Evaluation of land drainage system materials

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Summary

- This work showed a large variance between the sizes indicated by the quarries and the true gradation of the aggregate.
- A clean aggregate less than 20 mm in size would offer best results in the majority of soils.

Introduction

Subsurface drainage in agriculture plays an important role in the removal of excess surface and subsurface water from poorly drained soils. Drainage of mineral soils together with optimised soil fertility and appropriate management, facilitates productive grasslands. The removal of excess water has many benefits, including increased trafficability and crop yield, reduced surface runoff and improved soil structure. A typical subsurface field drainage system consists of a network of corrugated or smooth perforated pipes surrounded by an envelope material, which is typically stone aggregate in Ireland. The performance and lifespan of land drainage systems is highly variable and poorly understood, and is dependent on, amongst other factors, the quality and suitability of the materials used in field drains, and on keeping such drains well maintained.

Survey and Particle Size Distribution (PSD) analysis

A recent survey sought information on the types, size, lithology of stone aggregates and location of quarries throughout the country. The most popular stone sizes as indicated by the quarries were, 10 mm, 20 mm, 20 – 40 mm and 50 mm. The survey was followed by a Particle Size Distribution (PSD) analysis on seventy four samples, from sixty quarries, collected throughout the country. The results from this work showed a large variance between the sizes indicated by the quarries and the true gradation of the aggregate. This is indicated in Figure 1. The variance in a Q 50 mm aggregate can be seen visually with variance in size and lithology. The four most popular sizes from the survey were grouped and the results showed, the variance increased with increasing aggregate size. The sizes indicated by the quarries can be highly variable and may not accurately reflect actual material grading. A large proportion of available aggregates are larger than the 10 to 40 mm grading range currently recommended and an effort should be made to select a more suitable smaller aggregate material for drains.

Aggregate size criteria based on flow and filtration performance

The suitability and performance of aggregate sizes currently used for drainage systems in Ireland are mostly based on preference and availability. When design criteria, based on international specifications, are applied to a range of soil textures commonly seen in heavy soil farms, an aggregate size smaller than what is currently in use in Ireland is required. Testing of a range of aggregate sizes currently in use (up to 62 mm) was carried out to establish efficacy and determine a suitable aggregate size for heavy soil textures. This experiment indicated that aggregates < 20 mm in size performed best from both a filtration and hydraulic perspective. Increased filtration performance was observed in aggregates < 10 mm in size. The adoption of more appropriate aggregate size range specifications would optimise performance and extend the lifetime of drainage systems.

Figure 1. *A selection of Q 50 mm aggregates*

Conclusion

The current system of quarry aggregates being identified by a single size, or of a specified grading range, does not give a fair reflection of the true gradation of aggregate being sold. The sizes of aggregates currently in use are larger than what is recommended, and the suitability and preference of the current sizes of aggregate for Irish mineral soils does not conform to established international aggregate specifications which advise a smaller aggregate size than what is currently in use. Aggregates < 20 mm in size showed best results under performance testing, while those < 10 mm in size offered additional benefits. Such specifications are smaller than aggregate sizes generally used currently.