APPLYING CONTAINMENT 'CARPET' TO ACHIEVE COMPLIANT BUNDING

Secondary containment is an issue that storage terminals and refineries across the globe have been facing up to over the last few years, all following the catastrophic events at Buncefield in 2005. There have been numerous lessons learnt in the aftermath of this incident, and the need for a reliable containment solution is of vital importance in the construction and maintenance of the tank terminals within these sites. The volatile nature of petrochemicals makes them a demanding long-term challenge for the protection systems chosen.

Traditionally, the risk of spillage from storage tanks has been mitigated by the incorporation of an environmental protection barrier. Bunding is used to prevent the liquid contained within the tanks from causing damage (either by force or its chemistry) to the surrounding environment. If a large tank has a catastrophic failure, the liquid alone can cause extensive damage simply by the force it exerts on the floor and walls of the bund, and therefore the integrity and strength of the bund at maximum capacity is vital. The environmental protection barrier can be applied across the entire bund area, or it can be more targeted depending on individual site conditions (e.g. beneath the bunds or not). To comply with the designs set out in CIRIA C736 BS EN1992-3:2006 and specifically tightness class 1, BS EN 1992-3:2006 – water retaining, BS EN 1992-1-1:2004 – durability, bund floors in the UK are required to meet a maximum permeability of $1x10^{-9}$ m/s

Several options are available to engineers in the design of petrochemical containment to achieve this level of permeability. These include concrete, underlying (or imported) compacted clay, or membranes. Clay has traditionally been the barrier used at the older facilities, installed prior to the construction of the tanks and bunds around them. Some sites are located on good clay and tests have proved they meet regulation and need no further attention. Other sites, however, have been found to not meet requirements and need upgrading. The options to bring these bund floors up to regulation primarily involve the use of concrete or the use of a membrane as the importation and compaction of clay into existing sites is impractical. The membrane option is divided between geomembranes ('plastic' type sheets) and bentonite membranes known as geosynthetic clay liners (GCL's).

GEOSYNTHETIC CLAY LINERS

Concrete is commonly used and can provide a solid, stable, trafficable base to the bund floor. Concrete design and method of construction often requires the excavation of existing material from the bund floor to maintain the capacity required under legislation - 110% of the largest tank or 25% of the combined volume of all of the tanks within the bund. This factor alone can be cost prohibitive as removal of often contaminated material comes at a very high cost. Keeping the excavated material on site and in many cases re-using it as a confining

Rolls of Rawmat HDB installed on the 9m long, 40 degree slopes

The Rawcell is fixed to the Rawdrain with cable ties

Rawmat HDB laid across the floor and links to the slopes material over a GCL provides the cost-effective option being favoured by many operators.

One such site currently using a GCL to provide the secondary containment solution is located in Singapore. The site contains 12 tanks holding a variety of fuels. The site is of pre-World War II construction, and featured earth bunds constructed of clay with compacted floors and clay banks. Although the site is in Singapore, it falls under the COMAH regulations as it is run by a UK military organisation and therefore follows the UK compliance requirements. The upgrade of the site involves the installation of a prehydrated sodium bentonite membrane, Rawmat HDB, to the floors and slopes of the bunds to ensure the facility meets the impermeability requirements for COMAH compliance.

The project involved a number of challenges for UK-based material suppliers Rawell Environmental, engineers and project managers Ramboll and contractors Trant International. These included overcoming insufficient bund capacity in a number of the bunds by the use of weirs, maintaining continuity of the liner in the back to back bunds, minimising excavation to the bund floors and walls, all whilst the site remained fully operational for the day-to-day supply to its client.

RAWMAT HDB MEMBRANE

The Rawmat HDB membrane is a unique natural sodium bentonite membrane in which the bentonite has been pre-hydrated during its manufacturing process using a blend of water-carried polymers. These polymers activate the swelling of the bentonite before the material arrives on site and impart resistance to the hydrocarbons into the core of the bentonite needed to form a stable long-term impermeable barrier. This core of pre-hydrated bentonite is like plasticine and is encapsulated between geosynthetics, which provides protection to the core and allows the product to be handled like laying carpet. This material gives a simple, contractor-friendly lining to the base and walls of the bund. This same Rawmat HDB system has been used worldwide on bund lining and other environmental protection projects by some of the world's major oil companies and storage terminal operators.

To line the bunds the Rawmat HDB membrane is fixed from the crest of the slope, down the 9m long slopes where it links to the same membrane running across the floor of the bund. To maintain the integrity of the bund the Rawmat HDB is fixed to the concrete upstand constructed around the perimeter of all tanks. Using minimal excavation, the slopes were simply stripped of vegetation ready to receive the membrane, the floors levelled to falls of 1:100 away from the tanks.

Challenges came in the methods of anchoring needed to retain the confining backfill placed over the Rawmat HDB membrane. The crests at the top of the slopes of many of the bunds are extremely narrow and the construction of a traditional anchor trench was often not possible. Different anchorage designs were adopted to retain the 200mm deep stone backfill on the slopes with angles up to 40 degrees. These designs involve the use of a composite of Rawgrid triaxial geogrid and Rawcell cellular confinement system. The Rawcell, a honeycomb web of HDPE strips forming pockets to retain the stone cover, is secured to the Rawgrid using high strength cable ties to an engineered pattern calculated to resist the shear forces of the load on the slopes.

The anchoring details used on the site included traditional anchor trenches 500mm deep x 500mm wide. Others involve extending the Rawgrid 5m down the back of the slopes and pinning the Rawgrid into the formation at a given rate of pins per m2 and the self-supporting back to back installation of the grid from one side of the bund wall to the other, backfilling equal amounts of fill to stabilise the slopes.

Working from within the bund the slopes were installed leaving a leading edge to link the slope membrane to the floor membrane. The floors of the bunds were levelled, rolled and soft spots in-filled before the Rawmat HDB membrane was laid across the prepared bund floor. The sheets of Rawmat HDB were laid and overlaps were created sealed with Rawpaste mastic to provide an immediate secure seal at the joints. At all concrete pipe/staircase supports, a 500mm wide collar of Rawmat HDB was applied to the concrete held by a pre-hydrated bentonite mastic applied to the concrete and reinforced with a Rawseal TR35 angle fillet placed at the 90-degree angle between the horizontal and vertical membranes. This acts to reinforce and bond the Rawmat HDB membrane to the concrete. The same detail was used to seal the Rawmat HDB membrane to the tank berm which was replaced as part of the overall upgrade of the bunds.

Rawdrain is laid over the Rawmat before the stone backfill is placed

A completed bund after the installation of the Rawell system

As sections of Rawmat HDB membrane installation were completed these were overlaid with Rawdrain composite (a 12mm deep drainage sheet) before being backfilled with 300mm of clean imported stone. The build-up of the Rawmat HDB, Rawdrain and stone layers provides a positive free flowing drainage system within the bund flowing to a large newly constructed sump. The use of the Rawdrain means that the bund floor is flat and the flow to the drain is created as the cuspated composite fills and flows to the drainage sump through the fast draining stone.

The project is progressing well with three installation teams working simultaneously carrying out the tasks of the groundworks, Rawmat HDB installation and upgrading of the drainage from the bund through a sump/pump system and electrical upgrade. Other works that Trant is continuing with is providing new stepped access to the bunds, as well as site-wide infrastructure that supports the facility. Almost all of the other works, which are ongoing, require consideration for how they interface with the Rawell products.

Russell Butcher, who works for Ramboll as project manager for the client, says: 'The Rawmat HDB design has allowed us to achieve compliant bunding for the client by minimising the excavation and therefore the costly removal of spoil from the site, which ultimately has helped keep costs down.

'Even with the challenging weather conditions, the Rawmat HDB system has allowed us to progress well with the project whilst keeping the site fully operational. The technical support that Rawell have provided has been extremely valuable and I have always felt the advice provided has been cognisant of providing an overall solution which considers all of the site constraints and ongoing works on site rather than considering issues in isolation.'

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