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DEGRADABLE MASONRY BLOCKS FOR EROSION AND SILTATION CONTROL

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ABSTRACT
One of the significant environmental problems for local communities is safe disposal of sludge from the sewage treatment process. One of the alternatives for the disposal of this material has included combining with other organic products to produce mulch. This mulch is frequently now a saleable commodity, but it has a limited range of applications. One of the side effects of the push for the development of portable earth block machines for construction of low cost housing in the rural South Western USA is the ubiquitous presence of these machines in a large number of smaller rural communities. Block machines can be used with a wide variety of materials, to produce a wide range of block products. The first purpose of this paper is to outline the development of a degradable masonry blocks for erosion and siltation control, made using the block machines. The degradable masonry blocks are made from the treated sludge, clay and lime to provide one method for a small community to dispose of the waste product, whilst providing a community benefit. The second purpose of the paper is to document a number of suggested uses for the degradable masonry blocks, and document results of early experiments with the blocks in southern Texas.

KEYWORDS: degradable blocks, sludge, environmental protection.

INTRODUCTION
Masonry as a concept etches deep into the heart of cultures, because of its permanence, symbolism and beauty. Shakespeare in All's Well that ends Well stated:

" *I shal stay here ..Creeking my shooes on the plaine Masonry*."

J. M. Kelly in the text Short Hist. Western Legal Theory x. 444 stated

"*Christian morality had long since been inseparably mortared into the masonry of British society.*" [1]

It is therefore interesting to consider another approach in the use of masonry to provide a community benefit, in this case to minimize pollution caused by matter in storm water runoff from construction sites. The difference is the time scale of concern in this matter, the masonry for a National Cathedral is hard durable and attractive to the eye if it is to make an architectural statement, whereas the site pollution of lime, sand, and cement from the construction is at best a storm water problem for at most a few years. This short duration does not preclude one from making a system to reduce the transport of pollutants from a construction site using some form of masonry. The criteria for this masonry is however distinct from and to the masonry for the building. This short duration masonry needs to meet a number of criteria to be effective:

1. blend in with the environment and use local materials
2. last a tolerably short time, and be cost effective for maintenance
3. do not harm to the environment, if it is damaged
4. filter out most pollutants
5. work for small sites where earthmoving equipment is not readily available
6. be safe and support plant life

A form of adobe block can be used to meet these criteria to provide a cost effective method to control pollutants from smaller sites, whilst limiting the use of non-renewable resources. This paper discusses the development of these degradable blocks using commonly available renewable resources and block machines used in some communities, particularly in the South Western Region of the United States. This method does not replace the standard large earthen or concrete detention or sedimentation basins required for larger communities, it merely fills in a niche for some poorer communities.

BACKGROUND TO THE STUDY

Figure 1 shows a typical lime stabilized earthen block, which is a recent development with core holes for reinforcement. The purpose of this brick is to improve seismic capacity in Mexican housing.

Figure 1: Moulded Earthen Block – with Core Holes for Reinforcement

Graham [2] has been experimenting with the development of lime and cement stabilized blocks for several years as part of the Sustainable Construction Program at TAMU. The seismic problems associated with these blocks and soft bricks is well documented elsewhere [3, 4] and is not further discussed. These blocks, shown in Figure 1, do not meet criteria 1 and 6, because suitable clays are often distant from the site and this clay will not readily support plant life.

Figure 2 shows one of the machines developed for the moulding of earthen blocks. This machine has an inlet hopper, compression box and an ejection system. The system is capable of producing about 230 to 300 blocks per hour depending on the skill of the operator [2].

Figure 2: Moulded Earthen Block Machine at TAMU

The Texas Department of Transportation use a small stone weir to form a miniature sedimentation basin, as shown in Figure 3 from Highway 21 near North Zulch, Texas.

Figure 3: Simple TxDOT Sedimentation Trap

These types of small random stone masonry weirs occur commonly in man-made sedimentation systems throughout the world and have proven to be effective for the management of coarse pollutants, probably down to lager silt sizes. These systems are unsuited for settling of fine silts that frequently occur in the clays in the central Texas region around TAMU. Figure 4 illustrates the problem of settlement of some fine silt, which often has settlement times measured in months or years. These settlement experiments were completed by Professor Holland (2009, personal communication) at TAMU as part of a soils laboratory.

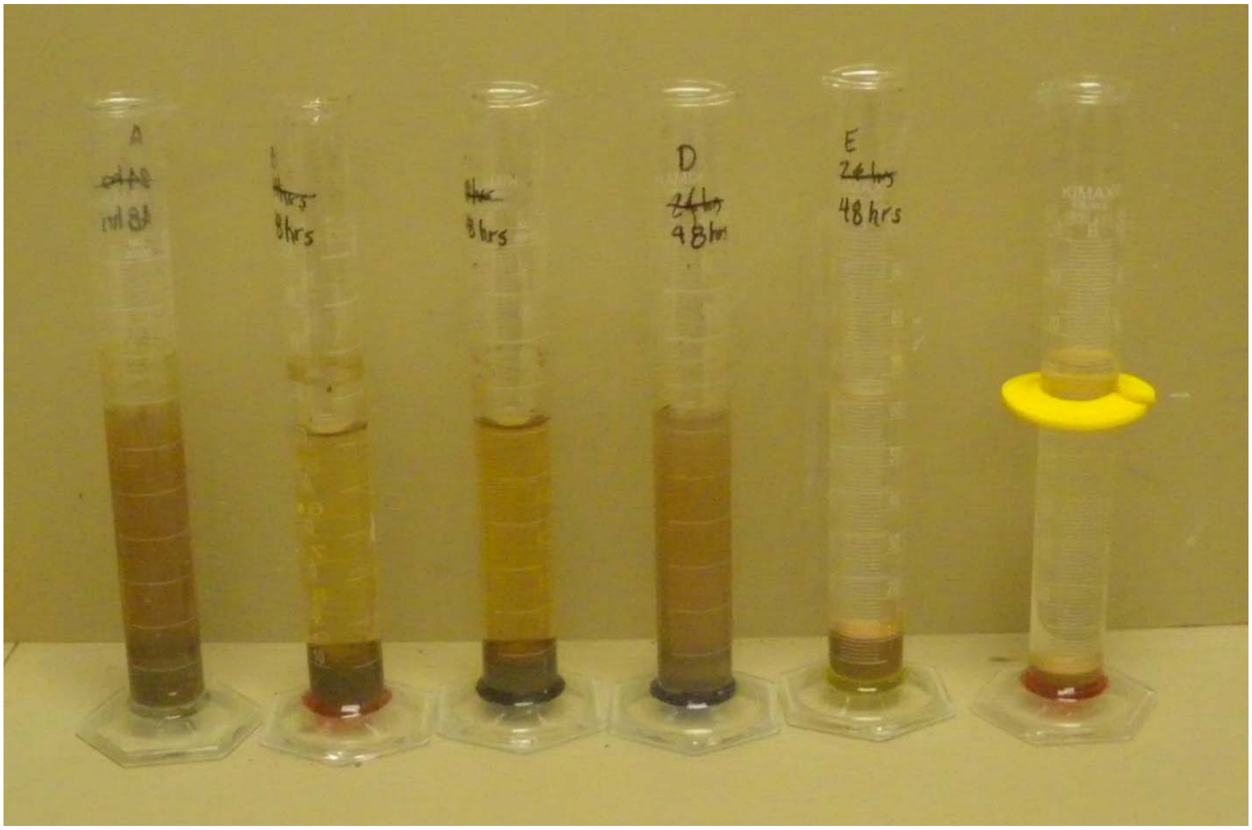

Figure 4: Clay Settlement Samples after 2 months (Courtesy N. Holland, TAMU)

There exist a number of issues with this standard design (Figure 3), which are discussed in terms of the previous criteria:

1. stone in this case is imported from the western regions of the State, and in it in no way blends in to the area, a similar problem has occurred in coastal areas where red basalt is imported to stabilize white beaches
2. stone if washed downstream will last a long time as sharp objects that can be a danger to animals, as an example to cattle who are not used to sharp stones embedded in the local clays. It is difficult to re-gather the rock for repairs and so more rock is required.
3. mesh can entangle local wildlife, which is an increasing environmental problem with manmade materials or structures
4. the stone size will be of a size and grading range that is ineffective at trapping sediment
5. does meet this criteria

6. does not support plants that act to filter some forms of pollution

Whilst this is a standard design is often in construction, one would have to consider it is less than ideal for all communities. The alternative structure is the commonly used silt fence. Figure 5 shows a sample silt fence construction drawing [5].

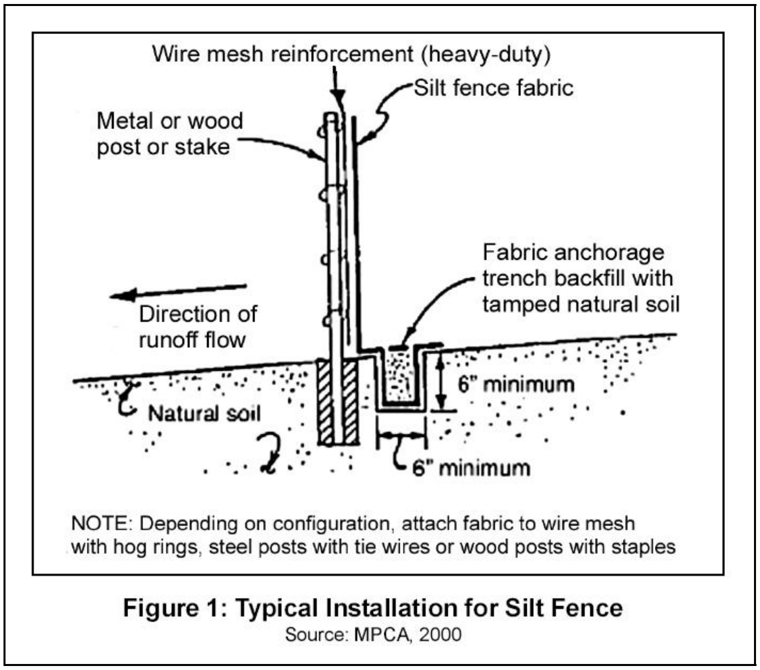

Figure 5:Typical Silt Fence from MPCA, 2000 [5]

On a construction site, one often encounters silt fencing as an initial perimeter control that is upstream of the sedimentation and detention basins. The silt fence design recommendations for this plan are:

A. Construct so that flow cannot bypass ends
B. Fence is stable for a 10 year recurrence interval storm
C. Provide 0.29 ha per 100 m of fence
D. Water depth not to exceed 0.6 metres

Design recommendation D will be hard to meet with this design with a 0.6 m flow depth. Evaluation of the Silt Fence Design against the six criteria shows:

1. material used in the construction is petroleum based and is difficult to dispose off after the work is completed, emptying the fabric of accumulated materials is difficult for re – construction and repairs
2. mesh will need to be land filled
3. if the mesh is washed downstream it will be a problem for many years, endangering wildlife who are caught in the damaged material

4. does meet the filtration criterion
5. does meet construction on small sites criterion
6. snakes and other harmful creatures can find habitat in the mesh fencing once material is piled against the wall. Steel stakes used to hold up the fence are a safety hazard for people falling. Often a cap is placed on the steel stake, but this is often displaced during the construction period and not replaced. A depth of 0.6 metres is sufficient for a small child to drown in, if the fence is displaced an a concentrated flow occurs

These are surmountable issues, but there is always a scientific endeavour to find alternative methods with a lower carbon footprint that are ultimately gentler on the environment.

DEGRABLE MASONRY BLOCKS

It is increasingly common for towns and cities to develop a recycling system for green waste and sludge from the local Sewage Treatment Works. Bryan, Texas has a recycled green material, used for these initial experiments. Figure 6 shows a sample of the material. Experimental work is proceeding on the material and further details on the material will be presented at the conference.

Figure 6: Green Recycled Material for making Degradable Blocks

The block mixture consists of hydrated lime, locally available clay, and the green recycled material from the City of Bryan. Figure 7 shows the material after mixing. The material proportions were by volume of clay to green material to lime of 1: 1: 0.3. The moisture content of the completed bricks was 30 ± 2 percentage. A number of mix designs were tried for the bricks to develop one that was not friable. Figure 8 shows some completed bricks. The bricks are 300 by 140 by 50 to 100 millimetres.

Figure 7: Sample of the Mixed Material

Figure 8: Sample of the Blocks – ~300 mm length

SEDIMENTATION DAM CONSTRUCTED FROM DEGRABLE MASONRY BLOCKS

A small sediment control trap is being constructed at TAMU. The researchers will measure the flows, sediment trapped and the rate of block degradation to determine the range of applications suited to the block. Figure 9 shows the generally flat floodplain for the Brazos River that forms the small catchment used to investigate the bricks ability to form a stable sedimentation basin.

Figure 9: Catchment Photograph from the Basin Location

Figure 10 shows the headwall immediately downstream of the basin. Figure 11 shows a water flow on the second day of construction through the sedimentation basin in the period after a rainfall event. This first element of the wall was constructed on the first day of construction. The wall, 100 mm high, showed no visible damage from the water flow. This masonry wall when compared to the standard criteria does:

1. blend in with the environment and use local materials, and has a low carbon footprint
2. last a tolerably short time, and be cost effective for maintenance
3. do not harm to the environment, if it is damaged as it is made from local materials that are stable or biodegradable
4. no research has been undertaken on the filtration capacity, but given a 10 year recurrence interval design storm the basin will not perform worse than standard basins
5. work for small sites where earthmoving equipment is not readily available
6. support plant life, with the grassed embankment and is as safe as a standard basin design.

Figure 10: Outlet Headwall located 10 metres downstream of Basin Wall

Figure 11: Flow around first layer of the Basin Wall

Engineering is about exploring ideas. The central feature of modern design is reducing the carbon footprint of human occupation of the world. The second feature is reusing some of the seemingly difficult to reuse material, such as sludge from Sewage Treatment Works. There are of course significant issues with this type of development, including the problems of metal and other contaminants in the sludge. However, the type of degradable masonry block developed at TAMU is designed to mitigate some of the environmental concerns in using stone weirs in farmland and in using silt fencing in urban and rural settings. The other form of site that would benefit from this type of construction is the sensitive wetlands, where the designer is not allowed to introduce normal earthmoving machinery, but is constrained to limited access and damage. The Shortland Wetlands in Australia exemplify this type of area, where access to the wetland is limited by the National Park Service.

One can argue that this is not true masonry in the sense of building construction, but the other side of the coin is that brick making tools are used to create a compressed building block that can be used to construct a wall in place of earthmoving machinery. One can of course develop the wall with unskilled labour and only a block machine.

CONCLUSIONS

Degradable blocks provide a tool in the engineering provisions for storm water pollutant control from construction work. This paper outlined the initial development of the block and the reasons for providing an alternative method for small area control. There is significant research required to provide the viability of this idea, but the masonry industry has proven adept over the millennia in meeting the engineering challenges. There is no reason not to expect the tools developed for the masonry industry to be used to solve some of the difficult problems of this era, including environmental problems.

ACKNOWLEDGEMENTS

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