Geotechnical properties of salt marsh and tidal flat substrates at Tillingham, Essex

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Introduction:

Salt marshes attenuate incoming currents. Hence, marshes are an integral part of the coastal profile that protects the hinterland from incoming waves or tides.

But, marshes are declining both worldwide and in the UK. Marsh stability depends on the hydrodynamic force incident upon the landform and the resistance of the marsh platform and margin to erosion. This resistance will reflect biological, biogeochemical and sedimentological marsh properties.

Figure 1: Photo taken at Tillingham (17/02/17).

Here, we present results of marsh and mudflat substrate geotechnical properties at Tillingham, Essex, (Fig.1) and place these results in the context of recent marsh morphological change. In future, this will improve understanding of how the natural marsh can be used in conjunction with engineered sea defences to reduce flood risk.

Field Site:

Tillingham Marsh, Essex (Fig.2) was chosen for the pilot study.

- Located on the Dengie Peninsula.
- Ridge-runnel marsh edge morphology.
- Open coast marsh. Fetch exceeds 100 km for certain wind directions.

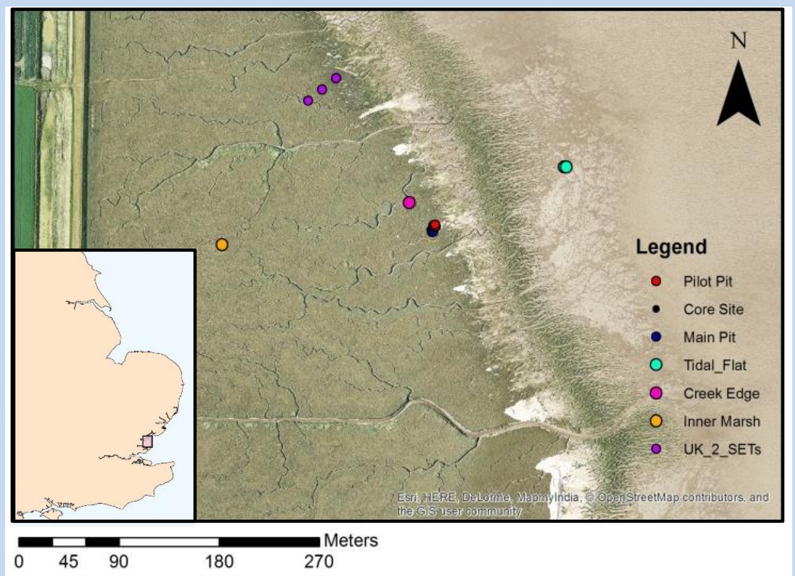

Figure 2: Map of sampling locations and surface elevation tables (SETs).

Why are we interested?

- There has been little research into marsh geotechnical properties and that which exists (e.g. ref.1) does not relate to the range of possible erosion mechanisms (e.g. ref.2).
- There is no systematic study relating marsh geotechnical properties to biological or geochemical properties.
- 'Erodibility coefficients' in marsh evolution models (e.g. ref.3):
  - are not linked to measured biogeochemical/biological properties.
  - do not encompass the range of possible erosion mechanisms (e.g. ref.2).

Particle Size and Organics:

- Variable LOI in upper core, lower LOI at base (Fig. 3).
- Fluctuating clay/silt/sand in upper core, sandy base layer.
- Generally low sand content (at least until base layer).

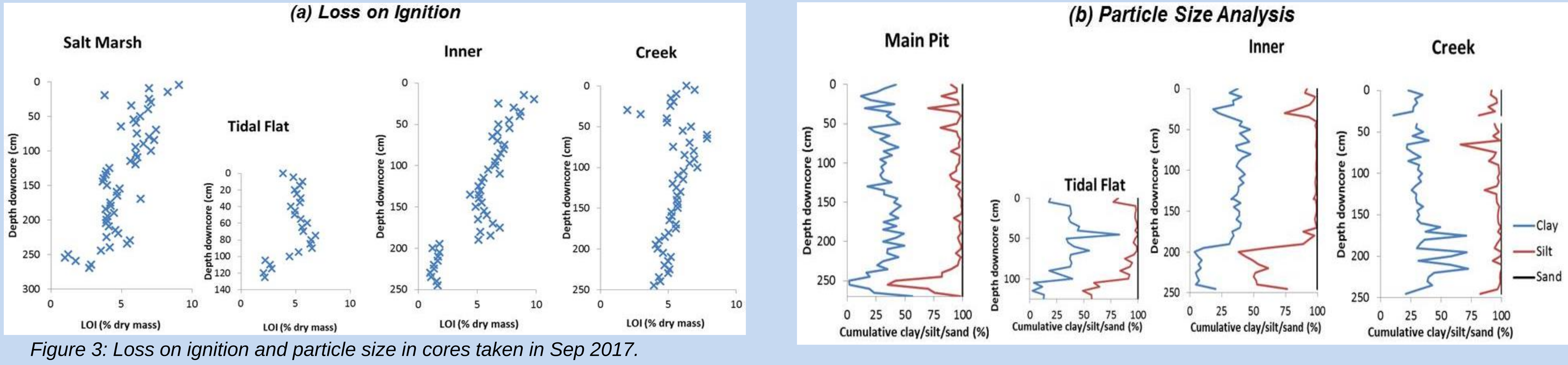

Figure 3: Loss on ignition and particle size in cores taken in Sep 2017.

Plasticity:

- High/very high plasticity clays on marsh, slightly lower plasticity on the mudflat (Fig.5)
- All values plot close to the A-line-mixture of clay-type and silt-type behaviour.
- No consistent variation with depth, though plasticity decreases with depth in the upper 30 cm for the main pit and the creek.

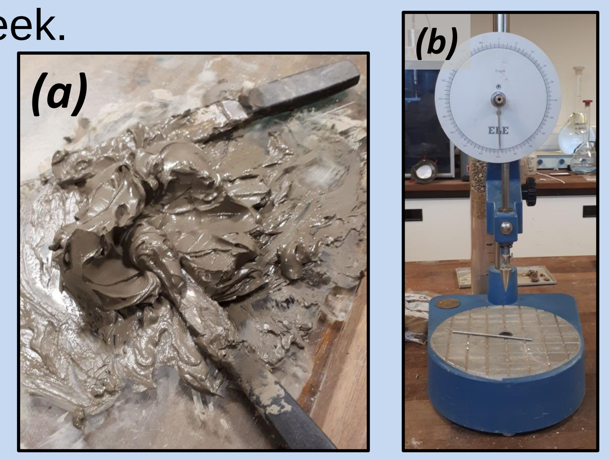

Figure 4: Example sample for liquid limit testing (a). Cone penetrometer, used to calculate liquid limit (b).

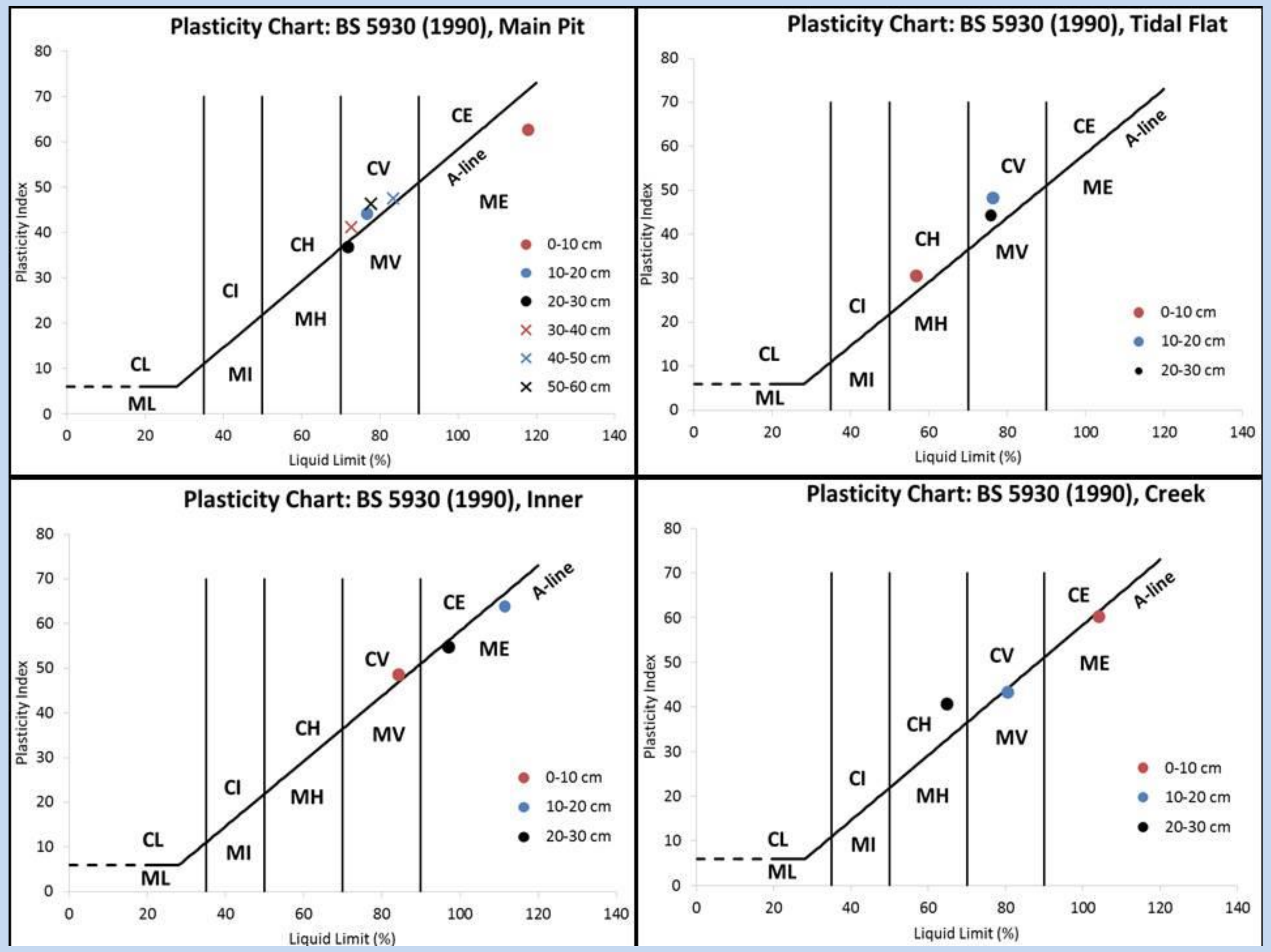

Figure 5: Plasticity charts for main sampling locations at varying depths.

Morphological Change:

Vertical:

- At SET sites (Fig.2), marsh accreted 10-20 mm (Nov 2012 to July 2017)

Lateral:

- Mapped from first and most recent aerial photographs (1992 and 2015).
- Initial analysis shows variable retreat along the Dengie peninsula (~15-60 m).

Future Research:

Assessment of links between geotechnical properties and marsh stability over instantaneous (erosion thresholds) and multi-annual timescales.

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References:
1. Crooks, S. & Pye, K. (2000). Sedimentological controls on the erosion and morphology of saltmarshes: implications for flood defence and habitat recreation. *Geol Soc, London, Spec Pub.* https://doi.org/10.1144/GSL.SP.2000.175.01.16. **2.** Mariotti, G. & Fagherazzi, S. (2013). Critical width of tidal flats triggers marsh collapse in the absence of sea-level rise. *PNAS*, **110**(14), 5353–5356. **3.** Mariotti, G. & Carr, J. (2014). Dual role of salt marsh retreat: Long-term loss and short-term resilience. *Water Resour. Res.*, **50**(4), 2963–2974.

Laboratory Shear Strength:

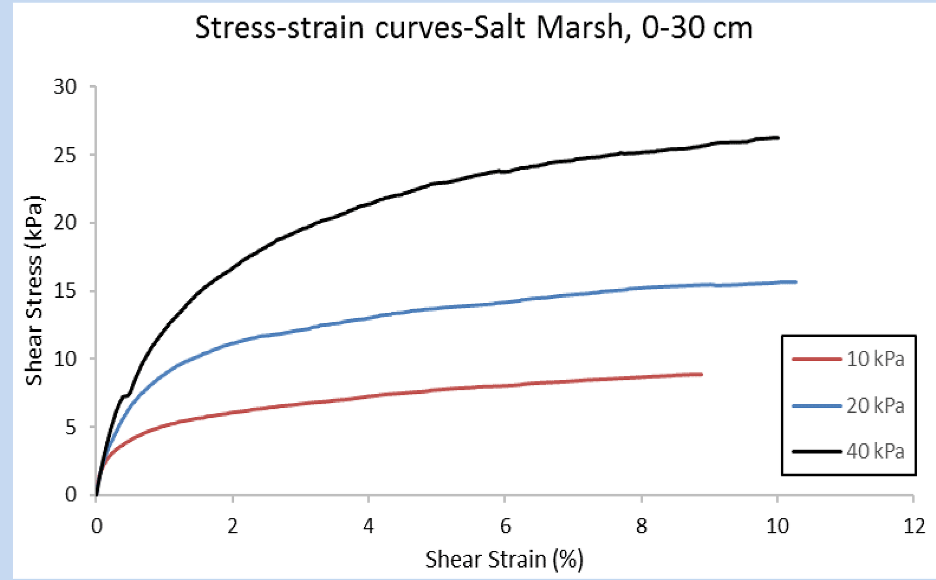

Figure 6: Example stress-strain curve (taken from 0-30 cm depth).

- Ductile behaviour (Fig.6)
- Shows stress-dependent strength behaviour

Sample ID	Cohesion (kPa)	Friction Angle (°)
Marsh, 0-30 cm	3.56	29.8
Marsh, 30-60 cm	5.68	29.9
Tidal flat, 0-30 cm	0	36.1

Table 1: Cohesive and frictional properties derived from shear box tests.

- Frictional strength has greater importance on the mudflat (Table 1).
- Cohesive strength is relatively more important on the marsh.

In Situ Shear Strength:

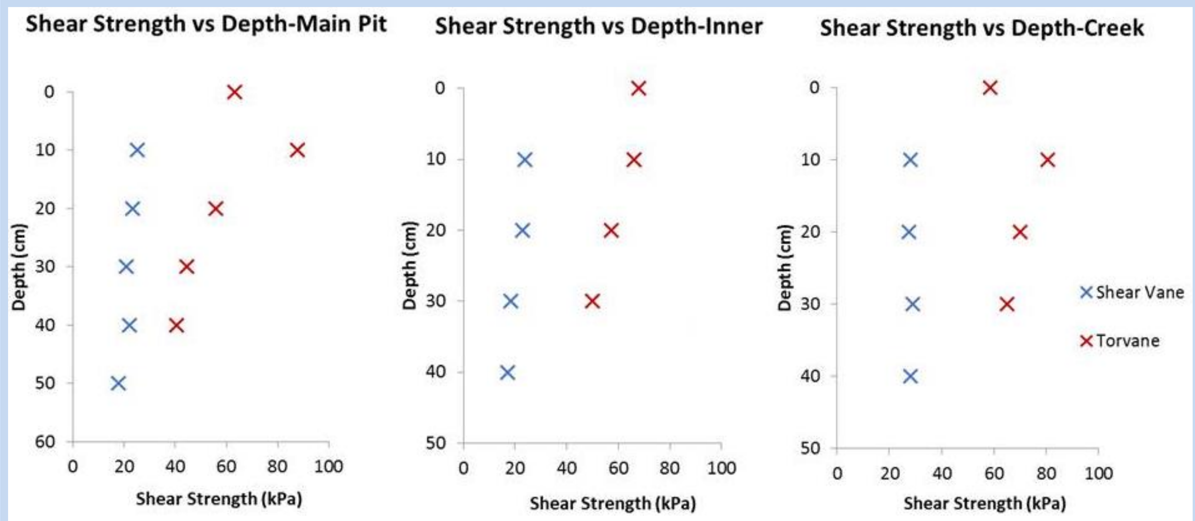

Figure 7: Shear vane and torvane results for main sampling sites.

- Measured using shear vane, torvane and cohesive strength meter (CSM)
- The torvane consistently recorded higher shear strengths than shear vane (Fig. 7).
- The creek edge was stronger than the other two sites.

Sample Location	Shear Vane (average; kPa)	Torvane (average; kPa)
Main Pit	21.89	58.32
Inner Marsh	20.58	60.31
Creek Edge	28.22	68.56

Table 2: Shear vane and torvane results for main sampling locations.