

Suffolk Estuary Flood Defence and Right of Way Trial on the Deben Estuary, (Flood Cell 12), north of Martlesham Creek

1. Background

Many of Suffolk's sea/estuary defences, often clay banks, have public rights of way (RoW) running along the top of them. Erosion related to high tides can damage or wash away the footpath surface and in extreme examples where the defence is breached, as seen during December 2013's storm surge, the RoW can be lost completely.



An example of an estuary defence footpath damaged in December 2013 surge

The role of a flood defence is to hold water back in order to prevent flooding and also to overtop without damage (breaching) in extreme events. The performance of a defence during overtopping depends on several factors, one of which may be the performance of the surface along the crest and landward slope.

Currently, when coastal/estuary defences are built or repaired the RoW surface is re-instated along the top of the newly constructed defence. The choice of surface of the RoW is the responsibility of the Suffolk County Council RoW team who have ongoing responsibility for the surface as the Highway Authority. The responsibility for the land beneath it lies with the landowner.

In a sensitive natural landscape and for resilience to overtopping, a grass-surfaced RoW is ideal. However, heavily used paths, particularly in wet conditions, can become muddy and in some cases impassable so it is often necessary to use a more robust surfacing material such as hoggin, type 1 crushed concrete, recycled furnace slag, road planings or granite. These surfaces have proved successful as walking surfaces but as the tidal surge of 2013 has shown, they are vulnerable to being washed off, particularly when newly laid. The aim of this trial is to be able to provide guidance on how to deliver a standard of defence able to withstand overtopping without breaching and, at the same time, create a suitable public right of way surface that is resilient to overtopping. The trial results will inform future recommendations to those carrying out repairs and improvements to clay bank defences. Any solution recommended must be effective, sustainable, low cost, and environmentally acceptable. Many of the important RoW along estuary banks lie within the Suffolk Coast and Heaths AONB and adjacent to internationally designated environmental areas.

2. Setting up the trial

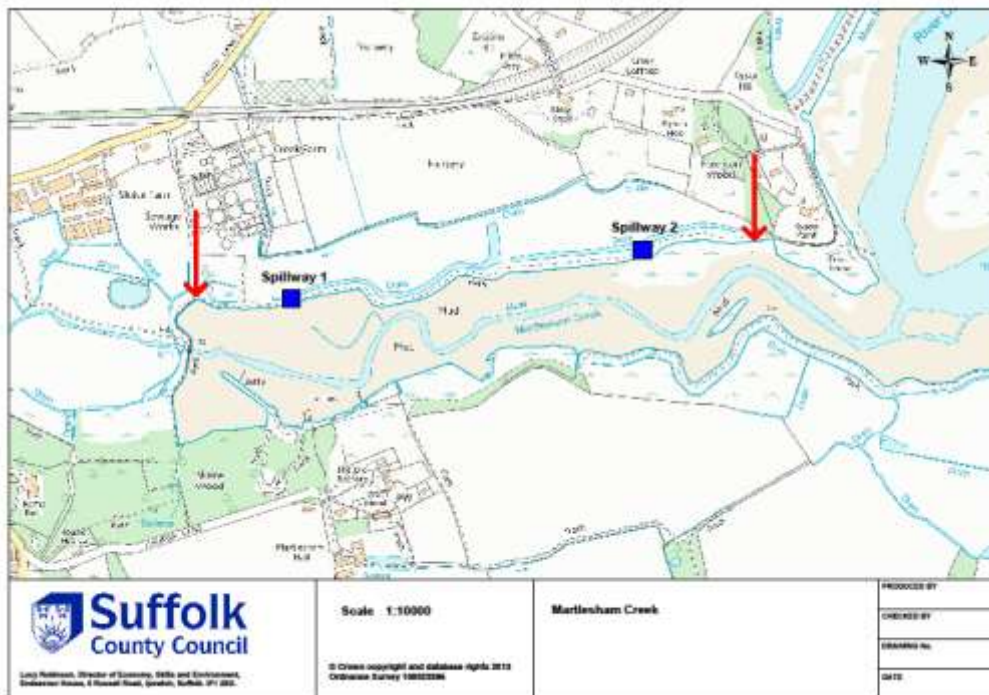
The Suffolk Coast Forum (www.greensuffolk.org/suffolkcoastforum) instigated the trial by requesting ideas from a range of engineers and, in conjunction with the wishes of the landowner, chose to test two materials in situations where over-topping is likely and compare them to footpath surfacing of compacted aggregate (crushed concrete) and hoggin. At Martlesham, only two of the materials are expected to overtop but there is already evidence about the performance of paths surfaces made from compacted aggregates and hoggin.

The assessment of the trial will involve technical monitoring of the defence and path surfaces as well as feedback from the RoW users. The results of this monitoring are unlikely to be available for at least 12 months as the path needs to be overtopped on several occasions to ensure it is robust and that the surfacing provides a safe and cost effective walking surface.

3. Introduction to the trial at Martlesham Creek

The location at Martlesham Creek was chosen for the trial as it offered an opportunity to test the surfaces in a situation where overtopping should occur about 1-2 times per year. The map below illustrates the location of the trial on the northern bank of the estuary at Martlesham Creek, and the two spillway sections on which the new RoW surfacing is being tested.

A small section of the bank is owned by Suffolk County Council, the remainder is owned by Notcutts. The work was carried out by Miles Drainage and jointly funded by the two landowners. Andrew Hawes oversaw the spillway works and contributed to the technical information in this report.



Map of trial site on the north bank of the River Deben at Martlesham Creek.

The trial section that will be assessed as a walking surface runs between the two red arrows.

The location of the two spillways is also marked.

Following significant damage to the wall (see picture below), as a result of the tidal surge of December 2013, a sustainable approach to the defence restoration was required.

In order to ensure minimum damage in any future surge event the design implemented allows the flood cell to drown out using grass reinforced spillways – areas lower than the main wall height. The lower level of each of the two spillways should result in overtopping at least once every winter on extreme spring or surge tides. When water flows over the spillways it results in full submergence of the grazing marshes behind the wall. This prevents overtopping of the higher, steeper sections of river wall, which are in a poor condition and liable to breaching. This design was regarded by the landowner as the most cost effective option – the more expensive alternative would have been to strengthen and broaden the whole length of the wall.



A significant length of footpath surfacing was damaged or washed away during the 2013 surge. In order to trial possible solutions to footpath damage due to overtopping it was decided to design into the restoration works two different footpath surfaces along the spillways. The footpath here is heavily used by the local community as part of a circular walk, thus some hard surface (i.e. not just grass) was essential.

In order to repair any such defence it is essential to ensure the availability of suitable clay material. In this location there was suitable material available on a redundant cross bank and further material was won on site, making the operation cost effective.

Once the clay wall was repaired, including levelling and profiling the spillway sections, the surfacing materials were applied. The main bank was levelled at 3.5 m AOD and the spillways at 2.8m A.O.D. The landward slope of the spillways was 1 in 4.

The landward slope of the spillways was covered with VMax C350 Turf Reinforcement Mat which will be seeded to encourage rapid grass growth. When laid onto earth works this mat allows direct seeding, even with limited topsoil. As the coir rots over several years it provides a source of humus for the developing grass sward. As the grass grows so it incorporates the polypropylene mesh into its roots, leaving the resulting grass cover is significantly more resistant to overtopping velocities in excess of 4 m/s – i.e. the bank can overtop for longer with no damage.

The four surfaces tested in the trial and their locations are:-

- Tenax PP-Flex (plastic cellular material filled with crushed concrete) – western spillway
- RPC Ankalok (concrete cellular blocks filled with crushed concrete) – eastern spillway
- Crushed concrete - on the rest of the repaired wall
- Graded path hoggin on top of compacted aggregate (Type 1 Furnace slag) – existing footpath not affected by the storm surge

The PP Flex surface was proposed by Robert Orford of Miles Water Engineering Ltd of Great Ashfield, Suffolk.
The Ankalok surface was proposed by Andrew Hawes.

Miles Water Engineering Ltd undertook all the works on behalf of the landowners – Suffolk County Council and Notcutts.

The paragraphs below outline the technical details of the surfacing materials, the installation method and comparative costs.

NOTE

Prior to works commencing ecological surveys were undertaken and flood defence consent issued. The method and timing of working ensured minimal disturbance to important protected species, e.g. reptiles and water voles and to nesting birds.

4. Technical details & comments on surfacing methodology

4.1 Tenax PP-Flex - western spillway

This 70m long 1.5m wide footpath section is constructed with a 50mm foundation of crushed concrete with interlocking H.D.P.E. cellular mats pinned in place and in filled with crushed concrete, compacted with a wacker plate.

Installation

As with the Ankalok section, this installation was manually intensive but in a normal situation the crushed concrete or Ankalok would be carried on mini tracked dumpers. The Tenax PP –Flex is very light weight and many units can be easily carried.

The Tenax is held down with small galvanised steel pins. These, however are considered to have limited anchoring abilities, so a section of the trial has been anchored with a plastic barbed peg approximately 180mm long.

Due to the curve of the wall in this location it was necessary to stagger the mats.

The amount of crushed concrete used in total was 250kg per metre square.

There was some difficulty experienced with maintaining a level surface as it was prone to movement when running the barrows of crushed concrete along the cellular material. This problem was also experienced with the Ankalok – and was largely caused by the soft condition of the clay repairs on both trials

The pictures below illustrate the installation process and completed surface.



Cellular HDPE mats (Tenax) delivered on site

*Excavation for crushed concrete foundation.
This photo illustrates the curve of the path at this location (looking west)*



*Foundations prior to mat placement
(looking west)*

*Mats laid out on the base being infilled with crushed concrete. This illustrates that the mats have to be staggered to accommodate the curve of the path.
(looking east)*



Partially complete of path surfacing across western spillway (looking east)

Note the use of the turf reinforcement mesh on the landward slope of the spillway



Finished path (looking east)

The only thing left to do is to seed the turf reinforced mesh. As well as a grass surface on the landward slope it is hoped that vegetation will re-establish itself along the path margins.



Close up of finished surfacing



4.2 RPC Ankalok - eastern spillway

This 30m long 1.6m wide footpath section was constructed with a mesh foundation placed directly on the levelled ground with 90mm thick interlocking concrete revetment blocks placed on top. Crushed concrete was brushed into the gaps between each block - approximately 25 kg per square metre was required.



Example of the double twist rockfall mesh used on the wall as the foundation for the interlocking Ankalok blocks. This illustration is from a previous defence repair at Orford.

Installation

The blocks were installed manually. The maximum block weight is 12kg, with the half blocks being 6kg, thus there is a risk on manual handling injuries, although none were experienced on this occasion. The blocks were quick to install due to the simplicity of preparation and placement.

The path on this spillway is straight, thus blocks did not need to be staggered and cut. It would be possible to lay them on a curved surface as for the PP flex cellular blocks, but this would add to the workload.

It is estimated that three people could complete the entire straight spillway of 48m² in a day

The photographs below illustrate the installation of the pathway.

Note: The installation of either the PP Flex or the Ankalok in a “real” situation of would be achieved mostly mechanically, although the actual positioning of the PP Flex and Ankalok is likely to be manual.



Site strip prior to mesh placement (looking west)

Completed path across spillway. (looking east).

Note the turf reinforcement mesh on the landward slope – awaiting seeding.



Close up of finished path surfacing

4.3 Comparative costs of the spillway trial sections

NB. Path width 1.5m

	PP Flex/m ²	Ankalok/m ²
<u>Materials:</u>		
PP Flex & Pegs	12.00	-
Ankalok	-	27.00
Rockfall Netting (based on 2m wide)	-	3.35
Crushed concrete	<u>4.60</u>	<u>1.95</u>
	16.60	32.30
<u>Labour & Equipment</u>	<u>13.40</u>	<u>10.00</u>
TOTAL/m²	30.00	42.30

Please note the material costs include 15% mark up to allow for overheads and profit.
The labour is costed at £18.00/hr

4.3 Compacted aggregate (crushed concrete) and hoggin.

Where no repairs were made to the wall, the existing path surfaced with hoggin remains. Whilst this section will not be tested for overtopping resilience on this site we have evidence of the impact of overtopping on that type of surface on other walls to use as a comparison.

Where the wall was repaired to full height (i.e. not on spillway sections) the surface used was compacted aggregate (crushed concrete)

Both the new compacted aggregate and existing hoggin sections will be used as comparisons to the spillway sections for their acceptability as walking surfaces. The approximate cost of these surfaces installed is £15-20/m² depending on depth of material used.

*Existing hoggin path
looking east towards spillway 2*



*Crushed concrete, prior to compaction,
on first section of the wall
(looking east)*

It is worth noting that due to the poor quality of the initial crushed concrete a further covering of finer crushed concrete was added about a month later both to the crushed concrete and Tenax infill surfaces.

5. Trial appraisal

The length of the repaired wall and the two spillways will be monitored over the coming months by a qualified engineer and the footpath surfacing regularly checked for any differential settlement that might develop resulting in maintenance work to avoid trip hazards. The monitoring will be carried out immediately after the installation is complete and at regular intervals, and particularly after significant rainfall and tides that overtop the spillway.

In addition a public survey will be conducted in order to assess opinion of the different walking surfaces. The Suffolk Coast & Heaths AONB volunteers will assist with this survey work.

Sign boards (see illustration) will be located at either end of the path explaining the trial details and providing a web link (www.suffolkcoastandheaths.org) for further information and to complete an on-line survey.

6. RECOMMENDATIONS

Once the results of the monitoring and public survey are complete this report will be finalised with recommendations about which surface or surfaces are most suitable for use on repaired/improved estuary walls. It is anticipated that this final report will be available in 12 – 18 months' time as it is necessary for the spillways to be overtopped on at least 3 occasions to be confident that they are robust.

Appendices/additional information (available on request):

- Eastern spillway: Cross section example of Ankalok proposal.
 - Ankalok 90 brochure.
- Western spillway: Proposals, plan & section.
 - Tenax PP Flex. Brochure.
- Turf reinforcement mesh brochure
- Monitoring details
- Public opinion survey



Footpath Surface Trial

Four different footpath surfaces are being trialled here.
What do you think of them?
Please let us know at www.suffolkcoastandheaths.org

			
Tenax	Ankalok	Hoggin	Crushed concrete

Designing for resilience
The river wall, and the footpath that runs along it, were damaged in the December 2013 storm surge. The landowners have repaired the river wall, which now incorporates two lower sections. These are designed to allow water to overtop in extreme tides in a controlled way so as not to damage the walls. The water will then drain back into the river at low tide through sluices. Two novel surfaces, Tenax and Ankalok, are being trialled on the low sections.

Walkers should not cross these low sections when water is coming over. During these extreme events the footpath will be closed.

For more information or to comment on the new surfaces please visit the Suffolk Coast & Heaths Area of Outstanding Natural Beauty website:
www.suffolkcoastandheaths.org




Update April 2016 – including interim recommendations

Public Opinion Survey

In the summer following the completion of the trial surfaces, a public survey was undertaken to public views on the surfaces. This was not as extensive as intended but some 31 walkers were surveyed. We did not manage to get opinions from anyone using the path with a wheelchair or pushchair, nor from dog owners. The sample is smaller than hoped so no firm conclusions can be drawn, but the headline findings from this survey provides the following:-

At the time of taking public views the surfaces were very new and so not surprisingly the visual impact of the original hoggin path, which had been softened by vegetation at the edges, was preferred to the other surfaces.

More people expressed a liking for the visual impact of the Tenax (40% like it) compared to the Ankalok (32%). Comments were made that the Ankalok was more suited to an urban environment and would not look good when used widely in rural situations.

In terms of a walking surface the original hoggin path was again the most favoured, with 83% stating they liked this surface. 60% said they liked the Tenax surface but only 43% expressed a liking for the Ankalok. Comments were made that the Ankalok did not make a comfortable surface to walk on and concerns were expressed about unevenness and potential trip hazards.

Assessment of the actual surfaces and vegetation growth

Following the installation of the new surfaces they have been regularly monitored and photographed. However, there has not yet been any occasion on which the surfaces have been overtopped by the tide, so their ability to withstand this has yet to be assessed.

The latest assessment/photos, carried out in March 2016 resulted in the following conclusions:-

The **Hoggin** surface, laid in September 2013 remains a level, firm surface for walkers. It is being colonised by surrounding vegetation which softens the visual impact and also helps to bind the surface together and to the wall. It is a good walking surface.

Crushed concrete – initially it was intended that type 1 crushed concrete would provide a good walking surface but the poor quality of the material provided resulted in the need for a layer of granite fines to be laid about a month later. Note this was also the case for infilling the Tenax. *Photo right.*

Vegetation is re-growing at the edges.

This section of the path is level and firm and is a good walking surface.



Tenax infilled with crushed concrete and granite fines: The grids are mostly covered and material does not appear to have washed out/eroded out of the cells. *Picture left.*

Vegetation is growing at the edges and on the backslope (except where the mesh was not pinned down flat).

It is level and firm to walk on and is very similar to the crushed concrete surface without the cells.

Ankalok blocks infilled with crushed concrete: The blocks remain in place and are firm and there is some vegetation growth between them. .



Ankalok blocks, March 2016

At the edges where the soil is flush with the surface of the blocks, the vegetation has regrown but there are short sections where the blocks stand proud (*photo right*)

The infill material is at a lower level than the surface of the blocks - material may have settled or washed/eroded since installation. The blocks are not all at the same level and although the differences in height are small at present (1cm), it is a concern that with further settlement or loss of infill, they will become trip hazards (*photo below*).



There is an inclination to walk this section watching your step.

It may be that there are other concrete products designed with walking in mind that might perhaps have avoided these issues – for example blocks fixed onto matting or those with different dimensions between block and infill spaces.

Interim Conclusions

The Hoggin, crushed concrete with granite fines and the Tenax cells with crushed concrete and granite fines currently provide satisfactory walking surfaces and are visually all very similar, especially when softened with vegetation growing over the edges. Suffolk Rights of Way are currently happy to recommend any of these as footpath surfaces.

The Ankalok blocks are less satisfactory and at this stage Suffolk Rights of Way will not be recommending their use as a walking surface over and above the other surfaces trialled on this footpath. The use of concrete products specifically designed for walking surfaces may ultimately prove more acceptable.

It has not, as described earlier, been possible to test these surfaces' ability to withstand overtopping and as this is a key aim of the trial, this will need to be assessed before a final conclusion can be drawn. In the interim, the preference will be to avoid the use of Ankalok blocks.

It is also worth noting the importance of ensuring the matting used on the back slopes (of the spillways) is laid flat. It has worked well and become grassed over except where the matting was not laid flat.

Additional conclusions resulting from the 2011 trial on the Orford Wall

In 2011 a trial was undertaken on the Orford Town Wall, primarily to assess a novel method to make estuary walls resilient to overtopping, by strengthening the back slope which is held in place with rockfall netting. The methodology was put forward by Andrew Hawes and supported by the local estuary partnership as affordable and easily achieved by local contractors.

This wall had a well-used footpath running along the top, thus as part of the trial it was necessary to reinstate this footpath to a good standard. It was felt that the rockfall netting alone would present a serious trip hazard and thus plastic turfmesh was added on the top of the wall, covered with soil and seeded with grass. The path was closed until grass growth was established on the path.

Subsequently this path has endured much use and several wet winters. The turfmesh has become exposed and there is little grass on the path. There are numerous locations where there are shallow voids under the turfmesh and the underlying rockfall netting is visible. It is clear that water collects in these voids and the subsequent mud gets squeezed up through the mesh when walked on. On a dry day (5th April 2016), the surface was not slippery and the turfmesh covering the voids was intact and hence not a trip hazard.

In the very wet winter of 2014/15 the original path became muddy where there was no vegetation, but the trial area became both muddy and slippery– albeit shallow mud on a basically level surface. The vegetation on the main path quickly recovered after the winter whereas the trial area remained without any substantial grass cover.

It is a concern that the turfmesh is sitting directly on, or suspended over the rockfall netting and thus may degrade or be physically damaged, resulting in difficult walking or trip hazards.

The conclusion from these observations is that the surfacing methodology used in this trial is not a suitable surface for such a well-used path. It may be suitable for lightly used paths. The photos below illustrate the issue.

Photos of path surface - April 2016

Immediately north of trial area



Immediately south of trial area



The trial area



Close up of exposed turfmesh



Mesh with void underneath



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