0.68	0.09	0.51
NORTH EDGE	0.12	0.66	0.98	0.68	0.1	0.51
AVG	0.11	0.69	0.98	0.71	0.1	
STDEV	1.4%	1.8%	2.5%	2.3%	0.5%	

Table 5-6 Node Vertical Magnitude Comparison for the in-plane nodes Bay 13-14

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.43	0.84	0.87	0.4	0.64
PANEL C	0.43	0.89	0.87	0.39	0.65
PANEL B	0.38	0.88	0.76	0.39	0.6
PANEL A	0.43	0.87	0.92	0.38	0.65
AVG	0.42	0.87	0.85	0.39	
STDEV	2.0%	1.8%	5.9%	0.7%	

The vertical heat map is generated based on the Tables above for Bay 13-14 (Figure 5-14).

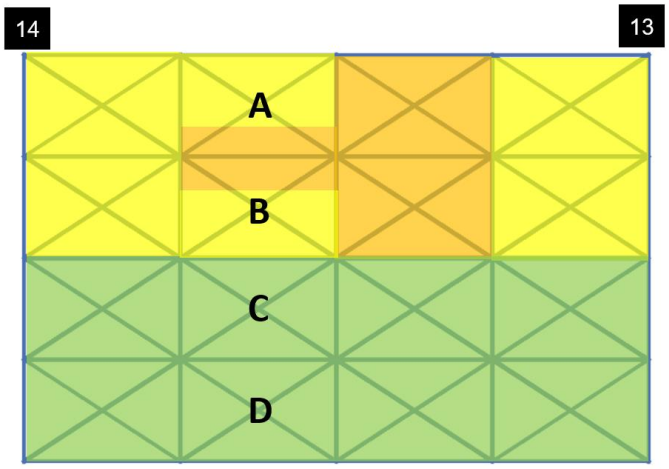


Figure 5-14 Vertical Heat Map for Bay 13-14

Bay 13-14 exhibits overall minor to moderate deterioration (Figure 5-15). In the transverse mode, localized anomalies were observed near Panel C, while the vertical mode heat map indicates moderate inconsistencies around Panel A and B. These findings align with the inspection photo,

which revealed visible spalling and delamination on Panel B (Figure 5-16), supporting the assessment of localized structural degradation in this bay.

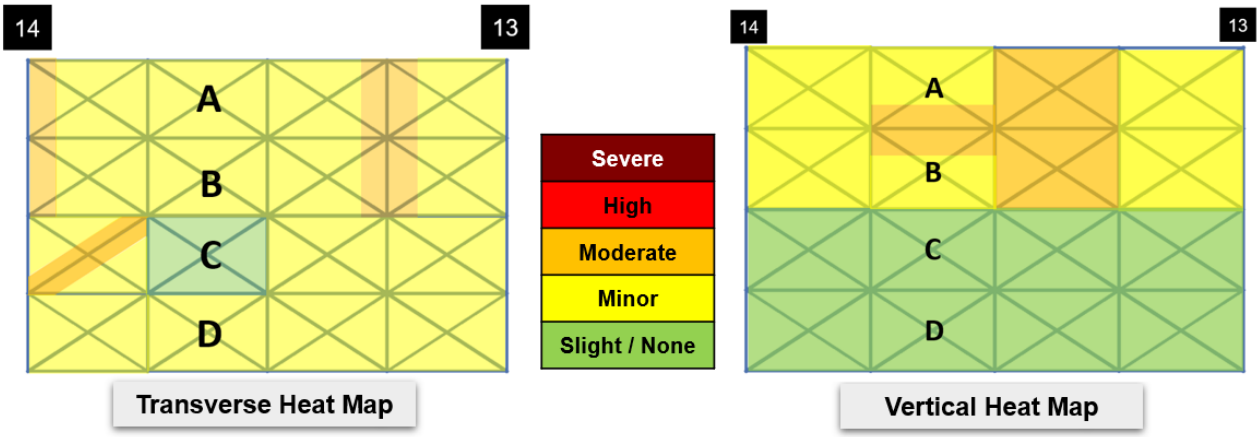


Figure 5-15 Combined Heat Maps for Bay 13-14



Figure 5-16 Delamination on Panel B of Bay 13-14

5.4 Mode Shape Evaluation - Bay 15-16

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 15-16 (Figure 5-17).

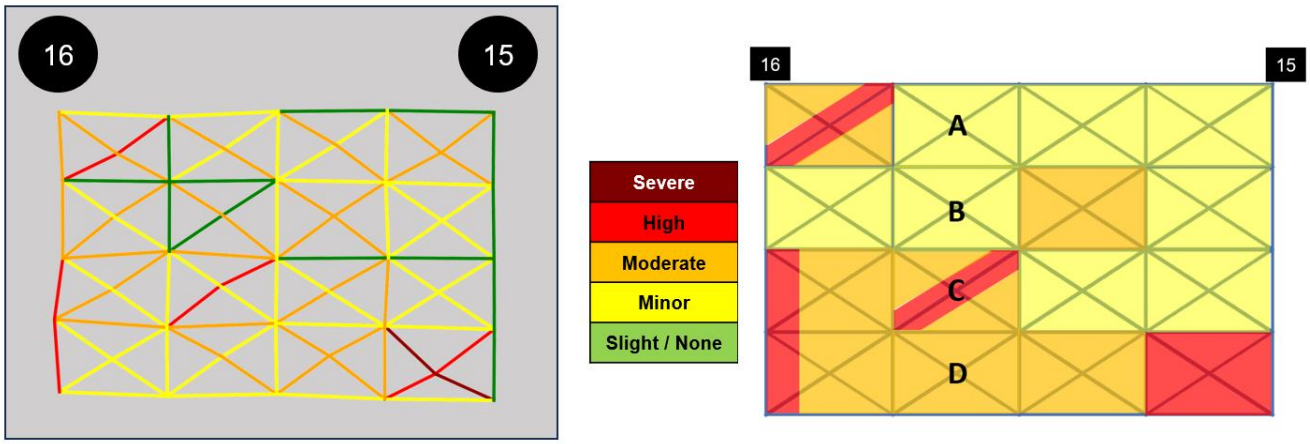


Figure 5-17 Transverse Heat Map generation Bay 15-16

For the vertical mode, the analysis identified localized irregularities (Table 5-7 and 5-8), particularly at the East node in Panels B and A, where the STDEV reaches 7.4%, indicating moderate inconsistency in vertical flexibility. Additionally, slight anomalies are observed at the Mid Node. These variations suggest that while most areas in this bay performed consistently, specific zones—especially on the east side—may require closer attention.

Table 5-7 Node Vertical Magnitude Comparison for the edge nodes Bay 15-16

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.06	0.66	0.93	0.65	0.08	0.48
SK C-D	0.07	0.68	0.94	0.67	0.10	0.49
SK B-C	0.08	0.67	0.95	0.65	0.11	0.49
SK A-B	0.07	0.66	0.96	0.69	0.12	0.50
NORTH EDGE	0.09	0.67	1.00	0.70	0.13	0.52
AVG	0.08	0.67	0.95	0.67	0.11	
STDEV	1.0%	0.6%	2.5%	2.3%	1.7%	

Table 5-8 Node Vertical Magnitude Comparison for the in-plane nodes Bay 15-16

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.45	0.88	0.87	0.35	0.64
PANEL C	0.44	0.92	0.87	0.34	0.64
PANEL B	0.42	0.9	0.88	0.49	0.67
PANEL A	0.47	0.89	0.92	0.49	0.69
AVG	0.44	0.9	0.88	0.42	
STDEV	1.6%	1.2%	2.3%	7.4%	

The vertical heat map is generated based on the Tables above for Bay 15-16 (Figure 5-18).

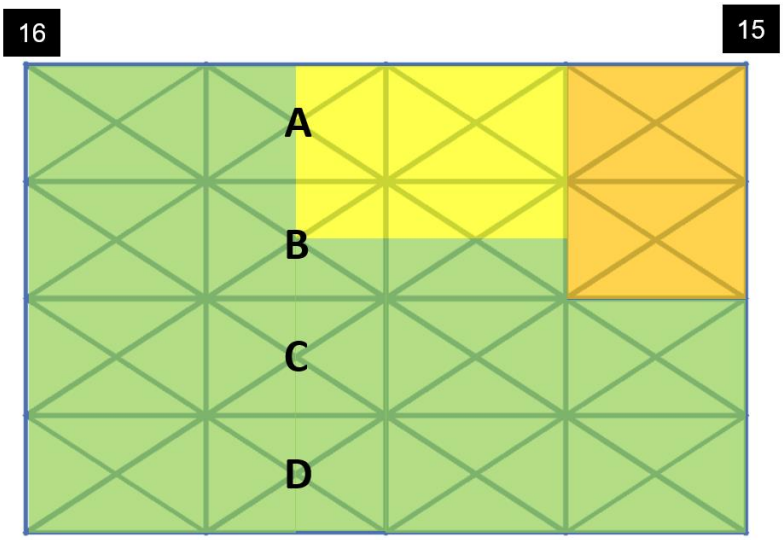


Figure 5-18 Vertical Heat Map for Bay 15-16

Overall, Bay 15-16 shows moderate to high deterioration in the transverse mode, with the most significant anomalies concentrated in Panels B, C, and D. The vertical mode reveals minor to

moderate irregularities, particularly on the east side of Panels A and B (Figure 5-19). Visual inspection confirms a large spalling area on Panel B (Figure 5-20) and localized surface damage on Panels C and D, which aligns with the structural anomalies indicated in the heat maps.

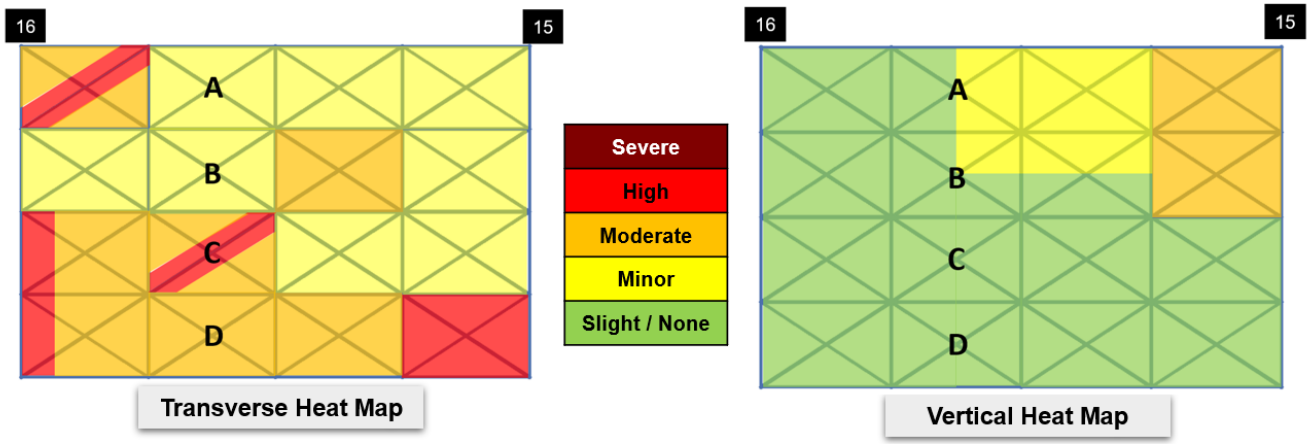


Figure 5-19 Combined Heat Maps for Bay 15-16



Figure 5-20 Panel B with large spalling area for Bay 15-16

5.5 Mode Shape Evaluation - Bay 18-19

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 18-19 (Figure 5-21).

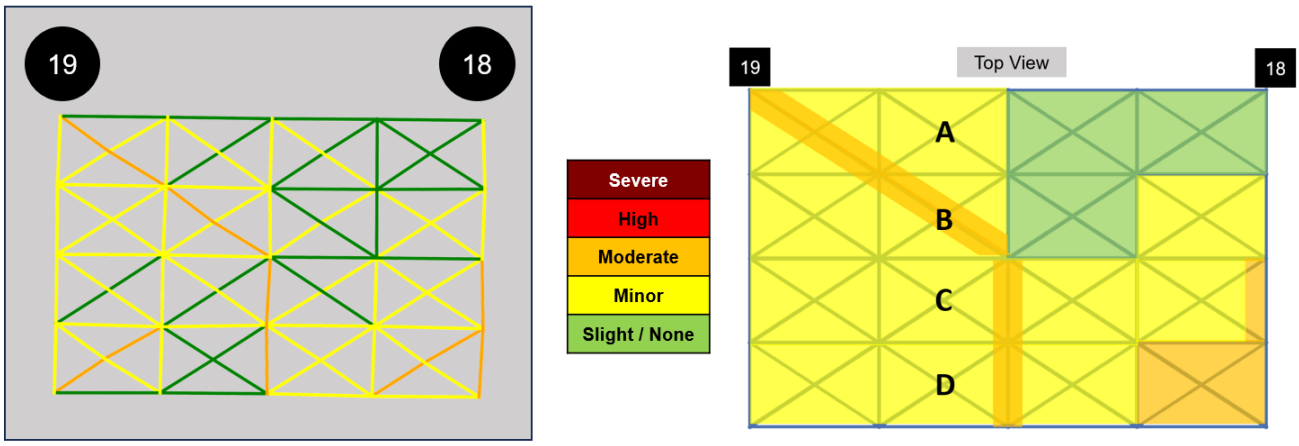


Figure 5-21 Transverse Heat Map generation Bay 18-19

For the vertical mode of Bay 18-19, analysis indicates a moderate inconsistency in mode shape amplitudes, particularly at the Mid Node and the West Mid panel zone (Table 5-7 and 5-8). The STDEV values reach 2.7% and 4.6% respectively, suggesting localized vertical flexibility irregularities. These findings point to developing anomalies that warrant monitoring, especially near the central and western areas of the span.

Table 5-9 Node Vertical Magnitude Comparison for the edge nodes Bay 18-19

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.13	0.7	1	0.76	0.12	0.54
SK C-D	0.13	0.74	0.99	0.78	0.11	0.55
SK B-C	0.11	0.72	0.98	0.75	0.13	0.54
SK A-B	0.11	0.72	0.93	0.74	0.1	0.52
NORTH EDGE	0.09	0.69	0.94	0.74	0.09	0.51
AVG	0.12	0.71	0.97	0.76	0.11	
STDEV	1.4%	1.6%	2.7%	1.6%	1.5%	

Table 5-10 Node Vertical Magnitude Comparison for the in-plane nodes Bay 18-19

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.42	0.9	0.95	0.47	0.69
PANEL C	0.41	0.92	0.93	0.45	0.68
PANEL B	0.41	0.83	0.89	0.46	0.65
PANEL A	0.37	0.81	0.9	0.45	0.63
AVG	0.4	0.87	0.92	0.46	
STDEV	1.9%	4.6%	2.2%	0.9%	

An additional anomaly is detected through visual inspection of the side-view mode shape (Figure 5-22), where the shear key C-D exhibits unexpected transverse movement on its western side.

This irregularity is also factored into the vertical mode heat map. Taking all findings into account, the comprehensive heat map for the vertical mode is presented in Figure 5-23.

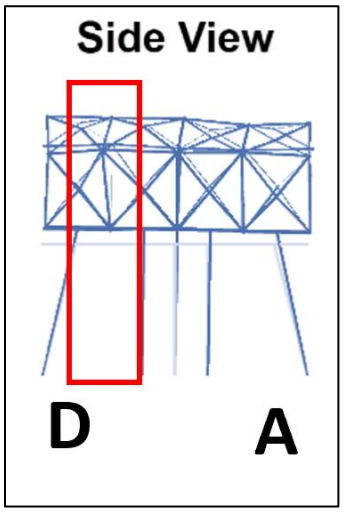


Figure 5-22 Unexpected transverse movement on shear key C-D Bay 18-19

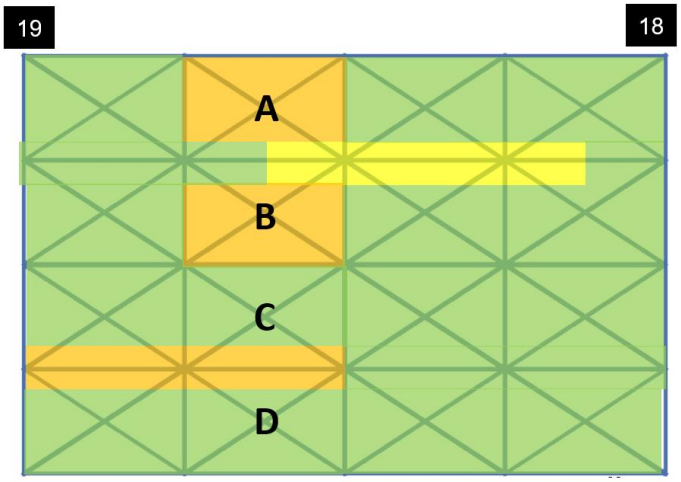


Figure 5-23 Vertical Heat Map for Bay 18-19

Bay 18-19 shows overall minor to moderate deterioration. In the transverse mode, localized anomalies are observed along the western portion of shear key C-D, where unexpected transverse movements are detected. This irregularity is confirmed through side-view mode

shape inspection and factored into the heat map. In the vertical mode, moderate inconsistencies are observed in Panels A and B, indicating localized vertical flexibility. These findings suggest developing structural concerns that merit continued observation (Figure 5-24).

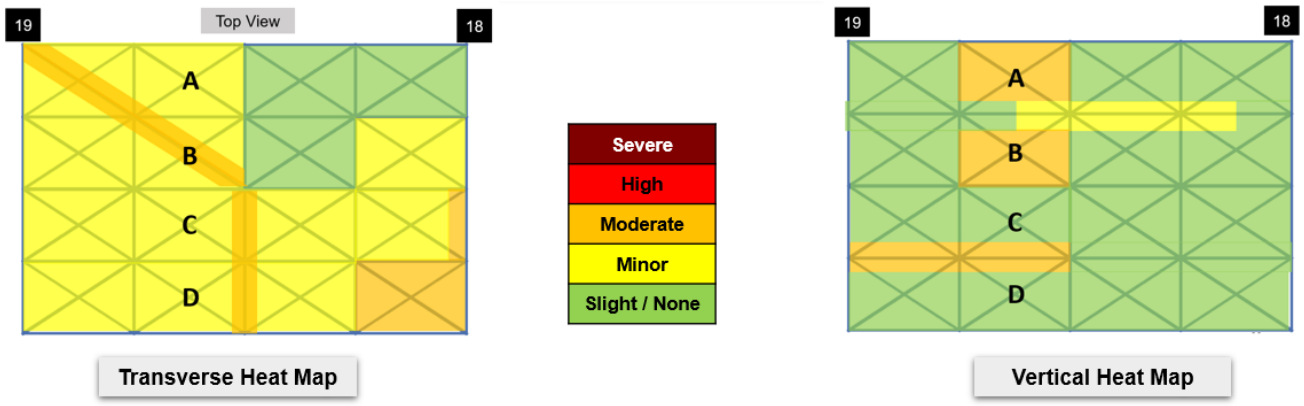


Figure 5-24 Combined Heat Maps for Bay 18-19

5.6 Mode Shape Evaluation - Bay 21-22

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 21-22 (Figure 5-25).

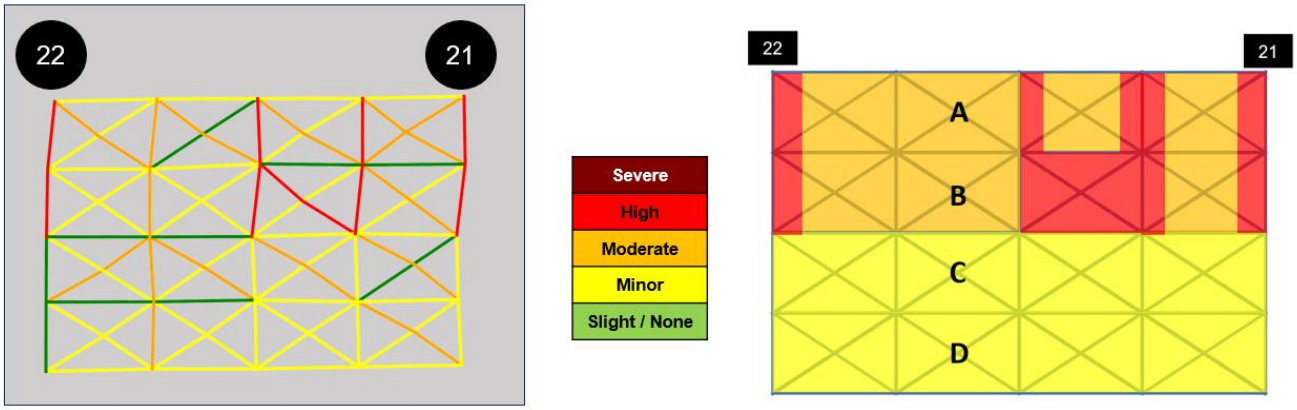


Figure 5-25 Transverse Heat Map generation Bay 21-22

For Bay 21-22, the vertical mode analysis reveals minor to moderate deterioration. Although the STDEV values remained within acceptable limits, several nodes (particularly along the West Midline) exhibit high mode shape magnitudes, indicating elevated vertical flexibility. (Table 5-11 and 5-12) Additionally, the North Edge shows slight inconsistency, which contributes to localized concerns. These findings suggest early signs of vertical irregularities that warrant continued observation.

Table 5-11 Node Vertical Magnitude Comparison for the edge nodes Bay 21-22

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.1	0.76	1.00	0.7	0.09	0.53
SK C-D	0.11	0.77	0.99	0.69	0.09	0.53
SK B-C	0.11	0.78	1.00	0.7	0.09	0.54
SK A-B	0.11	0.78	0.96	0.7	0.08	0.53
NORTH EDGE	0.12	0.73	1.00	0.69	0.08	0.52
AVG	0.11	0.76	0.99	0.69	0.08	
STDEV	0.5%	2.1%	1.4%	0.5%	0.8%	

Table 5-12 Node Vertical Magnitude Comparison for the in-plane nodes Bay 21-22

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.47	0.92	0.87	0.37	0.65
PANEL C	0.46	0.96	0.86	0.39	0.67
PANEL B	0.45	0.92	0.89	0.42	0.67
PANEL A	0.44	0.92	0.91	0.4	0.67
AVG	0.45	0.93	0.88	0.39	
STDEV	1.0%	1.8%	2.0%	1.8%	

In addition to the vertical flexibility findings, Table 5-13 shows that Panels C and D in Bay 21-22 exhibit noticeably lower average vertical frequencies (8.19 Hz) compared to Panels A and B (8.42 Hz). This reduction in frequency suggests a localized loss of stiffness in the southern portion of the bay, further reinforcing the observation of moderate deterioration in Panels C and D.

Table 5-13 In-plane Frequency Comparison Bay 21-22

Bay 21-22	Avg Frequency (Hz)
Panel A	8.42
Panel B	8.42
Panel C	8.19
Panel D	8.19

The excessive longitudinal flexibility observed in Bay 21-22 may also be attributed to deterioration in the bay structure beneath the deck. As illustrated in the comparison diagram (Figure 5-26), a healthy structure shows minimal lateral movement at the ends of the bent, whereas a deteriorated bent exhibits significant outward flexibility. This excessive flexibility is a strong indicator of weakened below-deck components, such as piles or pile-caps, which could contribute to the reduced frequency and observed irregularities in the mode shape behavior.

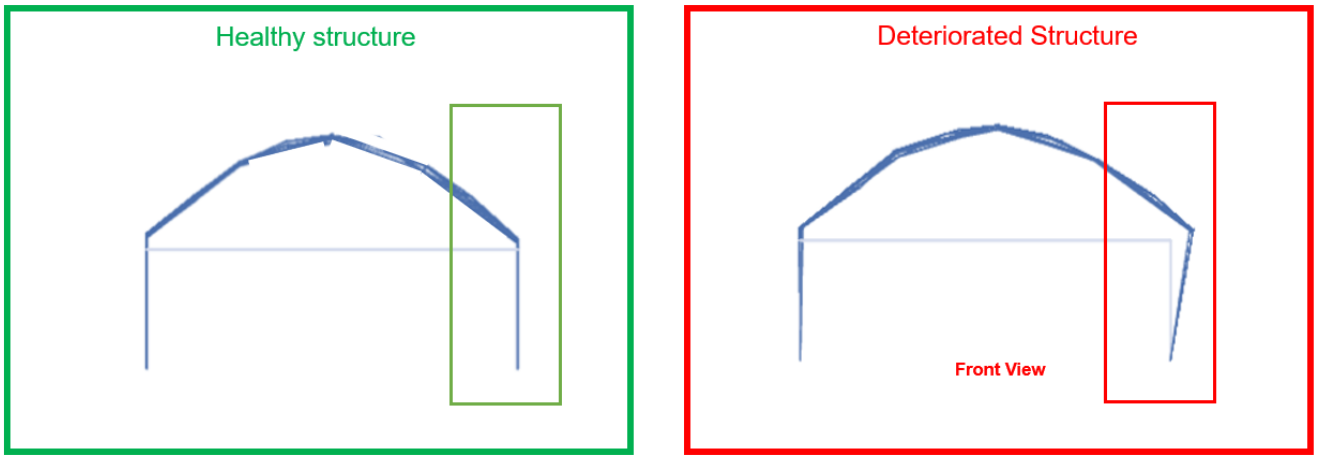


Figure 5-26 Unexpected Longitudinal Flexibility on the bents

Figure 5-27 highlights the excessive longitudinal flexibility observed on the shore-side bent of Bay 21-22. The noticeable outward displacement as seen in the front view, suggests deterioration in the below-deck structural components. This deformation pattern is consistent with weakened or compromised below-deck elements near the shore-side, further supporting the earlier findings of reduced frequency and vertical flexibility in Panels C and D.

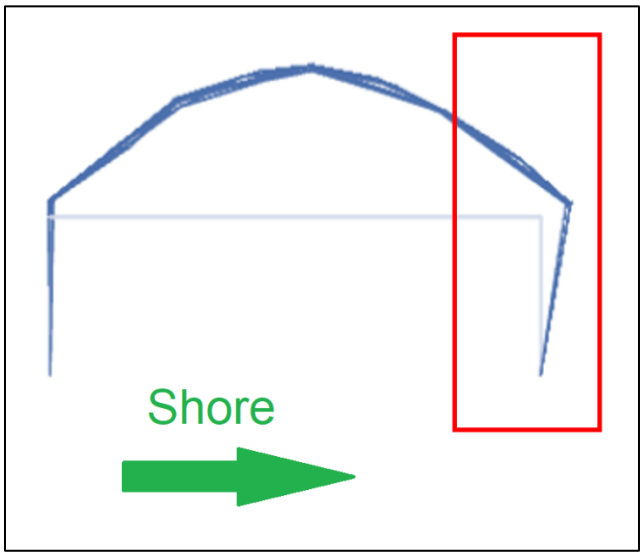


Figure 5-27: Bent 21 Unexpected Longitudinal Flexibility (Front view)

The vertical heat map is generated based on the Tables above for Bay 21-22. Panels C and D are rated as showing minor deterioration due to their lower average vertical frequencies compared to Panels A and B, indicating localized stiffness reduction. Additionally, excessive longitudinal flexibility is observed in Bent 21, particularly on the shore side, as shown in the mode shape deformation. This suggests deterioration in the below-deck components supporting Bent 21. These combined findings are reflected in the final vertical mode heat map shown in Figure 5-28.

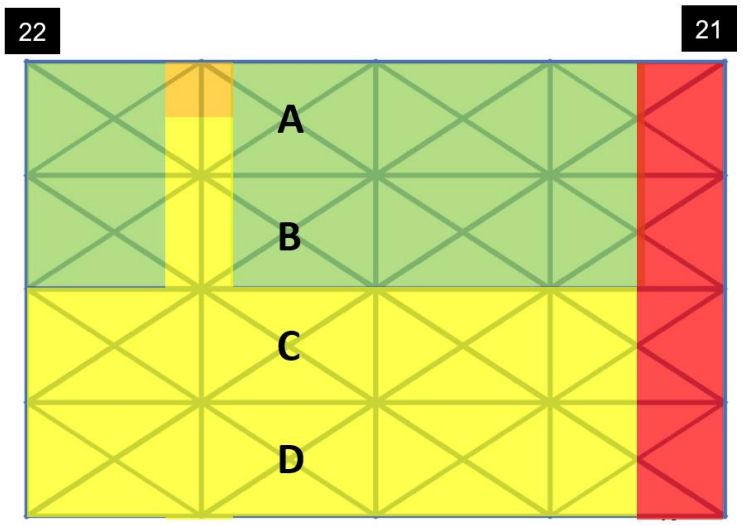


Figure 5-28 Vertical Heat Map for Bay 21-22

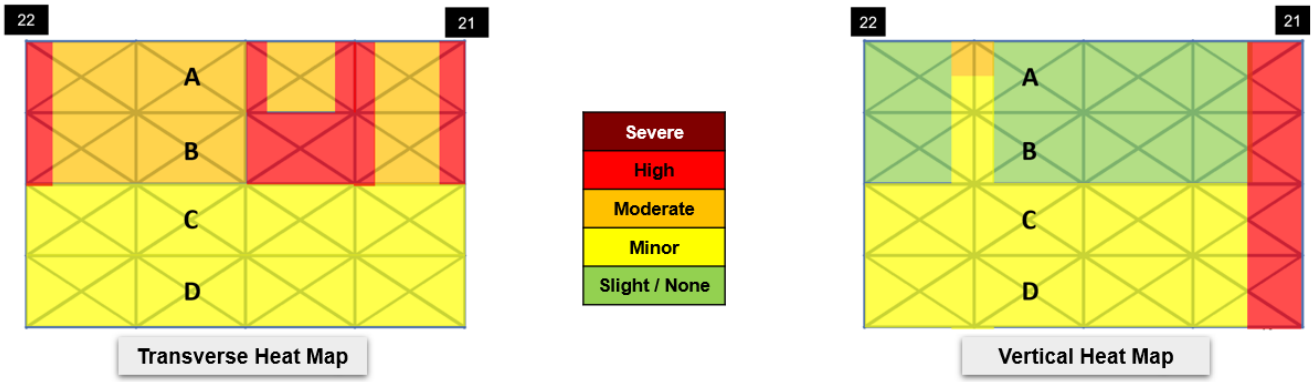


Figure 5-29 Combined Heat Maps for Bay 21-22

Bay 21-22 exhibits moderate to high deterioration, with pronounced anomalies in both transverse and vertical modes. In the transverse heat map, significant localized curvature changes are observed in Panels A and B, particularly near Bent 21. Vertical mode analysis also reveals reduced frequency in Panels C and D, along with excessive longitudinal flexibility in Bent 21, pointing to potential deterioration in its below-deck components. Visual inspection confirms heavy cracking and spalling on Panel B (Figure 5-30), further supporting the structural concerns identified through the analysis.



Figure 5-30 Panel B large cracking and spalling area Bay 21-22

5.7 Mode Shape Evaluation - Bay 27-28

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 27-28 (Figure 5-31).

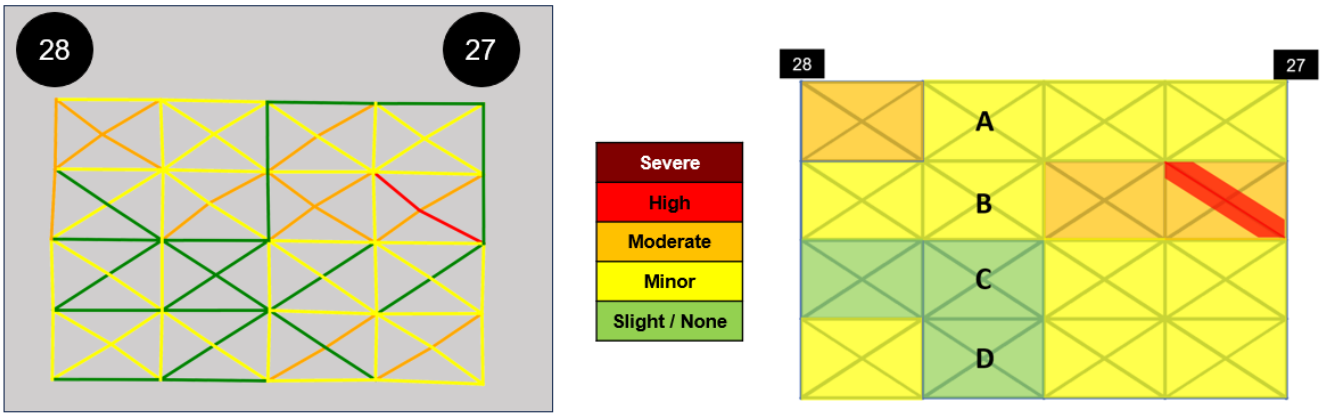


Figure 5-31 Transverse Heat Map generation Bay 27-28

For Bay 27-28, the vertical mode analysis reveals moderate inconsistencies across several key locations. The West-Mid and Middle Node rows exhibit elevated STDEV values of 4.6%, indicating irregular mode shape behavior. The West Mid panel zone also reaches a STDEV of 7.9%, approaching the threshold for high inconsistency. These findings suggest uneven vertical flexibility, particularly concentrated in the western and central sections, pointing to developing structural irregularities in this bay.

Table 5-14 Node Vertical Magnitude Comparison for the edge nodes Bay 27-28

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.11	0.71	1.00	0.56	0.10	0.50
SK C-D	0.12	0.72	0.98	0.69	0.11	0.53
SK B-C	0.11	0.68	1.00	0.69	0.11	0.52
SK A-B	0.10	0.66	0.91	0.65	0.09	0.48
NORTH EDGE	0.06	0.59	0.89	0.61	0.07	0.45
AVG	0.10	0.67	0.96	0.64	0.09	
STDEV	1.9%	4.6%	4.6%	5.0%	1.6%	

As is shown in Tables 5-14 and 5-15, Panels A and B exhibit unexpected behavior, with vertical flexibility levels deviating from adjacent panels, highlighted by elevated STDEV values and visible deformation in the mode shape side and front views. Additionally, the east side of Panel D displays localized inconsistency in vertical response. These findings are used to prepare the final heat map, identifying moderate to high deterioration concentrated in the upper and eastern portions of the bay. From the side view, Panels A and B display significant inconsistency in vertical flexibility, along with the East-Mid node on the southern edge of Panel D. These irregularities are further supported by the front view, which reveals that the in-plane nodes at both the West-Mid and East-Mid positions exhibit noticeable inconsistency (Figure 5-32).

Table 5-15 Node Vertical Magnitude Comparison for the in-plane nodes Bay 27-28

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.38	0.91	0.91	0.31	0.63
PANEL C	0.4	0.97	0.91	0.38	0.67
PANEL B	0.42	0.81	0.82	0.38	0.61
PANEL A	0.33	0.76	0.82	0.36	0.57
AVG	0.38	0.86	0.87	0.36	
STDEV	3.5%	7.9%	4.6%	2.9%	

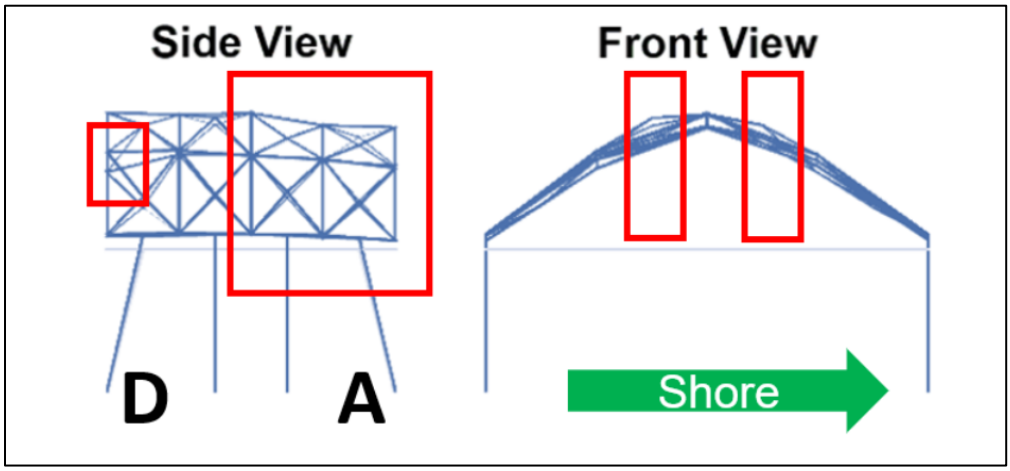


Figure 5-32 Side view and Front View of 1st Vertical Mode of Bay 27-28

Overall, based on all identified anomalies, the vertical mode heat map for Bay 27-28 was generated (Figure 5-33). The shear key between Panels A and B is marked in red due to a significant deviation in consistency at that location, indicating a concentrated change in structural

stiffness. This area represents a critical zone of concern where vertical flexibility irregularities are most pronounced.

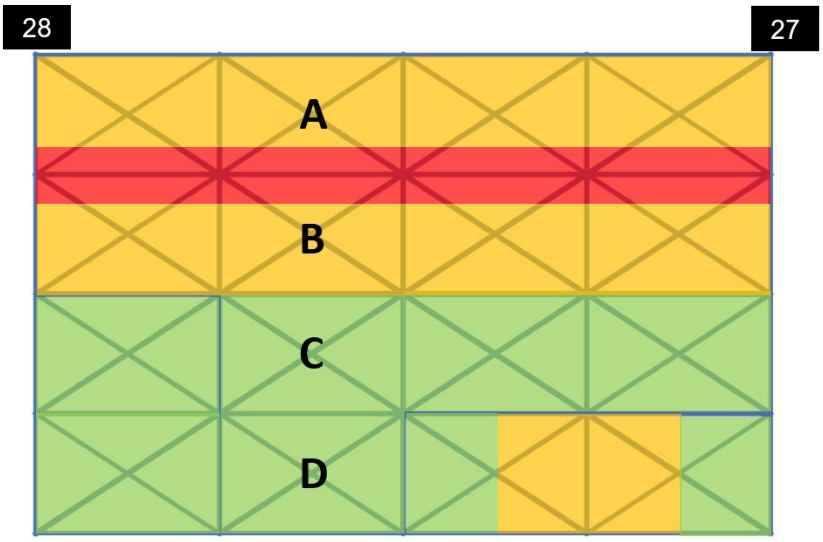


Figure 5-33 Vertical Heat Map for Bay 27-28

Bay 27-28 exhibits moderate to high deterioration overall. The transverse heat map reveals an unexpected inconsistency at Shear Key A-B, indicating a potential localized stiffness change. In the vertical mode, Panels A and B demonstrate significant flexibility deviations, with additional localized irregularities observed on the east side of Panel D (Figure 5-34). Visual inspection confirms these findings, with large cracks identified on Panel A and surface deterioration on Panels B and D (Figure 5-35). These combined observations suggest a need for further structural attention in the upper sections of this bay.

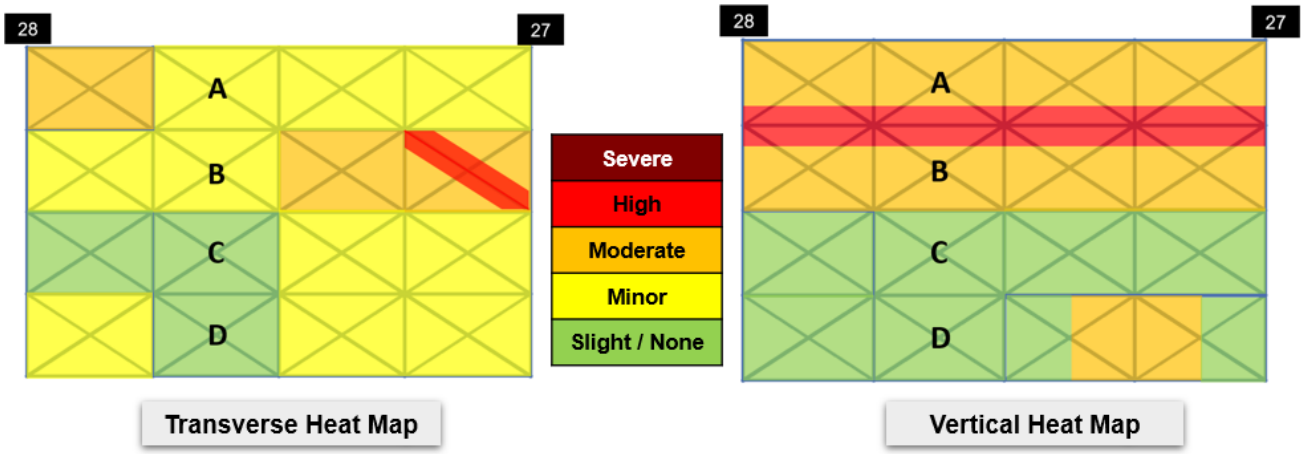


Figure 5-34 Combined Heat Maps for Bay 27-28



Figure 5-35 Large cracks have been observed on Panel A Bay 27-28

5.8 Mode Shape Evaluation - Bay 30-31

Based on the localized curvature change, the heat map for the transverse mode is generated for Bay 30-31 (Figure 5-36).

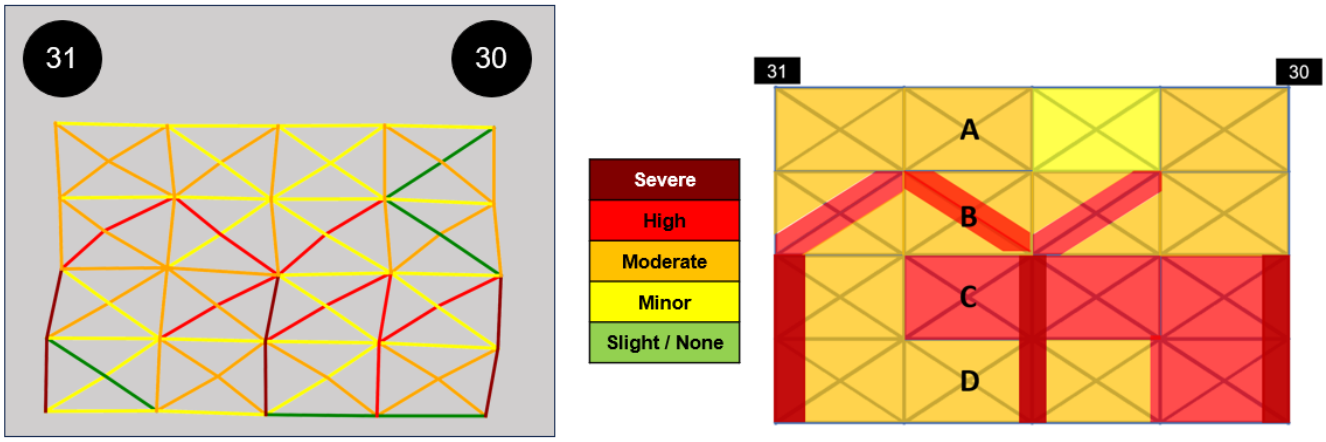


Figure 5-36 Transverse Heat Map generation Bay 30-31

Bay 30-31 exhibits significant deterioration in the transverse mode at 1.69 Hz. The heat map reveals severe localized anomalies, especially concentrated in Panels C and D. Panel B also shows high curvature deviations, indicating notable structural irregularities. The distribution of red and dark red zones highlights substantial stiffness loss and distortion, suggesting this bay has one of the highest levels of transverse degradation among the evaluated spans.

For the vertical mode, analysis indicates localized inconsistencies, particularly at the Mid Node and East-Mid zones. The Mid Node shows a STDEV of 2.5%, and the East-Mid panel zone reached 2.7%, both falling in the “Minor” anomaly range (Table 5-14 and 5-15). These results suggest mild deviations in vertical flexibility, especially around the southern and central sections. Although not severe, the presence of these irregularities supports the overall assessment of structural degradation observed in the transverse mode.

Table 5-16 Node Vertical Magnitude Comparison for the edge nodes Bay 30-31

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.15	0.77	0.98	0.75	0.1	0.55
SK C-D	0.14	0.75	1.00	0.73	0.09	0.54
SK B-C	0.11	0.76	0.98	0.68	0.09	0.53
SK A-B	0.12	0.76	0.93	0.65	0.06	0.50
NORTH EDGE	0.11	0.73	0.96	0.65	0.07	0.50
AVG	0.12	0.75	0.97	0.69	0.08	
STDEV	1.5%	1.2%	2.5%	4.0%	1.7%	

Table 5-17 Node Vertical Magnitude Comparison for the in-plane nodes Bay 30-31

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.47	0.94	0.93	0.47	0.7
PANEL C	0.47	0.94	0.9	0.42	0.68
PANEL B	0.41	0.9	0.93	0.43	0.67
PANEL A	0.44	0.91	0.98	0.46	0.7
AVG	0.45	0.92	0.94	0.44	
STDEV	2.3%	1.7%	2.7%	1.9%	

The shear key between Panels A and B exhibits vertical inconsistencies, as is shown in the vertical mode shape in Figure 5-37, not aligned with other shear keys, indicating localized stiffness variation. Additionally, in-panel nodes on the east side of Panels A and B show unexpected behavior, as confirmed through both side and front view observations (Figure 5-37). These irregularities contribute to the moderate anomaly ratings and highlight the need for closer monitoring of vertical performance in the northern portion of the bay.

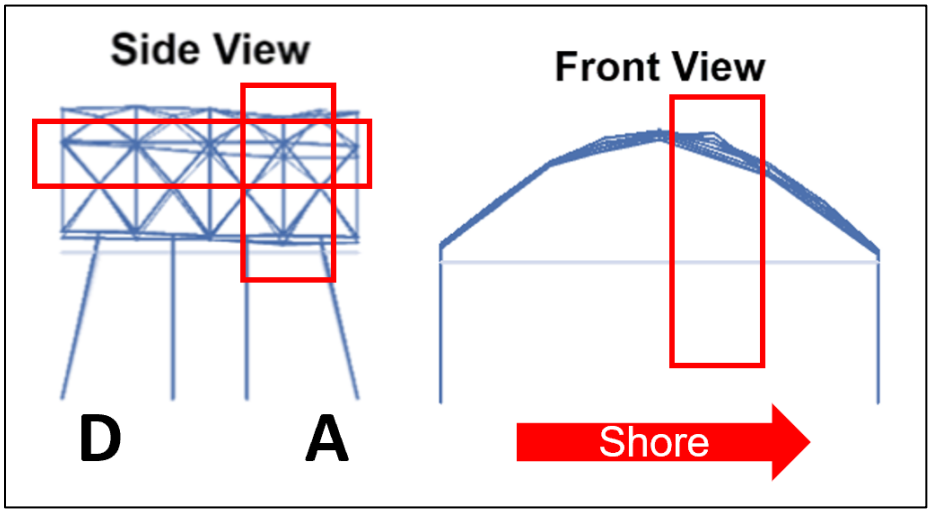


Figure 5-37 Side view and Front View of 1st Vertical Mode of Bay 30-31

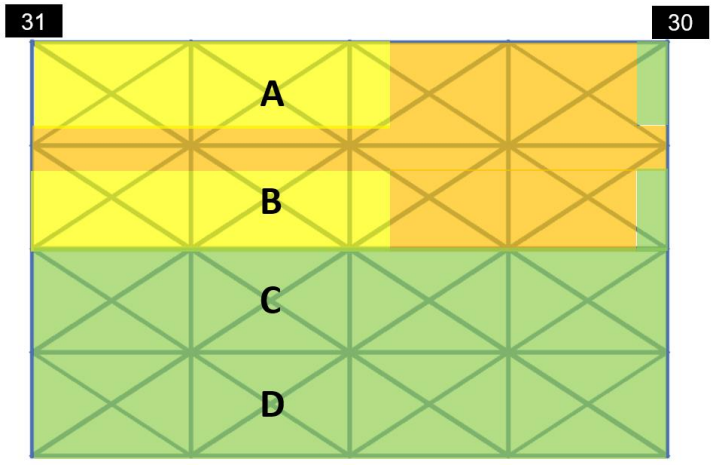


Figure 5-38 Vertical Heat Map for Bay 30-31

Overall, Bay 30-31 exhibits high to severe deterioration in the transverse mode, particularly concentrated in Panel C, which shows the most critical structural response. The vertical mode indicates minor to moderate deterioration, with irregularities noted in Panels A and B, especially on the east side (Figures 5-38 and 5-39). Visual inspection confirms structural distress in Panel C (Figure 5-40), where large cracks and spalling were observed on the soffit, reinforcing the heat map findings and underscoring the need for intervention in this bay.

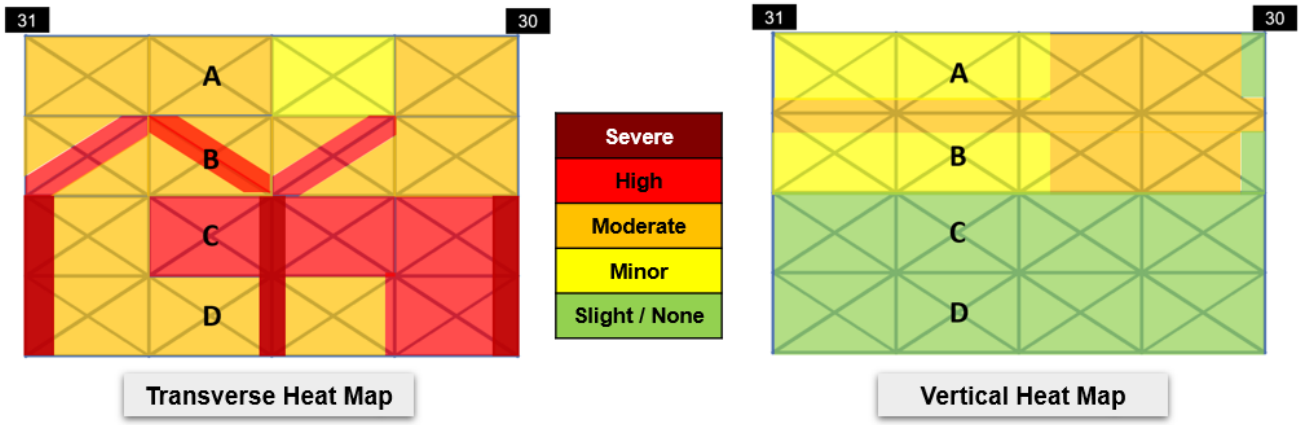


Figure 5-39 Combined Heat Maps for Bay 30-31



Figure 5-40 Panel C large cracks and spalling, Bay 30-31

5.9 Mode Shape Evaluation - Bay 32-33

Bay 32-33 exhibits widespread and severe deterioration in the transverse mode at 1.48 Hz. The heat map highlights a concentration of anomalies throughout the western half of the bay, particularly in Panels B, C, and D, where severe curvature deviations are observed. Panel B shows asymmetric deformation at multiple locations, and Panel C displays the most critical anomaly, extending fully across its width. These findings suggest substantial loss of stiffness and structural integrity, indicating that Bay 32-33 is among the most deteriorated sections assessed in the superstructure (Figure 5-41).

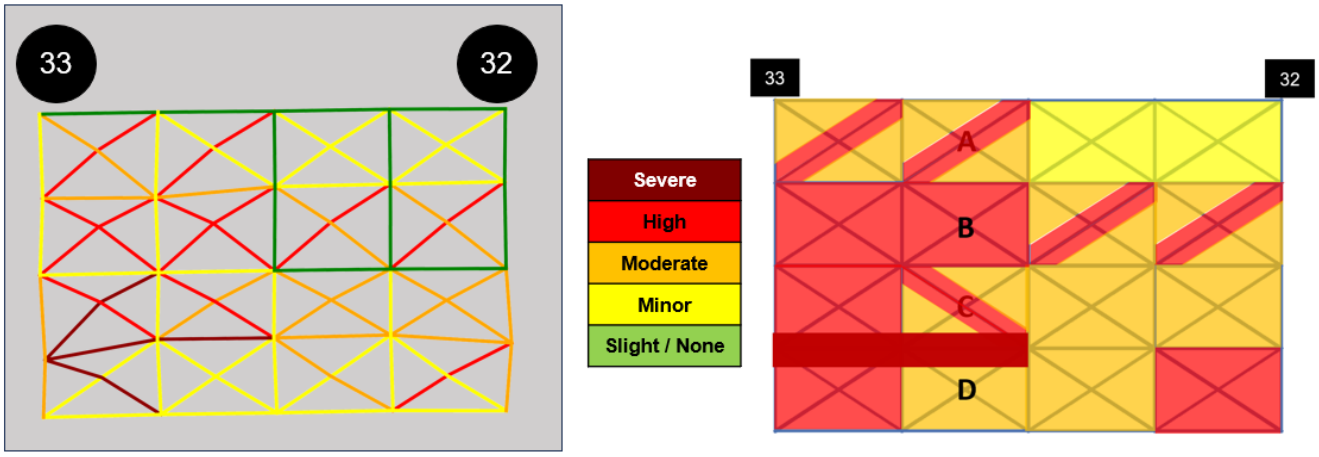


Figure 5-41 Transverse Heat Map generation Bay 32-33

For the vertical mode, analysis reveals severe inconsistency, particularly in the West Mid and Mid Node rows, and shear key B-C, where STDEV values reach 9.6% and 11.0%, respectively — well into the “High” and “Severe” ranges. These values indicate a substantial variation in vertical flexibility along those lines. Additionally, moderate irregularities are observed along the East-Mid line (Table 5-16). Panel-wise, flexibility appears more consistent, though slightly elevated variation is noted at the West Mid in-panel nodes (Table 5-17). These findings confirm significant degradation in vertical performance, supporting the severe deterioration observed in the transverse mode.

Table 5-18 Node Vertical Magnitude Comparison for the edge nodes Bay 32-33

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.10	0.58	0.73	0.52	0.05	0.40
SK C-D	0.09	0.55	0.72	0.52	0.06	0.39
SK B-C	0.12	0.76	1.00	0.71	0.09	0.54
SK A-B	0.12	0.74	0.71	0.53	0.07	0.43
NORTH EDGE	0.08	0.54	0.76	0.54	0.07	0.40
AVG	0.10	0.63	0.78	0.56	0.07	
STDEV	1.5%	9.6%	11.0%	7.1%	1.4%	

Table 5-19 Node Vertical Magnitude Comparison for the in-plane nodes Bay 32-33

IN-PANEL	WEST	WEST MID	EAST MID	EAST	AVG
PANEL D	0.32	0.67	0.71	0.31	0.5
PANEL C	0.32	0.69	0.69	0.3	0.5
PANEL B	0.32	0.63	0.67	0.28	0.48
PANEL A	0.3	0.63	0.7	0.27	0.47
AVG	0.31	0.65	0.69	0.29	
STDEV	1.0%	2.3%	1.7%	1.6%	

The side view indicates that the shear key between Panels B and C exhibits significant vertical flexibility, leading to the entire line being categorized as “High.” In the front view, Bent 32 shows unexpected longitudinal flexibility, similar to the behavior observed in Bay 21-22. This suggests that the below-deck components of Bent 32 may have deteriorated, contributing to the excessive movement and structural inconsistency in this area (Figure 5-42).

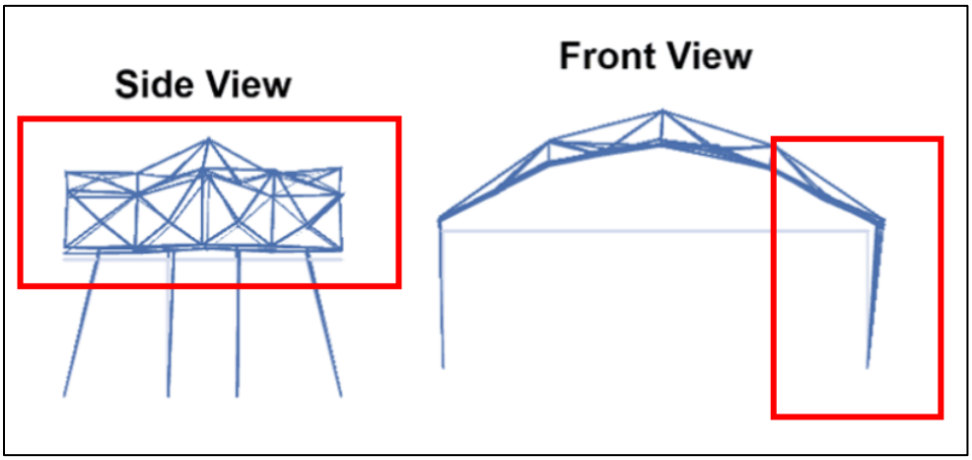


Figure 5-42 Side view and Front View of 1st Vertical Mode of Bay 32-33

Figure 5-43 presents the final heat map for vertical mode in Bay 32-33, incorporating all observed anomalies. The shear key between Panels B and C is rated as “High” due to pronounced flexibility, as confirmed from the side view. Additionally, the entire eastern edge and midspan along Panel B show severe inconsistency. The front view further highlights unexpected longitudinal flexibility at Bent 32, suggesting deterioration of its below-deck components. These combined factors result in the widespread red zones across Panel B and its edges, signalling a critical need for structural attention in this bay.

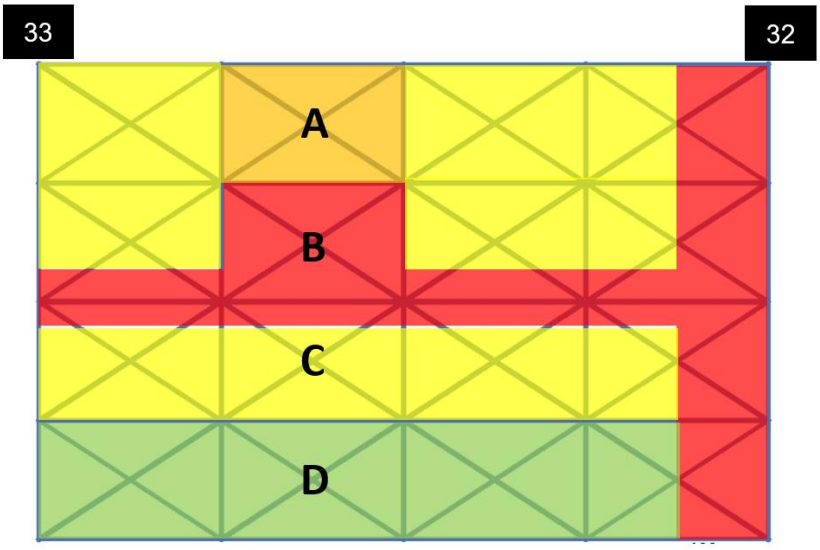


Figure 5-43 Vertical Heat Map for Bay 32-33

Figure 5-44 shows severe cracking in Panel C near the shear key B-C. The width and propagation of the cracks confirm the structural distress identified in the vertical mode analysis. This damage aligns with the high flexibility detected at the B-C shear key, further validating the heat map results and highlighting the need for immediate attention in this critical area.



Figure 5-44 Large cracking along the shear key B-C on Panel C, Bay 32-33

Bay 32-33 exhibits high to severe deterioration in the transverse mode and moderate to high deterioration in the vertical mode. Shear keys B-C and C-D show unexpected flexibility and

asymmetry (Figure 5-45), aligning with the severe deformation patterns seen in both mode shape heat maps. Notably, large cracks are visually identified in Panels A and C, particularly near the B-C shear key, as shown in the inspection photo. These findings confirm significant structural damage and highlight this bay as one of the most critically affected sections.

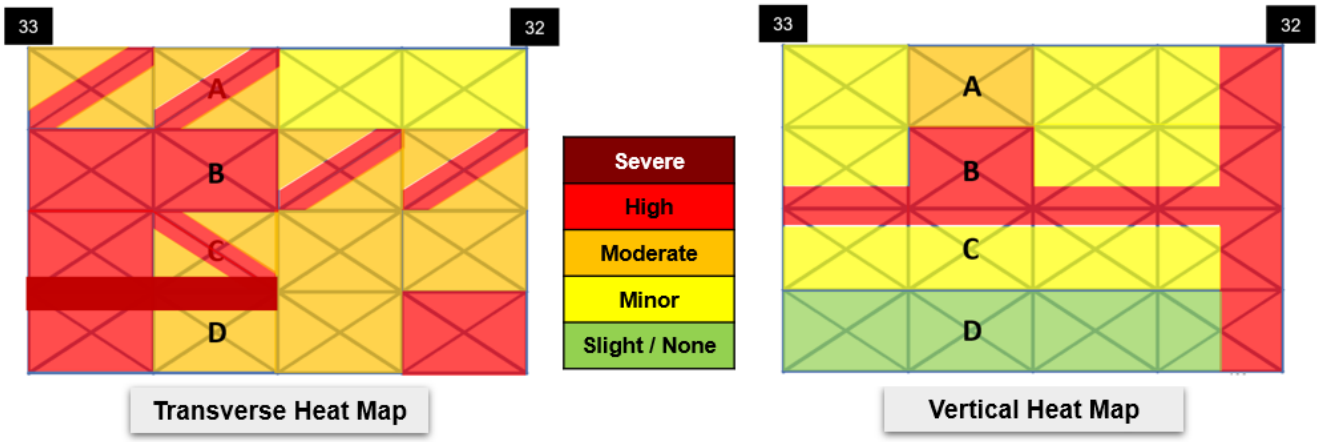


Figure 5-45 Combined Heat Maps for Bay 32-33

5.10 Mode Shape Evaluation - Bay 35-36

The superstructure heat map for the transverse mode provides a broader context for structural performance across the deck. Notable deformation is concentrated in the western region near the opening, where Panel B and the adjacent node area are marked in red, indicating severe lateral flexibility. Additional areas of high and moderate concern appear around Panel D and its eastern edge. This widespread pattern of irregularity, especially near key support locations and the central opening, reinforces previous findings and suggests significant lateral instability in the superstructure (Figure 5-46).

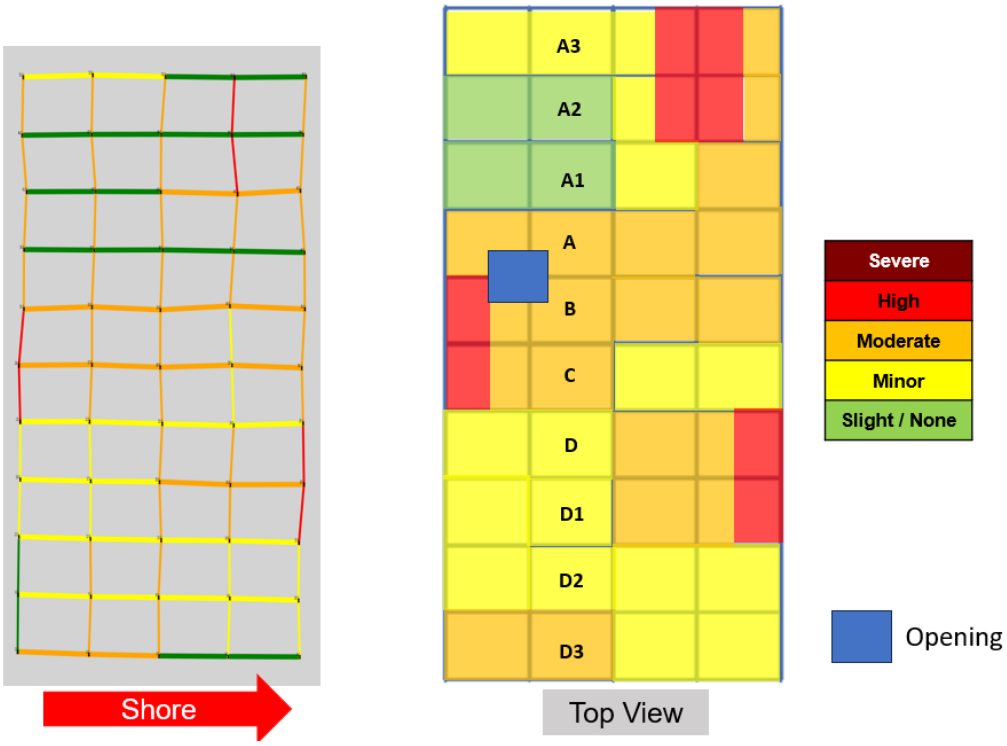


Figure 5-46 Transverse Heat Map generation Bay 35-36

Figure 5-47 highlights a critical area of deterioration observed at the west part of Panel A and B in Bay 35-36. The photo shows extensive spalling and exposed, corroded reinforcement, indicating severe degradation of the concrete cover. The mapped location on the floor plan corresponds with one of the severe anomalies identified in the transverse mode heat map, further validating the structural concerns in this region of the superstructure.

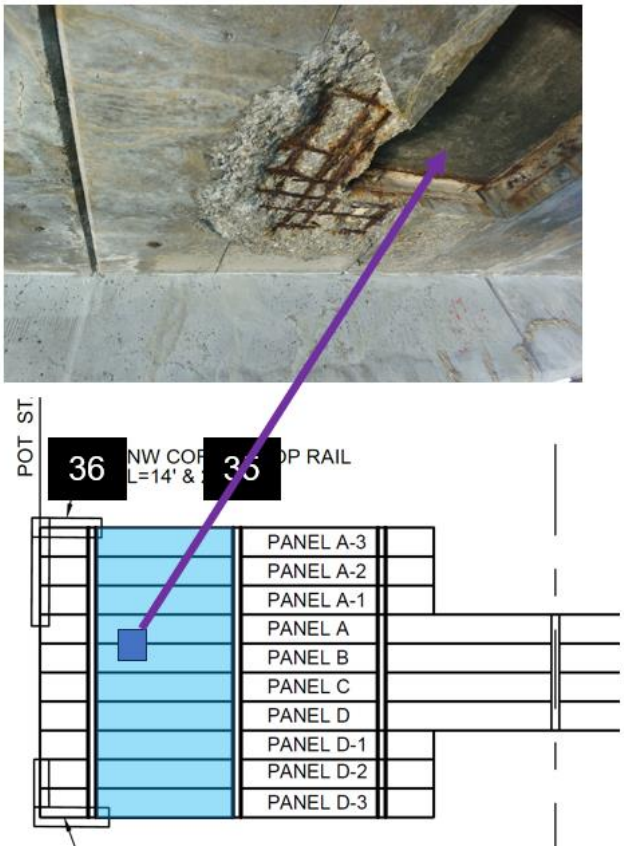


Figure 5-47 Large opening area on Panel A and B, Bay 35-36

For the vertical mode, the standard deviation (STDEV) values indicate that the nodes along the longitudinal direction—especially those between Panels D and C, A1 and A2, and A2 and A3—exhibit moderate inconsistencies in vertical flexibility, with STDEV ranging from 3.6% to 4.3% (Table 5-20). This suggests localized anomalies in these regions. While the mid nodes show consistent behavior, the surrounding edges and joints highlight variability. From the side view of the mode shape, the northern part of the east joint shows higher flexibilities compared with the west joint (Figure 5-48).

Table 5-20 Node Vertical Magnitude Comparison for the edge nodes Bay 35-36

	WEST JOINT	WEST MID	MID NODE	EAST MID	EAST JOINT	AVG
SOUTH EDGE	0.17	0.85	1.00	0.68	0.17	0.57
D3-D2	0.16	0.81	1.00	0.65	0.18	0.56
D2-D1	0.18	0.83	0.97	0.66	0.16	0.56
D1-D	0.16	0.82	0.95	0.69	0.18	0.56
D-C	0.02	0.79	0.98	0.68	0.17	0.53
C-B	0.15	0.81	0.95	0.65	0.19	0.55
B-A	0.11	0.81	0.95	0.67	0.20	0.55
A-A1	0.11	0.83	0.98	0.68	0.22	0.56
A1-A2	0.10	0.91	0.97	0.71	0.25	0.59
A2-A3	0.11	0.76	0.96	0.77	0.26	0.57
NORTH EDGE	0.13	0.75	0.99	0.76	0.26	0.58
AVG	0.13	0.81	0.97	0.69	0.20	
STDEV	4.3%	4.2%	1.8%	3.9%	3.6%	

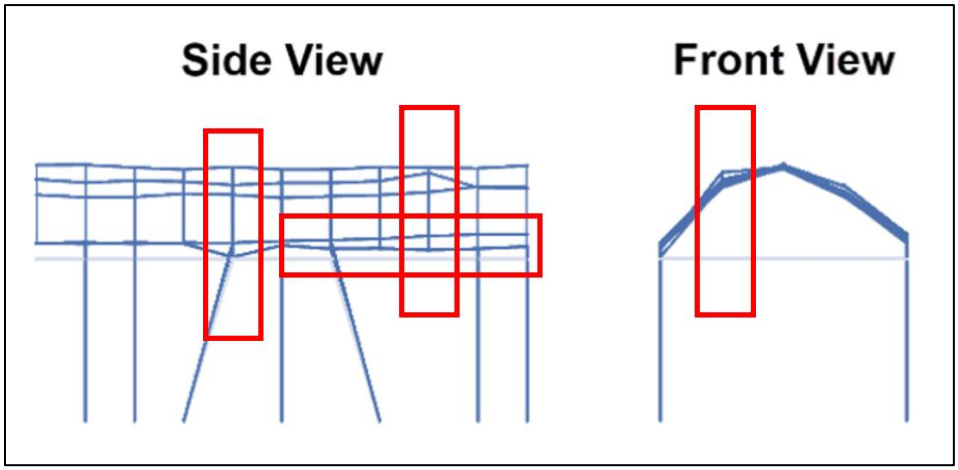


Figure 5-48: Side view and Front View of 1st Vertical Mode of Bay 35-36

Overall, the vertical heat map is generated (Figure 5-49) based on the identified inconsistencies in vertical flexibility, notably at Shear Keys A2–A1 and C–D, which both displayed behavior that deviated from adjacent shear keys. Additionally, the northern side of Bay 35-36 shows moderate vertical anomalies, suggesting localized stiffness variation. These findings align with the previously quantified STDEV results and observed below-deck deterioration near the northwest corner of the structure.

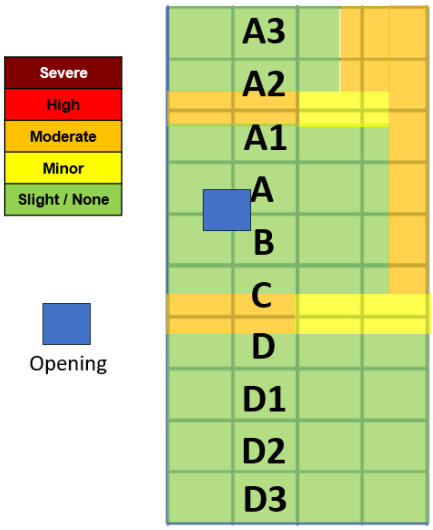


Figure 5-49 Vertical Heat Map for Bay 35-36

Overall, the transverse heat map indicates Moderate to High deterioration, particularly on the western edge near Panels A3 and D1 (Figure 5-50). The vertical mode results show mostly Minor to Moderate deterioration, with localized issues observed around Shear Keys A2–A1 and C–D. Notably, the opening between Panels A and B exhibits visible corrosion and spalling, as seen in the inspection photo, suggesting that this localized damage may contribute to further structural degradation in the area.

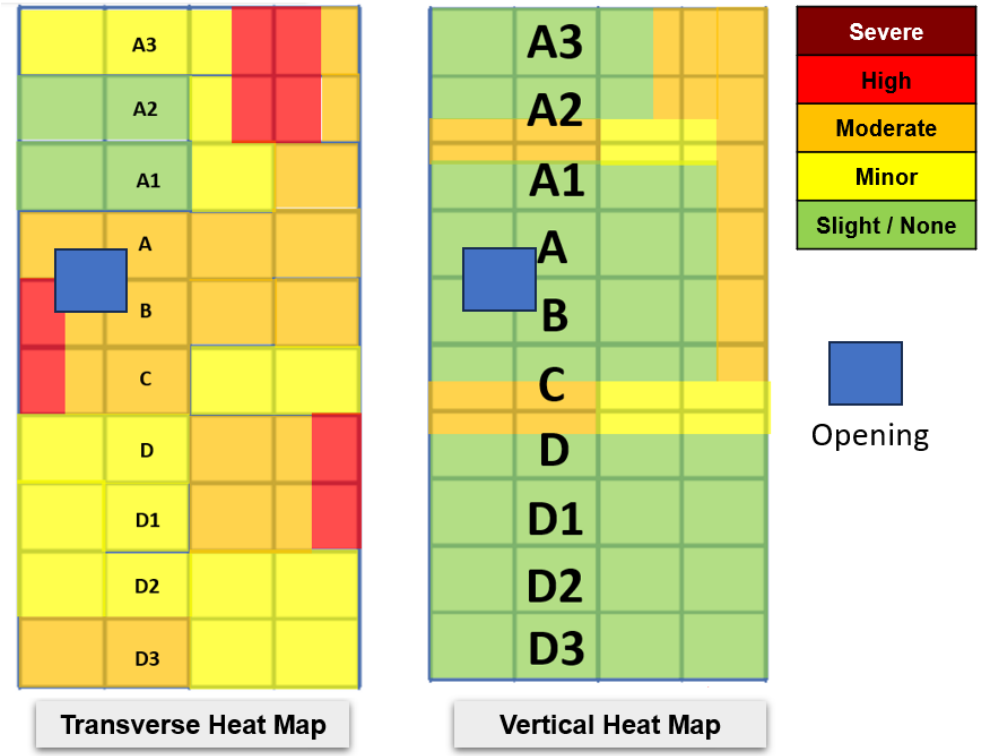


Figure 5-50 Combined Heat Maps for Bay 35-36

5.11 Frequency Comparison and Discussion

The frequency comparison across the evaluated bays reveals patterns in structural stiffness and potential deterioration (Table 5-21). In the 1st vertical mode, the most impactful mode for the structure, frequencies show variation depending on bay locations and structural integrity, providing insight into the relative stiffness of each zone. These frequencies were grouped among three groups: the three-pile bay configurations (blue), the four-pile bay configurations (green), and the uniquely shaped Bay 35-36 (orange).

Table 5-21 Frequency Comparison for all the tested bays

Frequency (Hz)	10-11	12-13	13-14	15-16	18-19	21-22	27-28	30-31	32-33	35-36
1st Vertical Mode	8.42	8.13	8.11	8.04	8.06	8.24	10.34	9.38	9.20	10.80

Among the three-pile bay configurations, Bay 15–16 exhibits the lowest vertical mode frequency at 8.04 Hz, indicating reduced global stiffness in this region. This observation aligns with mode shape analyses, which reveal high to severe deterioration, especially in the transverse direction. Such a frequency drop suggests possible structural weakening in both the superstructure and substructure components.

Among the four-pile bays, Bay 21–22 exhibits the lowest frequency of 8.24 Hz, approximately 20% lower than other bays such as 27–28, which recorded frequencies of 10.34 Hz. The drop in resonance frequency in Bay 21–22 corresponds to the excessive longitudinal flexibility observed in the mode shape, pointing toward possible stiffness loss in the Bent 21 support system or deterioration in below-deck components. This correlation reinforces the reliability of using modal frequency data as an indicator of structural condition.

Bays 30–31 and 32–33, also four-pile bays, show relatively low frequencies at 9.38 Hz and 9.20 Hz, respectively. These values, while not as low as bay 21–22, still fall beneath typical healthy thresholds for similar structural configurations. These results are consistent with observed damage in the corresponding heat maps, where both bays present widespread deterioration, particularly in transverse directions. The combined interpretation of frequency values and mode shape anomalies suggests that these bays are experiencing compromised structural performance and warrant closer inspection or mitigation planning.

Overall, the frequency comparison demonstrates strong alignment with visual and modal evaluation findings, offering a valuable diagnostic tool to identify zones with reduced stiffness and potential structural issues.

6 Conclusion

This report presented the results of the baseline test of targeted bays of the Hermosa Beach Pier using Sensequake's proprietary sensing-based structural health monitoring to evaluate its integrity and detect and locate major damage if any.

The Hermosa Beach Pier has overall 36 bays, 10 of which were selected for evaluation. The majority of the bays are constructed by four prestressed concrete panels linked by shear keys and supported by two bents, 30.5 feet in length and 20 feet wide for the span. The end bay, Bay 35-36 has 10 concrete panels linked by shear keys. The existing pier was constructed in 1965. Sensequake’s unique baseline identification of the Pier was performed to identify its as-is baseline parameters.

The following was achieved using the measured data:

- Multiple 3D mode shapes and natural frequencies (dynamic properties or stiffness baselines);
- Multiple structural integrity baselines for the individual bays of the Pier;
- [redacted]

The evaluation revealed that all tested bays exhibited varying levels of deterioration, with notable damage concentrated in specific panels and structural regions. Bays 15–16, 21–22, 30–31, and 32–33 showed moderate to high deterioration in both transverse and vertical modes. In particular, Panels B, C, and D across multiple bays were frequently identified as zones of concern, often associated with visible cracks, spalling, or delamination. Severe anomalies were most prominent in Bay 32–33, where both mode shape distortion and frequency drop confirmed critical loss of stiffness and structural degradation.

Vertical mode evaluations revealed widespread localized flexibility, particularly along shear keys and midspan nodes, with elevated standard deviation (STDEV) values often exceeding 3%, and in some cases reaching levels classified as “High” or “Severe.” The presence of excessive

longitudinal flexibility in Bents 21 and 32 suggested possible substructure deterioration, likely in the form of weakened piles or below-deck components.

Transverse mode shape assessments consistently highlighted curvature changes at shear key connections, with many spans showing clear asymmetries and deformation patterns. These findings were validated by observed damage, such as large cracks near shear key B–C in Bay 32–33 and widespread soffit deterioration in Panels C and D of Bay 30–31. In Bay 35–36, the unique ten-panel configuration displayed asymmetrical flexibility, particularly in the opening area, where exposed reinforcement and spalling were documented.

Frequency comparison across the spans further supported the heat map results. Lower natural frequencies correlated well with regions of reduced stiffness and higher deterioration. Notably, Bay 21–22 and Bay 15–16 had the lowest recorded vertical mode frequencies (8.04 Hz), indicating significant structural flexibility relative to other spans such as Bay 27–28 and Bay 35–36, which maintained higher frequencies over 10 Hz.

In summary, the combination of dynamic testing, curvature quantification, vertical flexibility analysis, and visual inspection has provided a detailed and reliable assessment of the Hermosa Beach Pier's structural condition. The findings confirm that multiple spans are experiencing progressive deterioration, with several regions requiring immediate attention or further investigation.

Future repetition of this same test can be used for long-term structural health management and support the development of targeted maintenance and retrofit strategies to extend the Pier’s service life.

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Appendix A – Sensor Layout



