Long-Term Settlement of the Caminada Headland Beach Nourishment and Dune Restoration in Coastal Louisiana

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Caminada Beach & Dune Restoration Project
Barrier Island Morphology

*Figure modified from Rosati (2009)
Areal Subsidence vs Consolidation

-9.27 mm/yr
-3.38 mm/yr
Settlement Theory

Terzaghi’s Small Strain (SETTLE\textsuperscript{3D})
- Small strain physically means the thickness of the compressible layer is significantly greater than the magnitude of compression.
- Constant coefficient of compressibility ($a_v = \Delta e / \Delta \sigma'$).

Finite Strain (PSDDF)
- Non-linear stress-strain relationships ($a_v$ changes with effective stress).
- Large strains are predicted.

Goal: Develop calibrated 1-D model using SETTLE\textsuperscript{3D} and PSDDF based on field measurements and show applicability of both software (theories) in foundation settlement.
Analysis Methodology

- Subsurface Investigation
  - Geotechnical Interpretation
  - Settlement Model (Settle\textsuperscript{3D}/PSDDF)
    - Settlement vs Time Comparison
    - Field Data (SP, Anchor)
  - Survey Data
  - Surcharge Load
  - Borrow Pit Data
Analysis Methodology

Subsurface Investigation

Geotechnical Interpretation

Settlement Model (Settle\textsuperscript{3D}/PSDDF)

Survey Data

Borrow Pit Data

Surcharge Load

Settlement vs Time Comparison

Field Data (SP, Anchor)
Soil Stratigraphy at Caminada Headlands

*Pleistocene depth from Heinrich et al. (2015)*
Caminada Beach & Dune Restoration Project
Sediment Layer Profiles

\[ k_v = c_v m_v \gamma_w \]
Caminada Headlands Compressibility Correlations

(a) $C_c = \frac{w_n}{106}$
$R^2 = 0.54$

(b) $C_c = \frac{w_n}{106}$
$R^2 = 0.54$

(c) $C_c = 0.39e_o + 0.06$
$R^2 = 0.63$

(d) Equations

(e) Equations
Caminada Headlands Compressibility Correlations

\[ e_0 = 2.61w_n + 0.07 \]
\[ R^2 = 0.93 \]

\[ C_k = 0.5e_0 \]
\[ C_k = 0.27e_0 \]
\[ R^2 = 0.62 \]
Analysis Methodology

1. Subsurface Investigation
2. Geotechnical Interpretation
3. Survey Data
4. Borrow Pit Data
5. Surcharge Load

Settlement Model (Settle$^{3D}$/PSDDF)

Settlement vs Time Comparison

Field Data (SP, Anchor)
Surcharge Stress Prediction

- Dredged sand moisture unit weight ~ 18.2 kN/m³ based on particle size gradation (Cu=4.06 and Cc=1.95).

- Analysis showed minimal stress distribution occurred, i.e. near constant increase in applied stress with depth through entire substratum.
Analysis Methodology

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Subsurface Investigation

Geotechnical Interpretation

Survey Data

Borrow Pit Data

Surcharge Load

Settlement Model (Settle^{3D}/PSDDF)

Settlement vs Time Comparison

Field Data (SP, Anchor)
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Settlement vs Time Relationships (Site B)

- SP
- 6.9 m
- 20.7 m
- 27.9 m
Settlement vs Time Relationships (Site C)

- Field Data
- Settle 3D
- PSDDF
Comparison of Laboratory Data to Calibrated Model
Contribution of Settlement from Compressible Layers

Site A

Site B

Site C

Depth (m)

Normalized Settlement (S/Sp)
Summary & Conclusions

• 1-D analyses using Settle$^{3D}$ and PSDDF were used to predict the field observed settlement at three instrumented sites. Both are applicable for foundation sediment.

• Provide guidelines for using both software packages (input parameters, loading, boundary conditions, and post processing).

• PSDDF can be applied in fine-grained dredged sediment (self-weight consolidation) in marsh creation projects.
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Questions?

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References