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Long-term performance of non-woven geotextile wraparound walls

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ABSTRACT: The long-term performance of retaining walls constructed using non-woven geotextiles as reinforcement still poses concern to designers. This is because of their unconfined, in-air low moduli properties. This paper fields the performance of several 6.0m high non-woven geotextiles walls built in the late 80's. It considers the performance of the geotextile against UV, creep and in-soil degradation in an semi-arid and chemically aggressive environment.In 1988, a number of trial walls were constructed at Woomera, South Australia to assess the effectiveness of different facing options including concrete blocks, reinforced concrete, steel and geotextile. All walls were destroyed by large explosions, simulating an explosion of an operational explosives building. An assessment was made of each wall type paying particular attention to the secondary damage from flying debris and shrapnel from the facing. The favourable assessment of the geotextile walls in these trials led to their use in full-scale traverse construction at the Mulwala Ammunitions Factory, NSW. Twelve years on, the walls have been resurveyed to determine the post construction creep in the non-woven geotextiles.

1 INTRODUCTION

Geotextile wraparound walls have been used extensively in areas where an economical, short-term solution is required. Temporary walls can often justify the use of geotextiles because of their good short-term tensile strength but would not normally considered in a "long-term" wall due to the creep under sustained loading.

In the following application, the use of a geotextile wraparound was chosen as a long-term solution in a difficult and challenging environment.

2 TRIALS

2.1 *Woomera Trial walls*

In 1987 the directorate of weapons engineering proposed a number of trials to access the effectiveness of wall traverses currently used to protect personnel, equipment and facilities from the effects of nearby explosions.

A number of trial walls were constructed at Woomera, SA. They were constructed from various materials including:

- concrete panel
- reinforced concrete
- geotextile
- steel

After construction, all walls were destroyed at various stages by large explosions. An assessment was made of each wall type, in particular to secondary damage from flying debris and shrapnel.

2.2 *Proposal from trials*

The favourable assessment of the geotextile walls in these tests led to their use in full scale traverse construction at the Mulwala Ammunition Factory, NSW. Other contributing factors that influenced the decision to use geotextile included:

- reduced construction costs
- speed of construction
- design flexibility.

3 A.D.I. MULWALA WALLS

3.1 *Description*

The initial walls considered were to protect the surrounding buildings and personnel in the event of a major explosion in one of two of the explosives buildings. (Buildings 831 and 837.)

The walls consisted of two types of walls:

- perimeter walls
- internal walls

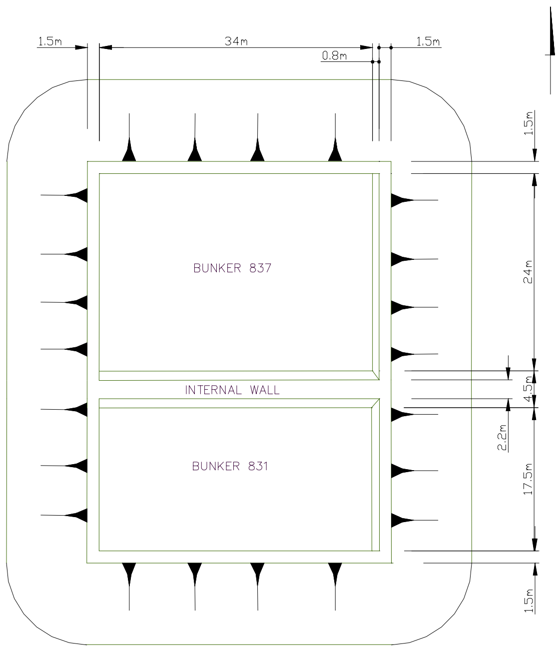

Figure 1. Plan view of bunker walls.

3.2 *Perimeter walls*

The perimeter walls consisted of 170 lineal metres of vertical wall surrounding two buildings. The height of these walls, from the base, are 6 metres and are made up of 20 lifts, each lift being 0.30m high.

Photo 1. During construction of the perimeter walls. Concrete culvert exit tunnel through reinforced wall.

The top 10 layers use an Australian made, non-woven continuous filament polyester geotextile with an ultimate tensile strength of 22.4kN/m, Type A, and the bottom 10 layers use a higher grade with an ultimate strength of 32kN/m, Type B.

The profile of the wall consisted of a 1.5m wide bench at the top of the wall and then a backslope of 26°, as shown in Figure 2.

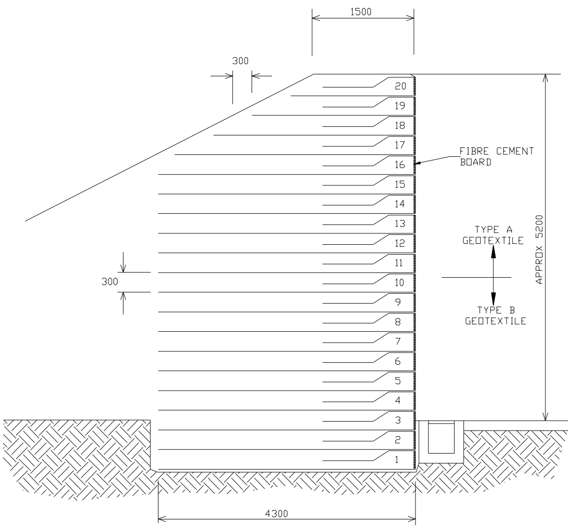

Figure 2. Perimeter wall cross section.

The facing was constructed using the geotextile to encapsulate the reinforced fill material and a smooth face was achieved with the inclusion of a 5mm thick fibre cement board. Although some boards were broken under the construction loads, 99% of the boards still remain intact today.

3.3 *Internal wall*

The internal wall is placed between buildings, which are connected by concrete culverts. This wall is also 6m high but was stepped back approximately 4.4 in 1 or 68mm per 300mm rise, as shown in Figure 3.

Photo 2. The "as constructed" internal wall above spray coating.

As with the perimeter walls, the geotextile layers consisted of 10 layers of 22.4kN/m UTS and 10 layers of 32kN/m UTS geotextile.

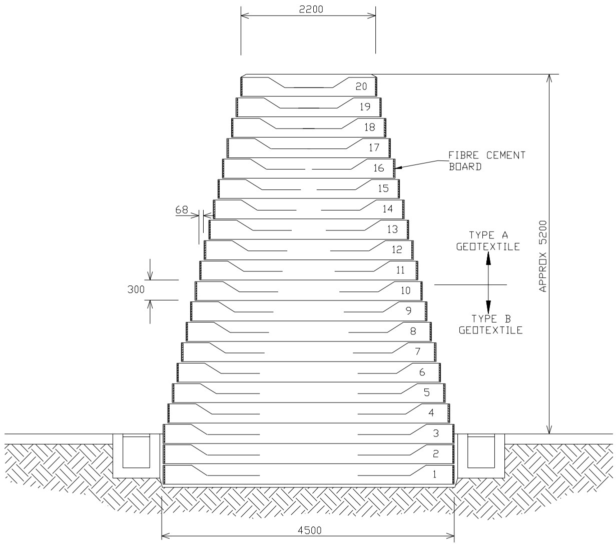

Figure 3. Internal wall cross section.

3.4 *Design issues*

In this application the walls were built to be flexible, so they can absorb the explosive forces and shrapnel. The designer considered a geotextile would absorb the explosive force and still stay relatively intact even after the blast. The geotextile has the flexibility and elongation needed. If a blast did occur, an assessment could be made on repairs or reconstruction.

The designer only considered a long-term (15-20 year) life for the structure. With this in mind the creep, chemical, biological and installation reduction factor was kept to 33% of the ultimate tensile strength of the geotextile. Even though this relates to a relatively low creep reduction factor, the post construction movement of the walls is minimal.

3.5 *Construction details*

Minimal site preparation was required. The foundation soils were leveled and then compacted to a minimum 95% MDD to establish stable foundation conditions.

The first wall built by the contractor was constructed with only minimal set-back on the facing boards. This became a problem as the elongation and sliding of the geotextile under the compactive effort forced the wall out of vertical alignment. The return or wrap back into the fill material was found to difficult to restrain from sliding forward. In later walls, the facing board setback was as much as 40-50mm to achieve the desired vertical facing. This was achieved using a L-shaped steel bracket plus timber formwork.

3.6 *Face protection*

Once construction was finished, the protection of the geotextile against the high ultra violet light experience in Australia was attended to. UV degradation of the geotextile is a major consideration. Assuming the correct design of the wall, UV degradation and vandalism are the main disadvantages of these types of wall. Since vandalism in this location was not considered a problem in a highly secure munitions factory, the only requirement was the UV protection and shotcrete coating wasn't considered. An elastomeric paint was selected and applied at a rate of approximately 0.8-0.9litres/m². The advantages of this system is:

- it remains flexible after long periods exposed to ultraviolet light
- a permanency of better than 10 years is achieved
- its ability to be recoated and patched if required
- availability in assorted colours, including army green
- can be applied direct from the tin by an airless spray gun

3.7 *Face protection*

To develop and keep a grass cover over the slopes and reduce the possible erosion of the sandy soils, an irrigation system was installed and then the slopes were topsoiled and grassed.

Photo 3. Finished walls after spraying face and grassed.

3.8 *Drainage*

In normal circumstances the geotextile layers would perform the task of major drainage paths. Also, the reinforced fill material is free draining. Therefore, the use of additional drainage to dissipate hydrostatic pressures would not be considered. However, since the face of the wall is treated with an elastomeric membrane, allowance was made in the lower layer to drain any water from the wall.

4 WALL SURVEY

In Nov 2001, Esler & Associates, surveyors, were contracted to perform a detailed survey of the current wall profiles. From the data gathered and in comparison with the as build profile, very little post construction movement was detected.

Table 1. Detailed survey at Bunker 831 Midpoint first wall built.

Panel No.	Height m	Top Offset mm	Bottom Offset mm
20.	6.0-5.7	25	50
19.	5.7-5.4	25	65
18.	5.4-5.1	55	80
17.	5.1-4.8	25	35
16.	4.8-4.5	35	60
15.	4.5-4.2	30	45
14. *	4.2-3.9	33	62
13. *	3.9-3.6	55	85
12.	3.6-3.3	40	75
11.	3.3-3.0	33	50
10.	3.0-2.7	48	78
9.	2.7-2.4	51	73
8.	2.4-2.1	55	77
7.	2.1-1.8	65	85
6.	1.8-1.5	53	90
5.	1.5-1.2	85	85
4.	1.2-0.9	85	85
3.	0.9-0.0	85	85

* Broken fibre cement board.

Table 1 shows the rotation of the facing boards. This was the first wall built and although it looks like there has been substantial movement of the wall, overall the forward rotation is 65mm. This is not considered as a major problem and is kept under surveillance, as are most walls on the ADI site.

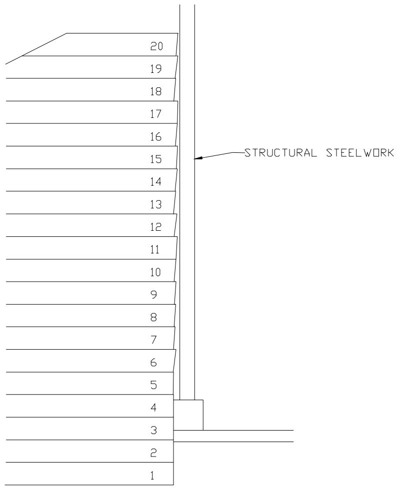

Figure 3. Detailed survey of the first wall built showing the forward rotations of the facing panels.

Photo 4. Detailed survey position. (first wall built)

5 DISCUSSION OF SURVEY

After 12 years of exposure, it still can readily be seen that all exposed geotextile surfaced used in the construction of the blast walls had been painted. Due to the general layout of the buildings and the bunkers themselves many walls have not been exposed to the sun. The general layout of the bunkers also has provided protection from weathering due to wind.

At this stage there are no plans to replace the geotextile and as such quantative measurements of the geotextile is not possible. Although there did appear to be some movement of the wall, it did not appear as if the fabric was pulling out, as all surfaces were painted. No repainting of the geotextile has taken place since construction. Although, some areas, if not all walls, are in need of a recoat

On several walls the backing boards had failed, however even though the deformation of these boards was obvious it appeared that after the initial movement the geotextile held and had been in the same position for considerable time.

The faces that had been exposed to the sun showed signs of degradation. It appears as if initially the paint was worn away (in places) by a combination of weathering mechanisms, such as wind rain and UV exposure.

Once the geotextile had been exposed the effects of UV would have been felt. However due to the thickness of the geotextile the degradation was limited to the surface, i.e. the surface layers acted sacrificially.

The surface of the exposed fabric had a dry fell and the filaments were brittle consistent with long term UV exposure, however in the authors opinion the fabric did not look any worse than his previous experience with test samples exposed for 1 year.

Fine sand/silt was observed on some of the steps, however, it could not be established where it originated from. However, the most likely origin would be from outside of the bunker (i.e. blown over the top), there is the possibility that it had come from in between the geotextile layers. The authors do not consider it possible that it could have washed through the face of the wall.

The terrace layers show no signs of settlement and are consistent and horizontal.

6 CONCLUSION

As a result of the success of first the trial, and then the subsequent walls in bunker 831 and 837, ADI Mulwala have constructed several other bunker walls and blast absorbing barriers. A brief survey of these walls showed no major deformations or problems with the performance of these walls.

Photo 5. Storage bunkers.

Photo 6. Blast protection bund.

7 REFERENCES

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