Building drainage systems for the future: How drainage material selection plays an important role in optimal system functionality

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1. The Key Message

An aggregate size range from 2 – 10 mm is optimal for a clay textured soil. Aggregates up to 20 mm are acceptable. The cost of aggregates are more expensive in the size lower ranges than the higher ranges. The adoption of aggregates from 0.7 to 20 mm will optimise performance and extend the lifetime of drainage systems in mineral soils.

2. Introduction

On poorly drained farms in Ireland, stone aggregates are the only drainage envelope material used by contractors. An aggregate survey conducted across quarries showed that the most popular drainage aggregate size (50 mm) available in quarries nationally is too large. Such a size is likely to decrease the system performance and lifetime due to sediment ingress. The objectives of this laboratory study were to: a) select a gradation of aggregates suitable for use in clay textured soils, and b) assess the performance of commonly used aggregates based on their hydraulic and filter function.

3. Methods

A bespoke laboratory setup consisting of replicated units containing clay textured soil with a series of aggregates size ranges was created (Figure 1). The treatments were 9 aggregates from 0.7 and 62 mm used in combination with a clay textured soil, replicated three times. Each unit had a 40 cm head of water, which was maintained above the top of the soil surface for 38 days. The following parameters were measured: Discharge rate of water through the drainage pipe outlet as an indicator to determine the hydraulic conductivity functionality of the envelope; Total Suspended Solids to determine the filter functionality of the envelope. Destructive sampling of the envelope after completion of the experiment to determine ingress of sediment into the envelope.

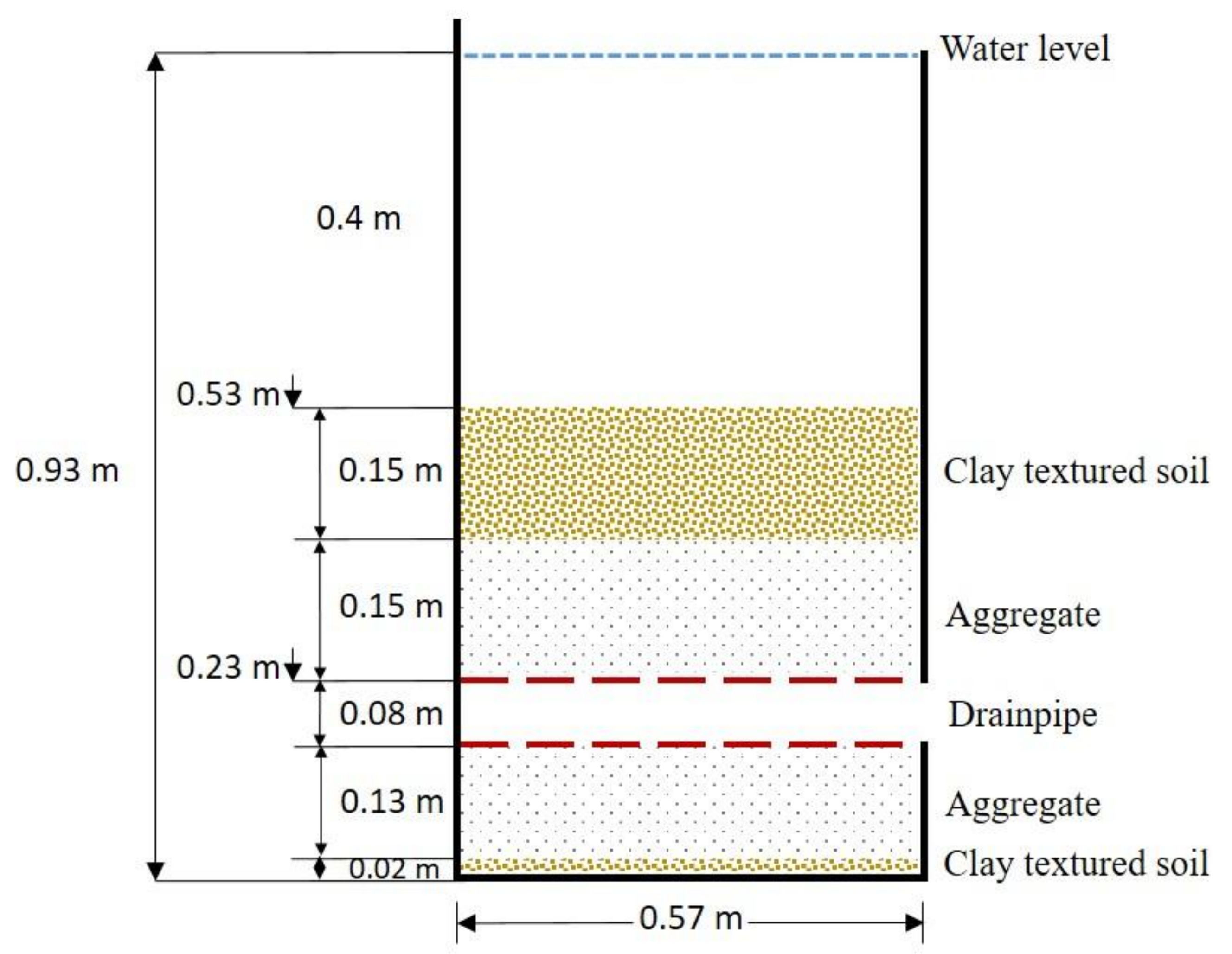

Figure 1. Laboratory unit setup showing flow through the system and depth profile.

4. Results

An aggregate in the 0.7 – 3 mm range preformed best from a discharge rate perspective (Figure 2a). Discharge was inversely related to aggregate size, with larger discharges being measured in the smaller aggregate sizes. For all aggregates examined, discharge was greatest at the start of the experiment, before reducing over time. From a sediment loss perspective, the best performing aggregate was in the 2 – 10 mm range (Figure 2b). Most of the sediment loss occurred within the first 8 days of the experiment. Lowest sediment ingress into the envelope was observed in the 0.7 to 10 mm range.

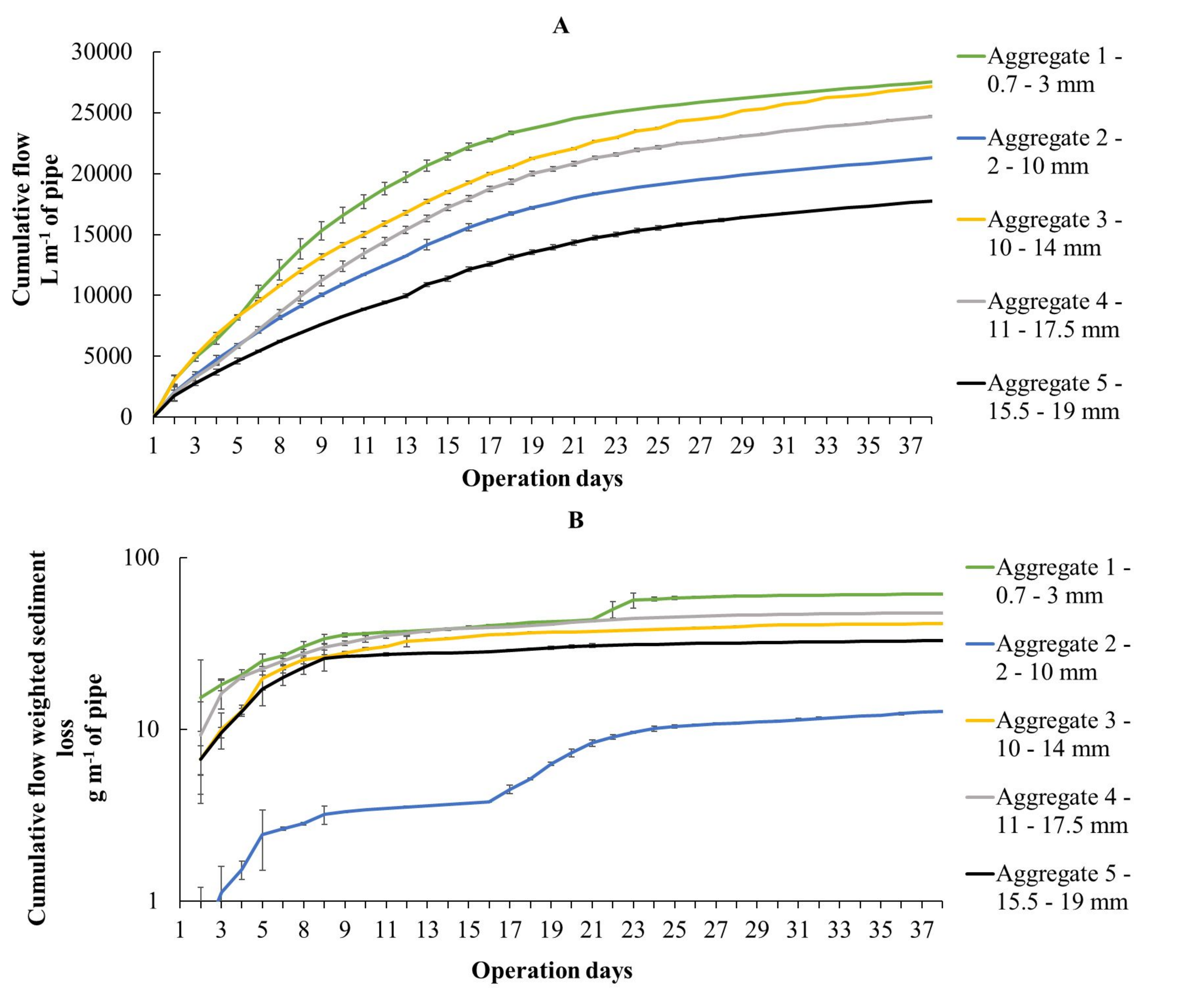

Figure 2. (A) Cumulative average discharge rate and (B) cumulative flow weighted sediment loss (error bars indicate the standard deviation). Discharge and sediment loss data for Aggregates 6, 7, 8 and 9 were not obtained, as they had met criteria for failure within the first 24 hrs of operation.

5. Conclusions

An aggregate size range from 2 – 10 mm is optimal from both filtration and discharge perspectives, for a clay textured soil. However, aggregate sizes up to 20 mm would be acceptable. Aggregates greater than 20 mm in size did not perform effectively and should not be used with a clay textured soil. When the cost of the aggregate material is also considered, aggregates in the lower range (0.7 to 10 mm) are 18 to 50% more expensive than aggregates in the higher range (10 to 20 mm). The higher range would be optimal from a performance and cost point of view. Contractors and landowners should source aggregates in these ranges for better performance and lifespan outcomes.

6. Acknowledgements

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