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FE Evaluation of Landowner Dispute Following Retaining Wall Failure

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Abstract

This forensic engineering evaluation addressed a dispute between two neighboring landowners regarding cost-sharing associated with the repair of a failed retaining wall dividing the two properties. Qualitative forensic analyses considered both demand-based (i.e., lateral earth pressures, pore pressures, surcharge) and capacity-based (i.e., materials, configuration, drainage) factors to illustrate influence both parties had on the magnitudes of these loads. This paper outlines the qualitative forensic analyses that aided in resolution of the dispute before trial.

Keywords

Lateral earth pressure, property line, retaining wall, soil movement, forensic engineering

Setting/Context

This case involves a dispute between two neighboring property owners regarding costs associated with replacement of a compromised retaining wall. The orientation and location of the retaining wall relative to the two properties is shown in **Figure 1**. The two properties are situated near the top of a gradually sloping topographic knoll. The defendant's parcel is situated up-slope of the plaintiff's property.

The original retaining wall was constructed from pressure-treated lumber. A chain link fence was also physically attached to the wooden retaining wall. The retaining wall, which is approximately 3.5 ft in height, is situated immediately adjacent to the property line between the two neighboring properties (**Figure 2**). The area in front of the retaining wall and behind the retaining wall were used primarily as parking areas — both before and after the replacement of the retaining wall. No design documentation or as-built information was available for the original retaining wall. Additionally, the retaining wall had been fully removed and replaced prior to the forensic engagement. Some photographic information was available, but no photographic information was available relative to the foundation conditions of the original retaining wall, which precluded meaningful structural analyses of the wall.

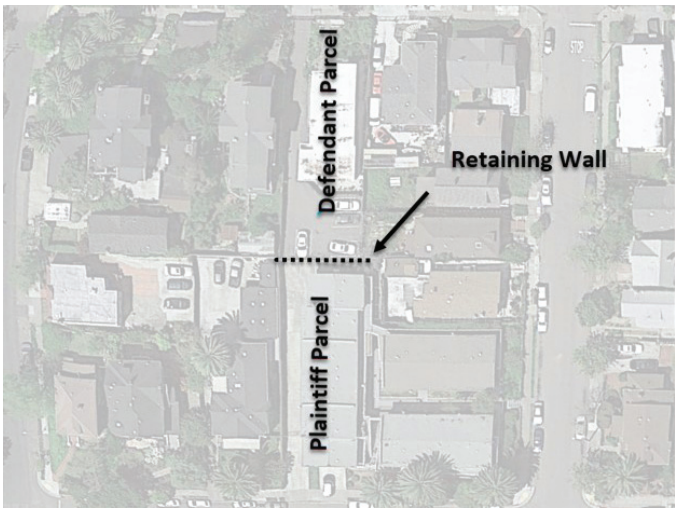

Figure 1
Site plan showing the location of the retaining wall in question relative to the plaintiff and defendant parcels.

Extension cracks were visible in the defendant's parking area (**Figure 3** and **Figure 4**). These cracks formed as a result of translation/rotation of the retaining wall, with the top of the retaining wall displacing away from the defendant's property toward the plaintiff's property. Drain

Figure 2
Photographs of the original wood retaining wall (2017).

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holes to prevent hydrostatic pressure behind the wall were also observed at the base of the retaining wall (**Figure 5**).

Figure 6 shows the exposed soil conditions following removal of the distressed retaining wall in 2018. These soils appear to consist primarily of cohesive clayey soils, which have the ability to "stand" with a near vertical cut.

Figure 3
Extension cracks were visible in the defendant's parking area as a result of rotation of the retaining wall toward plaintiff's property.

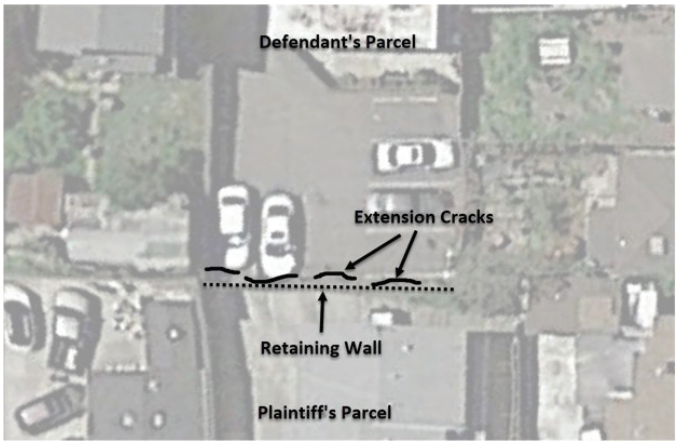

Figure 4
Location of extension cracks relative to the location of the retaining wall.

Figure 5
Drain holes in the original retaining wall to facilitate drainage behind the wall and mitigate potential for hydrostatic pressure loads on the wall.

The retaining wall was flagged as needing repair/replacement by the plaintiff's insurance company during a routine property inspection. The plaintiff made several attempts to contact the defendant, but no response was received. Under pressure to complete the repairs to satisfy the insurance company's concern, the plaintiff initiated demolition of the original retaining and installation of a new, reinforced masonry concrete block, retaining wall.

The plaintiff did not get a building permit for the construction of the replacement retaining wall. As a result, during the course of construction, the City Building Department visited the site and issued a notice of violation for performing work without a permit. The plaintiff then retained an engineer to develop plans and obtained a building permit to bring the work up to (and in compliance with) the local building code. The work started in late 2017, and was completed in 2019.

Approximate Timeline

A timeline of significant events is presented below. The structures on the two parcels were constructed at approximately the same time (early 1960s). The properties were more recently acquired by the defendant (early 2000s) and plaintiff (late 2000s).

- Early 1960s: Structures constructed on both the plaintiff and defendant's parcels with associated site grading.

- Early 2000s: Defendant purchases parcel and rental complex.

Figure 6
Exposed soil conditions following removal of the distressed retaining wall in 2018. Steel posts are bollards.

- 2005: Building department records indicate replacement of a 3-ft-tall retaining wall
- Late 2000s: Plaintiff purchases parcel and rental complex.
- 2016: Plaintiff's insurance company flags condition of retaining wall; plaintiff attempts to contact defendant to cost-share new retaining wall construction cost.
- Late 2017: Plaintiff initiates construction of new retaining wall without co-operation by defendant after multiple failed contact attempts. Plaintiff requests cost-sharing of the costs associated with the new retaining wall as it is located on the property line and benefits both parties.
- Early 2018: Construction of new wall halted by local building department due to lack of building permit.
- Mid 2018: Engineering completed and building permit obtained.
- Late 2018: Construction resumes.
- Early 2019: Construction completed. Lawsuit filed against defendant.
- August 2019: Expert retained by plaintiff.
- September 2019: Case settles two days after plaintiff expert deposition.

Plaintiff Contentions

The primary motivation for the plaintiff was to cost-share in the construction of the new retaining wall as it offered benefits for both parties. The plaintiff also noted that there were visible signs of distress that were unaddressed by the defendant and exacerbated the deterioration of the retaining wall. For the purposes of the litigation, the following claims were made by the plaintiff in formal court filings:

- In or around March 2016, the land and soil on the defendant's property moved, cracked the parking lot, opened a large hole that ran the rear boundary with plaintiff's property, damaged the fence, and resulted in a landslide onto plaintiff's property;
- At the aforementioned time and place, defendants negligently maintained, controlled, and managed their property and knew (or should have known) that the landslide resulted in an unreasonable risk of harm to plaintiff's property, to persons on plaintiff's property, and to those persons' personal property if not properly corrected or controlled.
- Defendants negligently failed to correct or control the landslide and soil subsidence, all of which caused the damages to plaintiff as described above.
- As a proximate result of the negligence of defendants, plaintiff's property was damaged and plaintiff incurred construction costs to repair the landslide and replace the rear fence and retaining wall that separates plaintiff's property from defendant's property.
- Pursuant to civil code, defendants are presumptively liable for at least 50% of the reasonable costs to construct the new fence and retaining wall.

Defendant Contentions

No formal rebuttal was provided by the defendant; however, the general response provided by defendant's counsel was that the defendant was "in no way responsible for" or owed any obligation to replacement of the retaining wall. The retaining wall was likely poorly constructed and provides benefit to the plaintiff. As such, the plaintiff should bear the full cost of the retaining wall, with no financial contribution from the defendant.

Forensic Evaluation

Following engagement by the plaintiff, the author initiated a forensic evaluation to understand and assess the merits of the contentions from both the plaintiff and defendant. The evaluation consisted of the following steps:

1. Collect and review the available discovery documentation;
2. Site visit to observe the site context and location of the retaining wall in question;
3. Review available historic aerial imagery to discover site changes (if any);
4. Characterize the suite of demands imposed on the

retaining wall that impact performance;

5. Evaluate factors impacting the capacity of the retaining wall; and

6. Develop opinions with regards to retaining wall performance and merit of plaintiff and defendant contentions.

Following completion of the forensic evaluation, the author participated in a deposition where the forensic evaluation process was outlined as well as the findings. These outcomes are discussed in more detail below.

Available Discovery

The available discovery consisted primarily of photographs taken of the distressed retaining wall in 2017, prior to start of construction and photographs taken during the course of construction of the replacement retaining wall in 2018 and 2019. The full inventory of discovery documents included:

- Pre-construction retaining wall photographs;
- Photographs taken during the course of the construction;
- Plaintiff property building permit history from local building department (Report of Residential Building Record);
- Plaintiff's Notice of Violation for the 2018 retaining wall work;
- Copies of engineering plans and calculations in response to the 2018 Notice of Violation; and
- Construction Formwork Certification by licensed land surveyor, which included formal delineation of property boundaries.

Figure 7
Example "street view" image available from Google Maps (note available timeline of photos in upper left).

Site Visit

A site visit and meeting with the plaintiff, the plaintiff's contractor, and the plaintiff's property manager occurred immediately following engagement in the case. This site visit allowed for a visual inspection of the topographic setting between the two properties, a verbal accounting of the sequence of interactions between the plaintiff and the defendant by the plaintiff, and description of conditions encountered by the contractor during the course of construction. Additionally, available imagery (aerial and "street view" on Google) were ground-truthed.

Available Imagery

Aerial imagery was available via Google Earth's "History" tool, which provided select aerial images between 2019 and 1993. Supplemental aerial images were obtained from a commercial aerial imagery company, which had images for the area between the 1950s and 2019.

In addition to aerial images, "street view" images (**Figure 7**) were also available from Google Maps, which allowed views of the retaining wall by looking from the street down the driveway toward the retaining wall in question. While this data is fairly recent, extending back to about 2010, it provides a valuable high-resolution perspective that is not available with conventional aerial imagery.

Retaining Wall Imposed Loads

The performance of a retaining wall can be characterized by a number of factors. For this forensic evaluation, lateral displacement (either through translation or rotation) was the primary performance metric considered. Lateral displacements of retaining wall can occur as the result of demands (or loads) applied. The greater the applied load, the greater the potential for lateral displacements.

Figure 8 shows a conceptual overview of typical loads imposed on retaining walls that impacts lateral

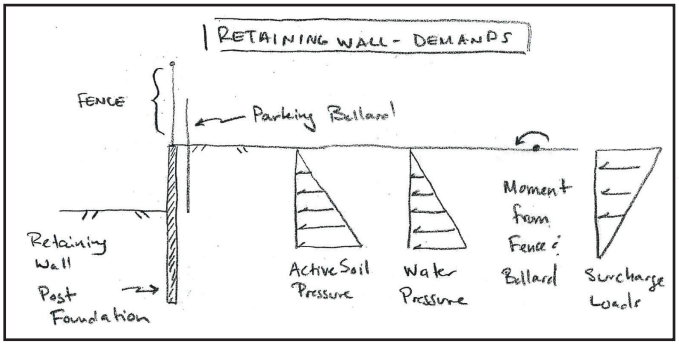

Figure 8
Conceptual overview of loads imposed on a retaining wall impacting lateral displacement (sketch by author, conceptual only).

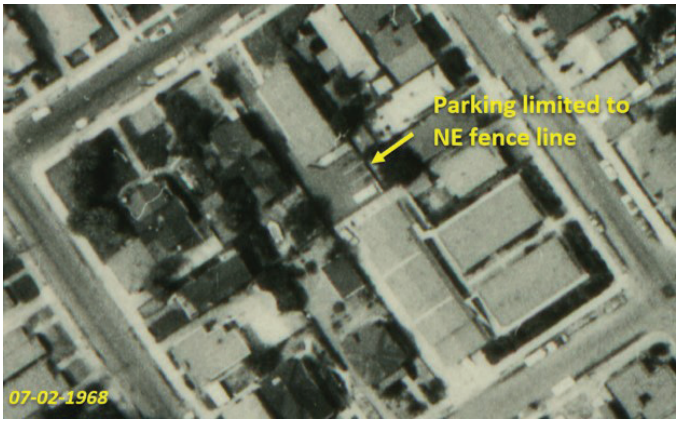

Figure 9
Original configuration of parking spaces based on aerial imagery from July 1968.

displacement(s) and include lateral earth pressures from retained soils and water (hydrostatic) pressures. Additionally, for this setting, the presence of a parking lot and fence attached to the retaining wall adds surcharge loading to the wall from parked vehicles and a moment load to the top of the wall from the fence when the fence is perturbed by either wind or lateral loading from vehicles. Note for this particular case, the configuration of the retaining wall results in all the imposed loads or "demands" being initiated on the defendant's parcel.

A review of the aerial imagery as well as the street view photos established that the area immediately behind the retaining wall was delineated as parking area on the defendant's property. The aerial imagery establishes the original (early 1960s) parking configuration (four parking spaces) as being limited to the northeast (NE) fence line (**Figure 9**). By the early 2000s, additional parking stalls were observed in the aerial images. **Figure 10** shows an

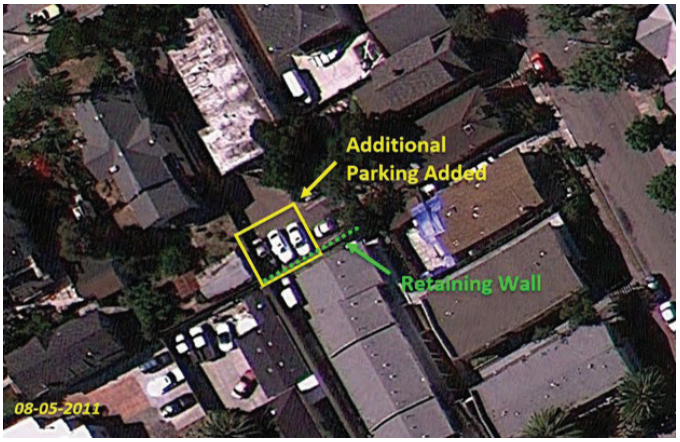

Figure 10
Additional parking spaces added on the defendant's parcel immediately adjacent to the retaining wall.

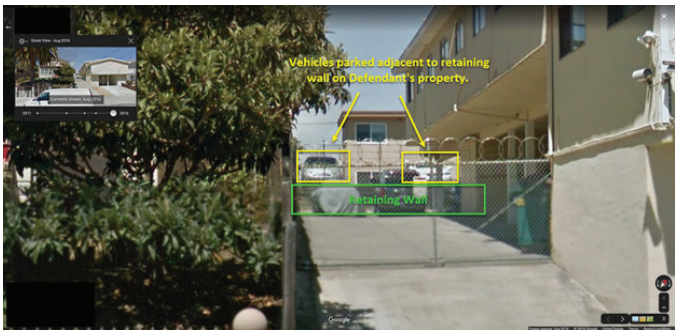

Figure 11
Vehicles parked immediately adjacent to the retaining wall exerting a surcharge load.

aerial image from 2011 with a total of four vehicles parked adjacent to the retaining wall on this particular day. **Figure 11** documents vehicles parked immediately adjacent to the retaining wall from a street view perspective.

Vehicles have the ability to "bump" into both the bollards along the alignment of the retaining wall as well as the fence secured to the retaining wall, resulting in moment loads on the wall. These moment loads directly impact the lateral displacements of the retaining wall. A review of the available photos (such as **Figure 6**) did not reveal the presence of any curb stops in the parking spaces that would have limited the ability for vehicles to accidentally bump into the bollards or fence as well as imposing a "setback" between the parked vehicle and the retaining wall, thereby reducing the magnitude of the surcharge load from the vehicle and the retaining wall.

In addition to the surcharge and moment loading onto the retaining wall from the defendant's property, the observed expansion cracks enabled water to infiltrate the asphalt concrete paving and increase the hydrostatic loading on the wall. While the hydrostatic loading was likely not significant, the cohesive/clayey soils would be subject to increased volumetric expansion as a result of increased moisture content. This volumetric expansion results in a direct increase in lateral earth pressures on the wall.

Retaining Wall Capacity

The ability to resist the imposed loads is the capacity of the retaining wall. The resistance is comprised of both the structural integrity of the retaining wall as well as the passive and soil bearing pressures (**Figure 12**).

Due to the lack of information, it was not possible to ascertain the actual structural integrity of the wall in 2016/2017. The available photographs suggest that the retaining wall had sufficient integrity to behave as a "unit."

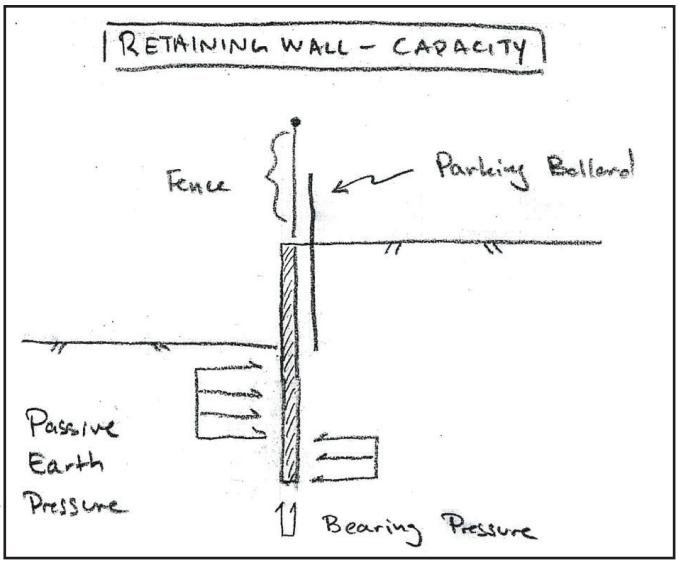

Figure 12
Primary retaining wall capacity elements include passive earth pressure, bearing pressure, and structural integrity of the wall (sketch by author, conceptual only).

However, for the purposes of this qualitative evaluation, the actual condition of the wall is ultimately not important. The inquiry here is to illustrate the contribution both parties have to the actual performance of the wall and that both parties receive benefit from the structure.

Unlike the retaining wall demands, the soil passive and bearing pressures are largely derived from the Plaintiff's parcel. A review of the available aerial and 'street view' images revealed no site modifications that may have altered the capacities of the retaining wall from the Plaintiff's parking area. Additionally, discussions with the property owner and property manager confirmed no known site modifications in the plaintiff's parking area adjacent to the retaining wall.

FE Opinions

The presence of the retaining wall provides a grade separation between the plaintiff's and defendant's properties. While offering some benefit to the plaintiff, and counter to the defendant's claim of the retaining wall offering no benefit, the retaining wall, in fact, offers significant benefit is provided to the defendant. Without the retaining wall, the defendant would actually lose parking area as a "stable" slope would need to be graded, sloping up from the plaintiff's parcel to the defendant's parcel at a slope on the order of 2.5 horizontal to 1 vertical (**Figure 13**). Thus, a significant benefit is provided to the defendant.

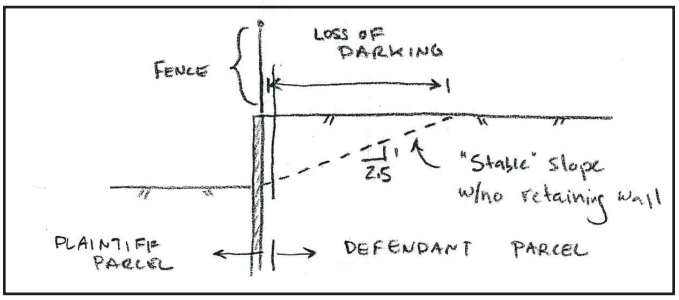

Figure 13
Retaining wall provides the defendant the benefit of parking space that would be "lost" if the retaining wall were removed and the transition graded to a "stable" slope (sketch by author, conceptual only).

The retaining wall is situated on the property boundary between the plaintiff and the defendant (**Figure 14**).

The majority of the demands imposed on the retaining wall originate from the defendant's parcel. The plaintiff has no ability to moderate these loads as they are not situated on his property.

As a result of the retaining wall demands being situated on the defendant's property, there were a number of measures available to the defendant to minimize degradation of the retaining wall integrity. These measures include:

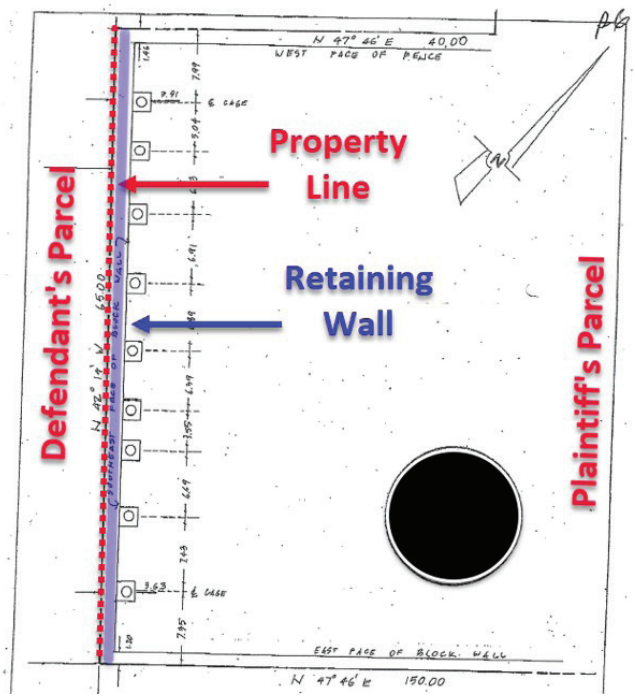

Figure 14
Copy of construction formwork survey showing the retaining wall relative to the property line.

- The observed expansion cracks were indicators of potential loss of wall integrity, requiring a heightened level of mindfulness, monitoring, and care by the defendant to ensure additional loss of integrity from excessive demands does not occur;

- The observed expansion cracks allow for the infiltration of water into the soils behind the retaining wall. These expansion cracks could have been sealed by the defendant to limit the quantity of water infiltrating the soils, which in turn, would limit the potential for increased hydrostatic pressures and the potential for increased lateral soil pressures due to swell of the cohesive clayey soils;

- The observed expansion cracks were an indicator of lateral displacements of the retaining wall. The defendant had the ability to limit the magnitude of surcharge loading on the retaining wall by eliminating or offsetting the parking stalls;

- The defendant had the ability to eliminate 'bumping' of the parking bollards and/or fence on the retaining wall by installing curb stops to enforce a suitable offset between vehicles and the fence/bollard;

The plaintiff, in their complaint, referred to "landslide[1] and soil subsidence[2]." These terms have specific technical meanings. A landslide is "the movement of a mass of rock, debris, or earth down a slope." Subsidence is settlement as a result of lowering the groundwater table. Neither of these mechanisms were applicable in this case. Rather, this was the result of the plaintiff's attorney not being familiar with these technical terms and attempting to describe the observed phenomena.

In summary, the forensic engineering evaluation found that the plaintiff's allegation that actions (or inactions) by the defendant exacerbated the distress of the shared retaining wall is valid and supported by the case facts. As a result, the defendant does receive benefit from the shared retaining wall and — from the perspective of received benefits — should cost share in the replacement of the retaining wall.

It was determined costs associated with the Notice of Violation by the local building department should not be shared and should be the responsibility of the plaintiff. All other costs, including engineering design, building permit fees, inspection fees, and construction costs are eligible for cost-sharing.

Conclusion

This case involves a dispute between two neighboring property owners regarding costs associated with replacement of a compromised retaining wall. The retaining wall was flagged as needing repair/replacement by the plaintiff's insurance company during a property inspection.

The plaintiff made several attempts to contact the defendant, but no response was received. Under pressure to complete the repairs to satisfy the insurance company's concern, the plaintiff initiated demolition of the original retaining and installation of a new, reinforced masonry concrete block, retaining wall. Litigation for cost-sharing of the incurred construction costs initiated immediately following completion of construction in early 2019.

The forensic engineering evaluation was initiated several weeks prior to trial and considered both demand-based (i.e., lateral earth pressures, pore pressures, surcharge) and capacity-based (i.e., materials, configuration, drainage) factors.

Prior to forensic engagement, the opposing party was unwilling to settle. Following completion of these forensic analyses, the case settled in less than two days, due to the clear delineation of causative factors.

References

1. Crudent, D.M. 1991. A Simple Definition of a Landslide. Bulletin of the International Association of Engineering Geology, No. 43, pp. 27-19.

2. Peck, Ralph, B., Walter E. Hanson, Thomas H. Thornburn. Foundation Engineering. Second Edition. John Wiley & Sons. Toronto. 1974.