Parking Lot Ponding and Erosion

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Abstract:

The parking lot outside of 249 North Clemson Ave experiences severe ponding as well as erosion issues. This is due to the poor geometric planning of the parking lot in terms of runoff management. The parking lot has been repaved several times to help remediate the issue however it has been unsuccessful as erosion leads to more potholes throughout the year. Geometric measurements were taken of the parking lot in order to attempt to quantify the problem. Several possible solutions were investigated including bio retention cells and implementing a drainage system. The best solutions however was determined to be a total redistribution of land within the parking lot in order to create the necessary slope to allow for runoff to travel through the parking lot to a drain without ponding in the middle or causing severe erosion upon exiting. While this is the most complete solution it is possible the landowner would rather deal with a low quality parking lot than invest in a permanent fix.

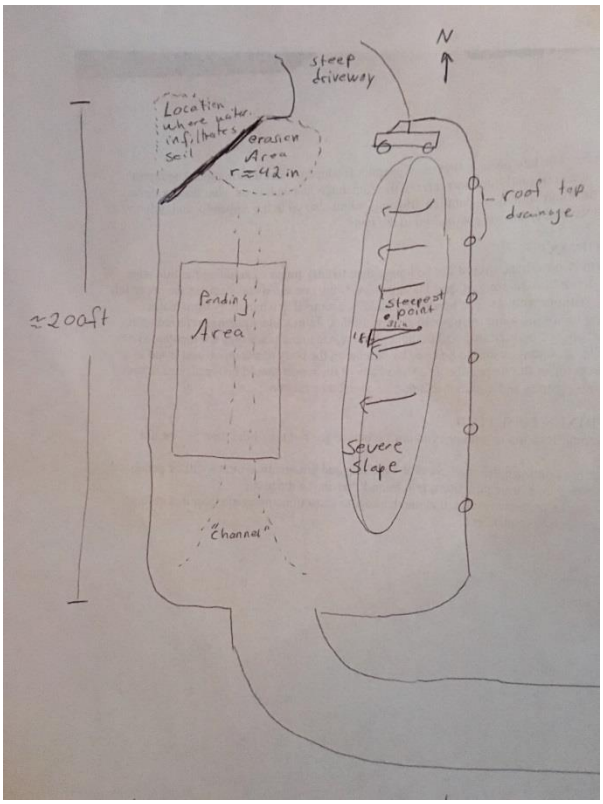
Introduction:

The parking lot on the East side of 249 North Clemson Ave receives runoff from a perpendicular street that empties into the parking lot. The initial design team probably planned for the runoff to continue to run through the parking lot to a severe slope on the other end that empties into an area with a street drain. However the parking lot does not have a steep enough slope in the north south direction in order to properly drain the parking lot causing ponding to happen. Additionally the parking lot is sloped westward causing water along the width of the parking lot to accumulate in the parking spots on the western side of the lot. The flat, channel like shape of the parking lot leads to a spot where it eventually drains when the water level is high enough however the asphalt there has experienced severe erosion. An interviewee who chose to remain anonymous said she was scared to drive her car over the eroded section and that several more smaller potholes had formed just this semester. The lot appears to have been repaved multiple times already to no avail so a holistic solution must be determined. The parking lot must be redesigned in order to prevent ponding and more effectively allow for runoff to travel through without furthering the eroded drainage point.

Body:

Principles and assumptions:

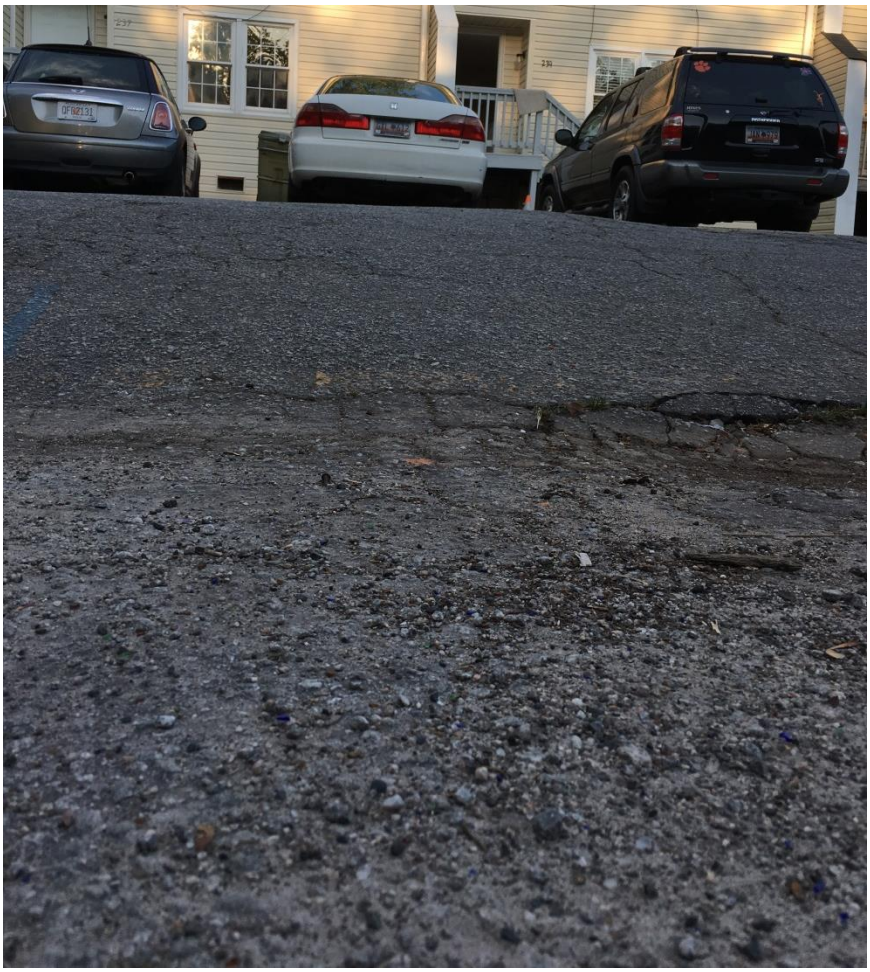
The first pair of principles and resulting assumptions has to do with open channel flow as diagram 1 below shows the channel that is formed from the downward slope of the parking lot that runs perpendicular to the parking spaces.



If this channel was more to the middle of the parking lot it would be able to run through and down the steep parking lot entrance towards the drain at the bottom. However since it doesn't and the severe east side 30 degree (calculation 1) slope forces the water to pond in the middle spaces on the west side the north south slope is not steep enough to cause runoff through the parking lot despite being on asphalt which has a high run off coefficient.

Calculation 1: $Tan^{-1}\left(\frac{18}{31}\right) = 30\ degrees$

Figure 3 shows a picture of how steep that slope is.



An additional principle is infiltration but the majority of the parking lot is cement so there is none. However on the west side of where the ponding section eventually drains, when the water level is high enough, in the north west corner of the parking lot, there is no asphalt allowing for Infiltration of the water that then potentially flows under the asphalt causing the severe erosion seen in figure 2 on the next page.

There was not enough acquired data to determine the ponding time of the ponding section however Figure 1 below depicts the section four days after the most recent rain with water still waiting to be evaporated as there is no other exit.

This data could have possibly been acquired through rain data and hydrographs to determine the peak flow rate and then accumulation and retention times. This information along with the

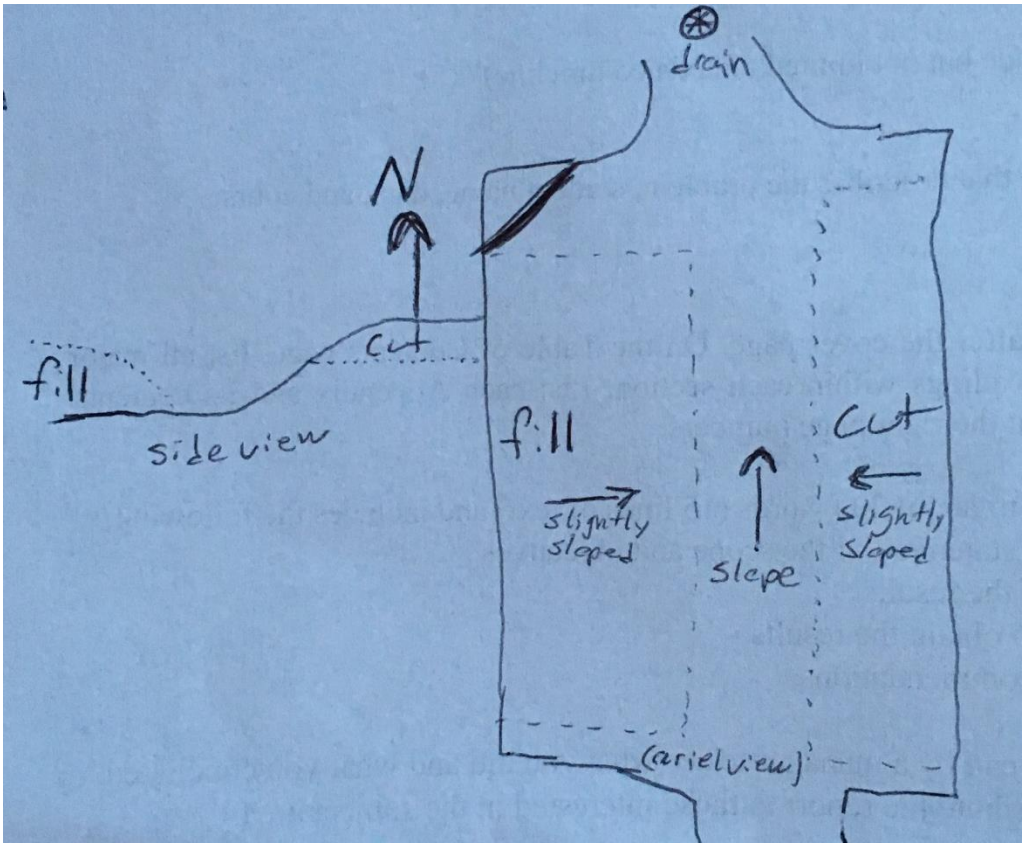
geometry measurements taken of the parking lot could have been used in order to find the height of the water level as well as the water volume necessary to overflow the ponding area. All this information could be combined to determine how long and at what intensity it would have to rain in order for maximum ponding to occur. After a necessary rain in order to flood the ponding area, data could have been acquired to determine how long it takes for the ponded section to evaporate. This information however wouldn't do much in terms of solving the issue as the main issue is the geometry of the parking lot itself. Additionally there aren't many measures to be taken to stop the inflow of runoff into the parking lot since it arrives from a perpendicular street that slopes right into the lot. Also a portion of the water comes from the surrounding houses' roofs that drain into the parking lot.

Potential Solutions:

Placing a bio retention cell above the parking lot would cause a lot of the upstream accumulated runoff to infiltrate before entering the parking lot and getting trapped in the pounding area. This however would have to only be a part of the solution as a significant amount of the ponding water rains within the parking lot or the surrounding rooftops which would still lead to ponding but it would be less severe. An additional tactic would be simply repaving the parking lot to remove the eroded sections however as mentioned in the introduction it appears as though this has been tried several times. A third option would be to implement a drain in the ponding section however this would require an extensive project as a lot of land would have to be torn up to get the necessary pipes and drainage put in.

Final Solution:

The best solution may seem like the most work however it is necessary. Since simply repaving the area hasn't worked in the past and implementing a drainage system would require excavation anyway the best means of solving the problem is by using cut and fill techniques in order to move the unsuccessful channel pathway more towards the middle of the parking lot so it can flow through to the drain down the driveway. While this would be costly there have already been sunk costs going into the previous repaving. Rather than continuing to Band-Aid the surface this is more of a long term solution since editing the geometry of the parking lot will allow for the erosive forces to act in different locations that will be suited to handle it as depicted in diagram 2 on the following page.



Additionally increasing the north to south slope will allow for the water to not get caught in the middle of the parking lot. This may pose a safety issue if the runoff rate is to high causing water to cascade down the entrance to the parking lot affecting tires friction forces however there would need to be an extremely severe storm for that to come close to happening. While cut and fill would be expensive the exact cost could not be determined as elevation data was hard to find. However repaving the site after the cut and fill was determined to be $30,000 using the average price of asphalt of three dollars per square foot (Cost to Build) multiplied by the area of the parking lot in calculation 2.

Calculation 2: $\$3\ x\ 50ft\ x\ 200ft = \$30{,}000$

While extensive work needs to be done this solution solves the issue of both ponding and erosion within the parking lot.

Conclusions:

The redistribution of elevation within the parking lot provides the necessary geometric changes in order to prevent ponding from occurring without continued eroding of drainage points. This solution is similar to the way football fields are slightly parabolic except that the

concavity is in the opposite direction. While this solution is the most complete the fact that multiple repavings have already occurred and the housing area is quite old it is logical that the landowner would not see this as a fit investment and may be considering a complete teardown and rebuild anyway with the recent Clemson area growth.

References:

"Build Asphalt Driveway Cost." *Cost to Build an Asphalt Driveway*. N.p., n.d. Web. 26 Apr. 2016.

Owino, Tom. "Hydrology Power Points." Lecture.

"Phase I - Cut and Fill." *Phase I - Cut and Fill*. N.p., n.d. Web. 27 Apr. 2016.

Appendix:

View of “channel”

Triangle used to find slope of steepest East to West sloped point