

# Water Retention Properties of Avonlea Badland Sediments

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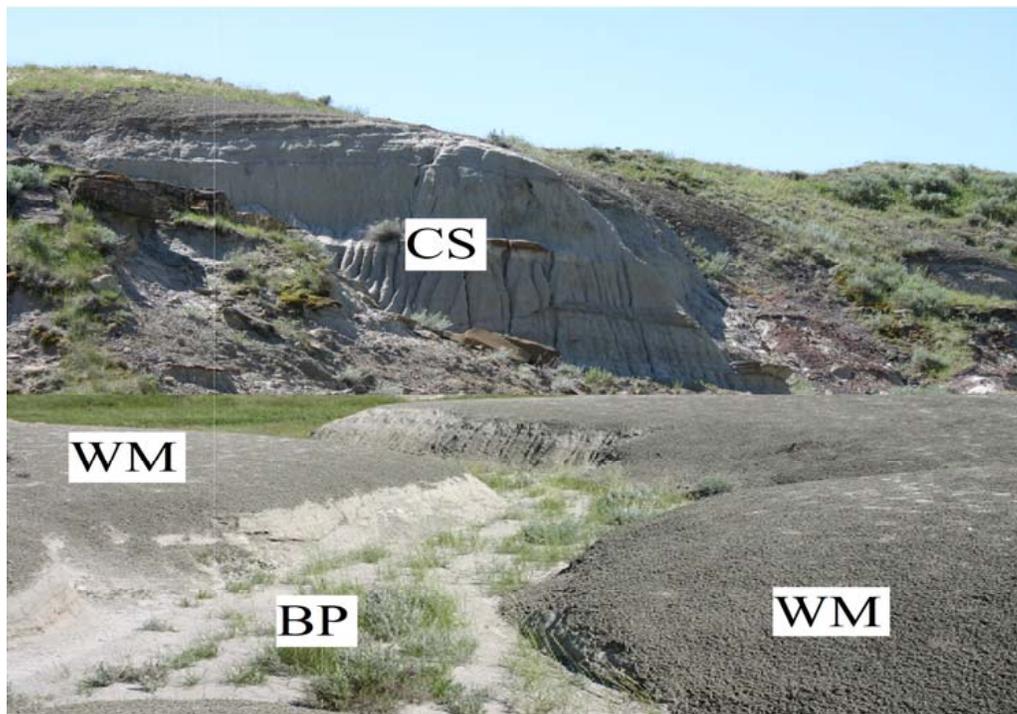
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*The soil water characteristics curve was determined for three distinct sediments from the Avonlea badlands to understand their response to alternate saturation and desaturation. The water retention capacity was found to be highest for the weathered mudrock, followed by the cemented sandstone, and then by basal pediment. This suggests the presence of a genetic relation between the cemented sandstone and the basal pediment. Erosion is expected to be highest for the basal pediment and negligible for the weathered mudrock that favors sheet flow.*

**Keywords:** Avonlea, Badlands, Engineering Properties, Soil Water Characteristic Curve

## 1 INTRODUCTION

The engineering behavior of badland sediments is derived from geologic history and climatic conditions. Different types of geomaterials are generally encountered in such landscapes as evident from lithologic variations in composition and texture (Azam, 2008). The Avonlea badlands are located at a distance of about 60 km SSW of Regina, Saskatchewan. Figure 1 shows the general layout of badland sediments at Avonlea. Three distinct slope surfaces (steep cemented sandstone (CS), mildly-sloped weathered mudrock (WM), and flat basal pediment (BP)) characterize the Avonlea badlands. These surfaces intimately reflect lithologic variations and different erosion resistance (Warren, 1984). Seasonal variations in water availability (snow melt in spring and rainfall in summer) and water deficiency (low rainfall and freezing in fall and winter) result in periodic saturation and desaturation of surface soils in the area. The alternate weather changes affect the water retention properties and consequently the erosion susceptibility of indigenous badland sediments (Faulker et al., 2003). Given the increasing economic activity, a geotechnical evaluation of marginal materials is required for construction in such terrains. The main objective of this paper was to investigate the water retention behavior of Avonlea badland soils. For this purpose, the soil water characteristics curve (SWCC) was determined for selected samples.



**Figure 1.** General layout of badland sediments at Avonlea

## 2 LABORATORY TESTING

Representative surface samples were retrieved from the three types of sediments at the Avonlea badlands site. The SWCC, which is a plot of the volumetric water content versus soil suction, was determined at the field dry unit weight of each sediment type. A total of 18 specimens were prepared for each soil type by adding different amounts of water. The soil suction was measured using the potentiometer (Model WP4-T) whereas the gravimetric water content of the samples was determined according to the ASTM Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (D2216-05) and subsequently converted to the volumetric water content. The laboratory measured SWCC data were fitted using the method described by Fredlund and Xing (1994).

## 3 RESULTS AND DISCUSSION

The SWCC plot represents the flow of water through the soil pores under saturated and unsaturated conditions. It is the primary tool to understand the engineering behavior of soils under fluctuating water availability conditions. With increasing suction, materials remain saturated up to the air entry value and store water equal to the saturated volumetric water content. Thereafter, soils undergo desaturation with a corresponding decrease in volumetric water content up to the residual value. Further decrease in volumetric water content is very difficult to achieve and require a high amount of suction: all soils converge at  $10^6$  kPa, which corresponds to the wilting point of plants.

Figure 2 gives the SWCC of the Avonlea badland sediments and the results are summarized in Table 1. The data shows different water retention capabilities for the investigated sediments. The four characteristic indicators (Table 1) suggest that the water retention capacity is highest for weathered mudrock, followed by cemented sandstone, and then by basal pediment. In general, a low dry unit weight, a high amount of fine-grained materials, and an abundance of active clay minerals or cementitious compounds result in a high air entry value and residual suction. The data depicted herein correlates reasonably well with the field dry unit weights and the observed soil texture. Detailed mineralogical composition and grain size distribution analyses are required to confirm the findings.

The three types of sediments at Avonlea respond differently to the same rainfall event. Possible erosion from the cemented sandstone (at a higher elevation) is accumulated in the basal pediment (at a lower elevation) and not retained in the intermediate weathered mudrock because of the high air entry value (416 kPa) of the latter material. The weathered mudrock with negligible erodibility would favor sheet flow because all of the pores are sealed due to saturation. This suggests that a genetic relation exists between the cemented sandstone and the basal pediment. With an insignificant amount of cementation and cohesion due to clay minerals, the basal pediment is a material that is highly susceptible to fluvial erosion.

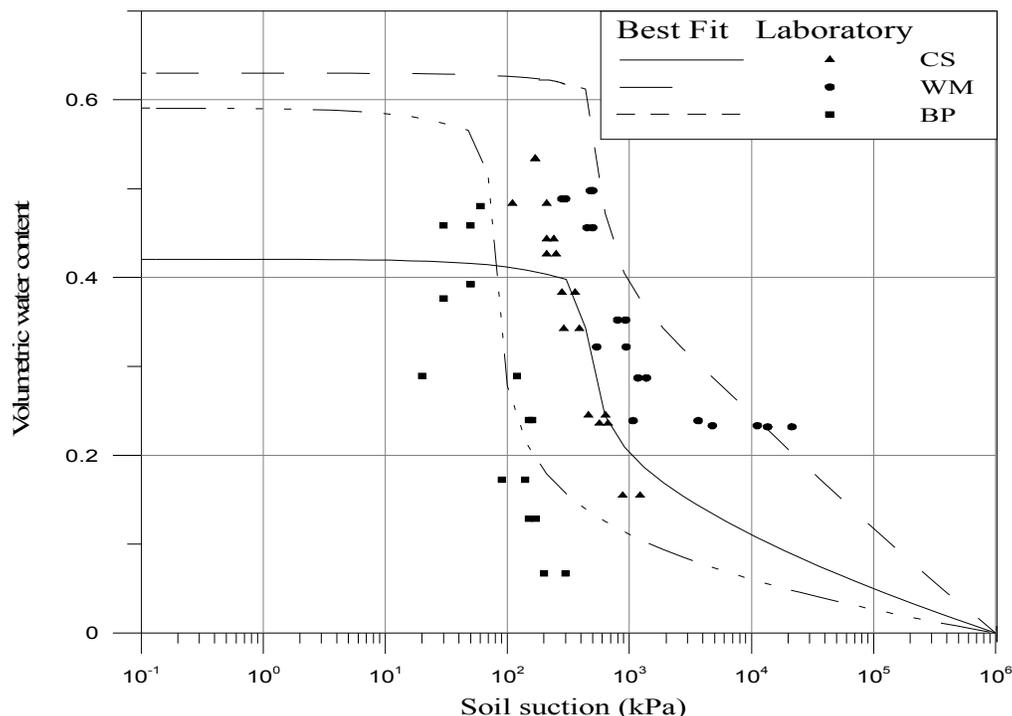


Figure 2. Soil water characteristic curves of the investigated badland sediments

**Table 1.** Summary of the SWCC results for the investigated badland sediments

Sample type	Dry unit weight (gm/cm <sup>3</sup> )	Saturated volumetric water content	Air entry value (kPa)	Residual volumetric water content	Residual suction (kPa)
Cemented sandstone	1.60	0.39	327	0.20	1150
Weathered mudrock	1.06	0.62	416	0.32	2950
Basal pediment	1.10	0.53	62	0.16	273

#### 4 SUMMARY AND CONCLUSIONS

Laboratory investigations were conducted for three surfaces sediments of Avonlea badlands. The water retention capacity was found to be highest for the weathered mudrock, followed by the cemented sandstone, and then by basal pediment. This suggests that a genetic relation exists between the cemented sandstone and the basal pediment. The investigated materials respond differently to the same rainfall event. Erosion is expected to be highest for the basal pediment and negligible for the weathered mudrock that favors sheet flow.

#### ACKNOWLEDGEMENT

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