Tensioning of Loose Rock Boulders Underneath a Parking Deck with Spider Mesh

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Materials

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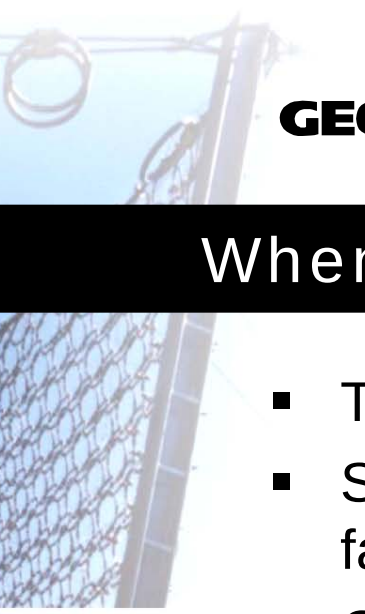
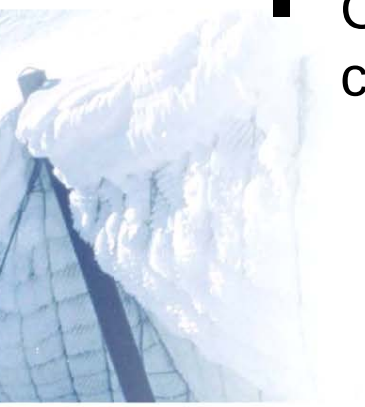
When Choosing Mitigation Methods





- There is no “one product fits all” solution
- Site’s prevailing geology and characteristics are important factors
- Cost always enters into the selection process – may combine several concepts for best overall solution

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Active Stabilization

Active stabilization measures

- Retaining walls
- Excavation of the unstable material
- Pattern anchoring
    - without facing material
    - with facing material (shotcrete, mesh)

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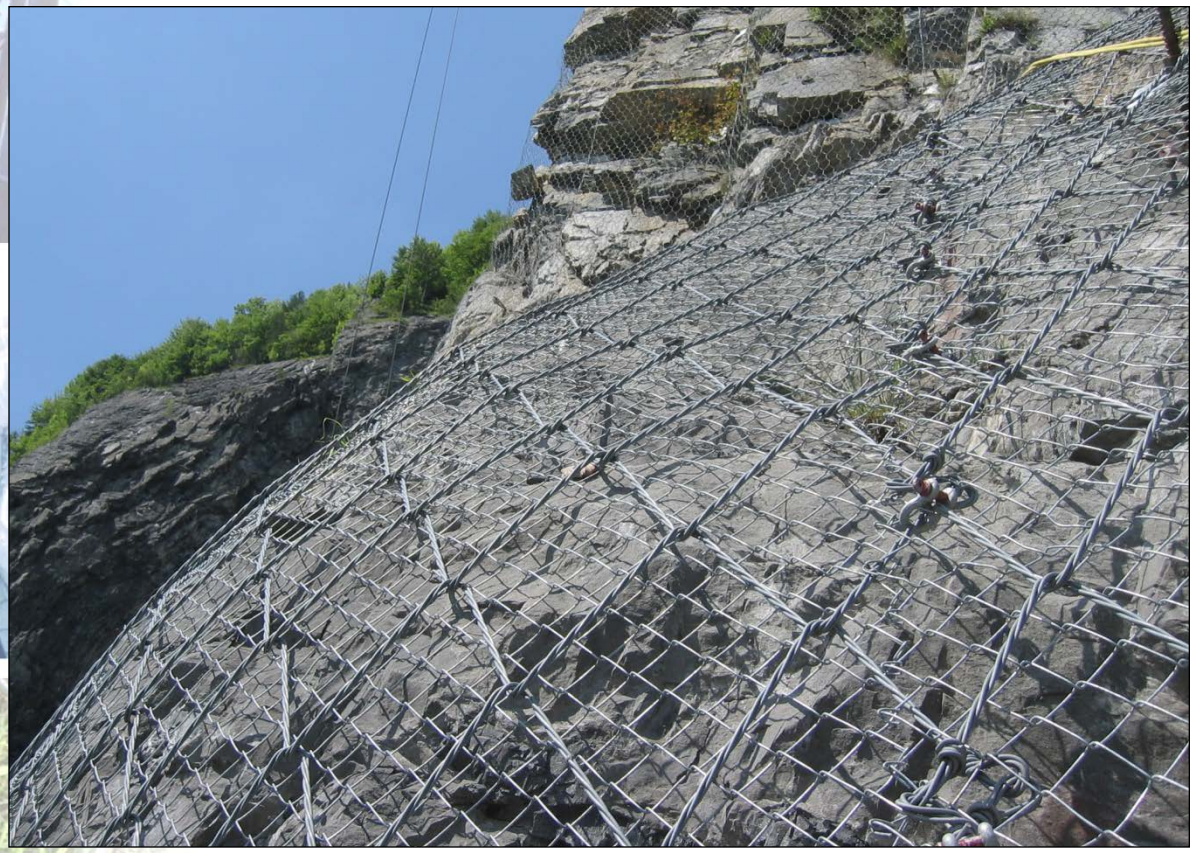
SPIDER® - construction



Chain-link net made from 1x3 spiral rope (4 mm high-tensile wire)
Breaking Load = 7.5 tons/ft

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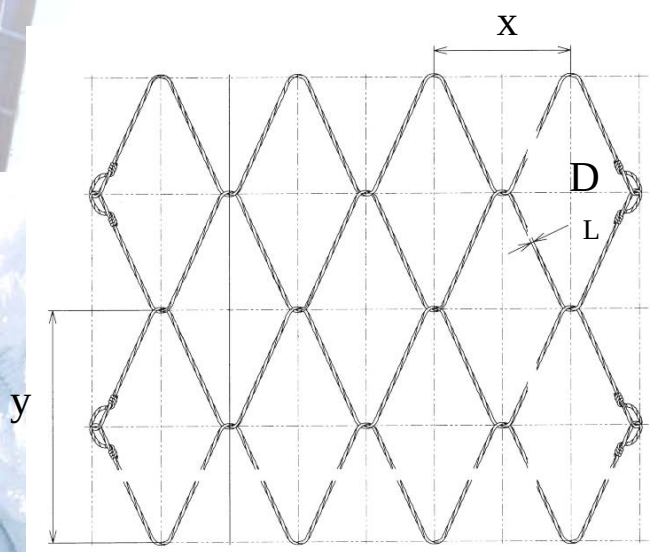
SPIDER® - construction



Mesh width	x = 11.5 in (+/- 5%)
Mesh length:	y = 19.7 in (+/- 5%)
Strand diameter:	D_L = 0.339 in
Wire diameter:	D_w = 0.157 in
Spiral rope construction:	1 x 3
Mesh edges:	strand ends nodded
Tensile strength wire:	> 256 ksi
Corrosion protection:	5% alu / 95% zinc
Coating:	> 0.0256 lb/ft^2

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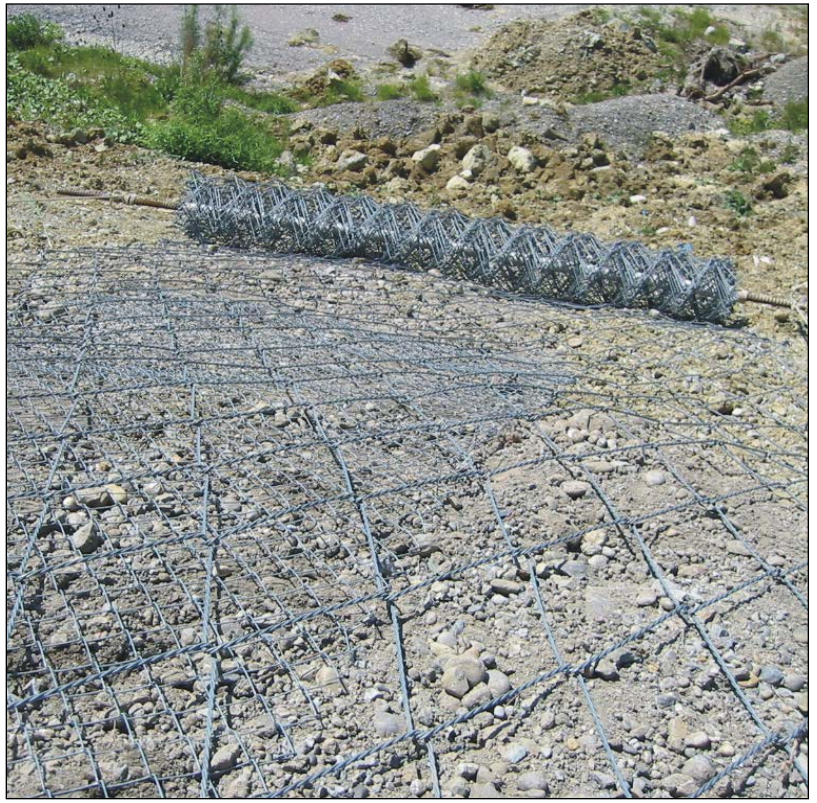
SPIDER® S4-230 spiral rope net



Size of a standard SPIDER® roll: 11.5-ft x 66-ft (420 lbs)

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System components

- SPIDER® S4-230 spiral rope net
- System spike plates
- Anchors
- Boundary ropes
- Shackles
- Secondary mesh (optional)

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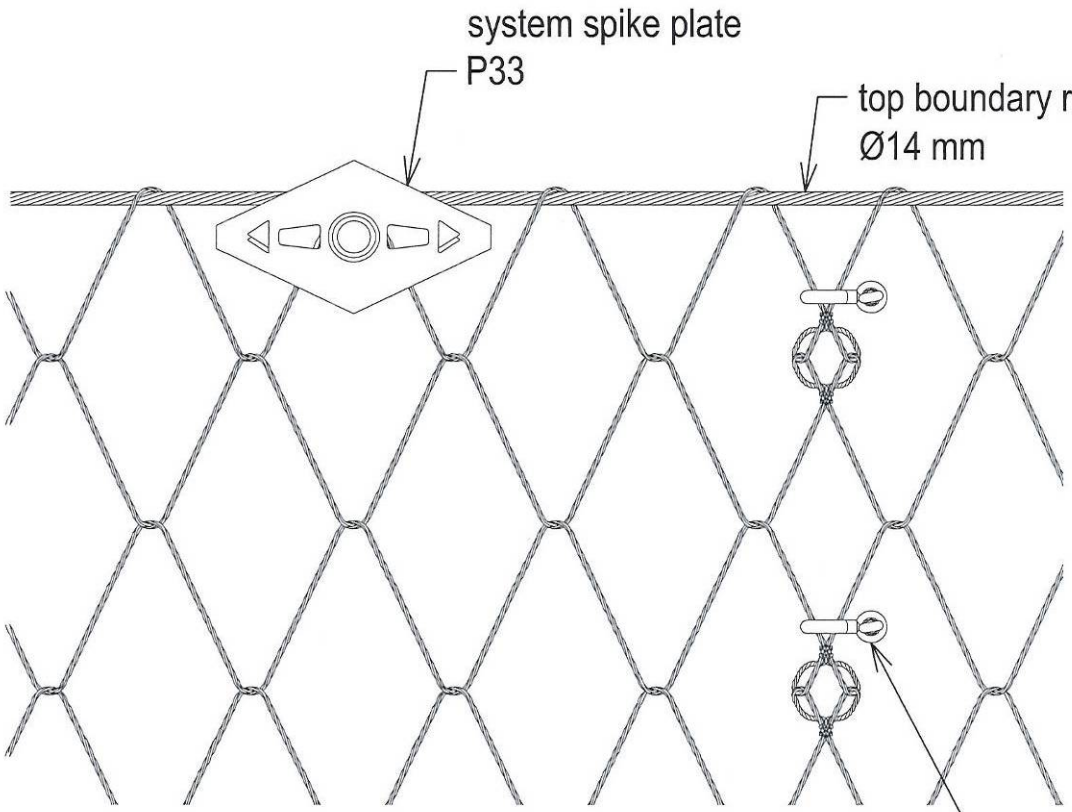
Connections



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SPIDER® - securing large rock

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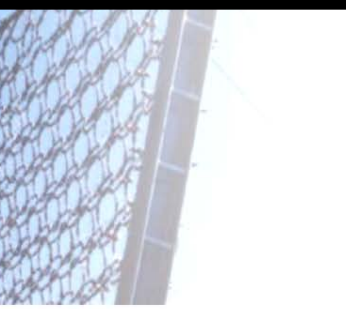
SPIDER® - preventing breakaways



Pinned and drapery material

Weston, WV –
SPIDER & RCN

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Installation

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Boulder Wall Below Parking Deck

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Before Construction

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Before (cont'd)

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Application

- Boulder wall beneath a parking deck was beginning to fail because lack of maintenance of drainage on upper side. Upper retaining wall and boulder wall were leaning and pushing the entire parking deck laterally. If movement continued, the large boulders could strike the columns, and cause the parking deck to collapse.
- After consideration of several options (adjacent retaining wall, soil-nail/shotcrete), the most cost effective solution proved to be one that utilized Geobrugg's SPIDER® net.
- A unique design was employed that involved anchoring to the existing retaining wall to prevent further movement and then encapsulating the boulder field with a high tensile net before pinning the net against the boulders themselves.
- Immediately after the construction was completed, a large earthquake shook the surrounding area and the system proved resistant to the earthquake forces.

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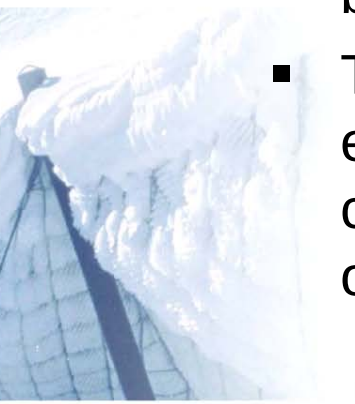
Remediation steps to stabilize wall



- Evacuated an 8’ deep pit on the uphill side of the existing retaining wall on which the boulders were stacked.
- Titan 30/16 bars were then drilled into the bedrock at a batter and stubbed out just before the wall itself.
- Then the wall was cored so the tiebacks could be extended through the wall and secured against two (2) 15” channel whalers and bearing plates placed on the outside of the retaining wall.

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Installation Sketch

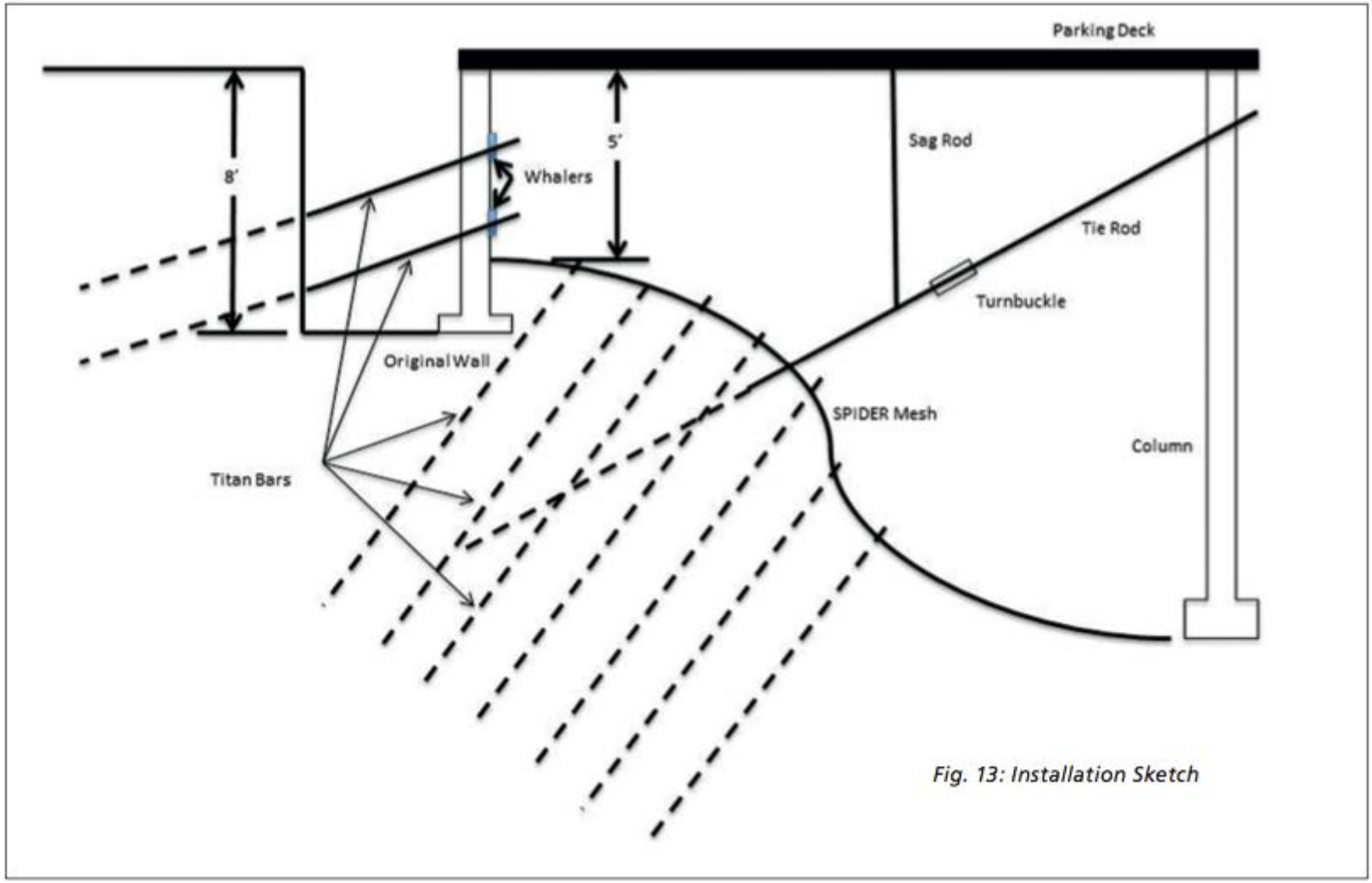

Fig. 13: Installation Sketch

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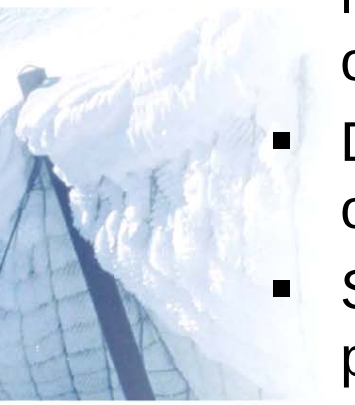
Steps to secure the mesh



- Build an access road to the underside of the deck – very difficult
- Attached the SPIDER® net to the bottom channel whaler's row of anchors above the boulders and draped the net over the rock face
- Drilled rock anchors down each side and along the bottom of the boulder wall
- Secured the SPIDER® net along the boulder field's perimeter.



Steps to secure the mesh (cont'd)

- Drilled the remaining Titan 30/16 and Titan 40/20 hollow bar injection anchors throughout the middle section of the boulder wall.
  - As the anchors were installed and reached their capacity, the spike plates were added and secured against the SPIDER® net.
  - The anchors were placed at roughly 8' centers and in all approximately seventy (70) anchors were used.
  - The rock anchors were drilled five to ten feet into rock to develop their design capacities.
- A boundary rope was added around the perimeter of the SPIDER® net and all the Spike plates were tightened to the design torque against the net to secure the whole system.

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Upper pit

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Drilling Titan bars in boulder field

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Drilling Titan bars in boulder field (cont'd)

Steps to strengthen the support columns

- Additionally a 1” diameter rod was drilled and epoxy doweled into each of the three (3) 2’x 2’ parking deck support columns
- This rod was then tied into a rock anchor before turnbuckles were used to tension the rod.
- After the prerequisite torque was applied, a sag rod perpendicular to the parking deck tied into the tie rod.

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Tensioned mesh

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Spike Plates and Boundary Rope

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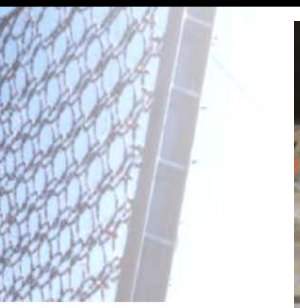
Mesh and Spike Plates



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Mesh, Whalers, and Drainage

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Storm water drainage added

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Finishing the deck

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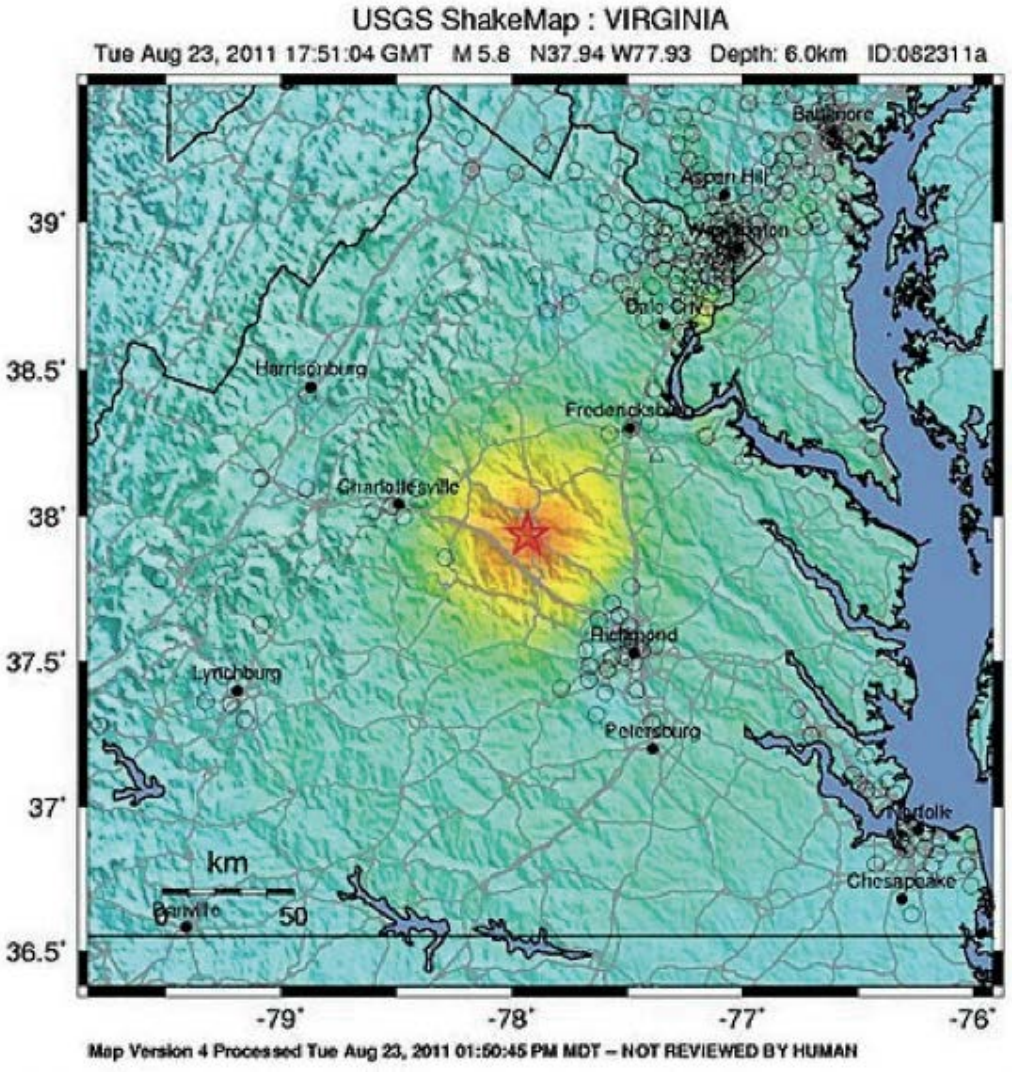
Earthquake!!!





Earthquake (cont'd)

- The earthquake happened the day after all the spike plates were tensioned and several of the installation contractors employees were standing on the parking deck
- The condos and parking deck started to rock back and forth.
- Due to the flexibility of the SPIDER® net and the fact that the system was securely tensioned to the bedrock behind the slope, the entire system was elastic enough that the boulders and columns below the parking deck were kept in place – nothing sheared and nothing moved.
- A more rigid system, such as shotcrete facing or a cast in place wall, probably would not have fared so well under the same circumstances.
- We considered the entire project to have been tested and to be a success!"

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Thanks for your attention!