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Reinforced fill for temporary work in Hong Kong

G. Ng
Director, G and E Co. Ltd., Hong Kong.
Southeast Asia Area Manager, Tenax International B.V., Italy

ABSTRACT: This paper reviews the use of reinforced fill in three case studies (Belcher Garden at Pokfield Road, Po Tat Estate at Po Lam Road and Tseung Kwan O Subway South Station) as temporary structure with different applications and under different site conditions. The flexibility of using reinforced fill solution for difficult site conditions has appealed to engineers in temporary application in construction industry and perhaps leads to more innovative and ingenious usage of the technique.

1 INTRODUCTION

In the last decade, we have seen reinforced fill construction matured, design innovated, new aesthetic facings emerged and advance geogrid debut, so much so that a great many renowned projects have become to look like monuments. While the technique is well established, applications are largely adopted towards permanent works. Temporary works, which often do not require stringent submission, spectacular appearance and long term performance assurance, have received much less enthusiasm. It could have been that temporary features are put up and removed over a relatively short period rendering their existence unnoticeable. But this down to earth and practical solution to create convenience is made possible with reinforced fill construction. The merits and advantages are being reviewed in three projects, with different applications and under different site constrains.

2 BACKGROUND

Reinforced fill design and construction in Hong Kong is governed by Geoguide 6 – Guide to Reinforced Fill Structure and Slope Design prepared by the Geotechnical Engineering Office of the Hong Kong Government. The guide provides good practice in stability design and construction and a model specification which stipulates quality of material, standard of workmanship, testing method and acceptance criteria for reinforced fill construction. For temporary reinforced fill construction, some of administrative requirements have been streamlined, e.g. design submission and supervision report can be undertaken in the site office instead of going through the Central Government. Maintenance manual is also not necessary. For polymeric reinforcement elements, approval is governed by a material certification system and design and reinforced fill construction is therefore closely monitored. Prior to the inception of Geoguide 6 in 2002, Geospec 2 and GEO Report No. 34 were adopted as the design guideline.

The three case studies were designed and constructed based on these documents.

3 CASE STUDIES

3.1 *Belcher Garden, Pokfield Road*

A residential complex was developed over a hilly terrain and site formation was a challenge when bore pile crane was to be brought in an already heavily congested site. A temporary reinforced fill structure was proposed to extend and widen a working platform. The platform allowed equipment to be mobilized close to pile A5, A6, A7 and A8 which would otherwise be inaccessible from elsewhere. Refer to Figures 1 & 2.

A reinforced fill structure of 7 m × 12 m × 6.5 m height was put forward. This extended platform had two right angle facings and the facing inclination was 85°. Polymeric geogrid was designed for reinforcement and its length was 6.5 m. A wrapped back type of construction was chosen. The facing concrete blocks were placed with a set back between layers of reinforcement and were slightly tilted inwards. Refer to Figure 3.

Reinforced fill was thought of because:

- No other access is workable to mobilize the crane;
- There were abandon supply of fill material which, if not used, would have to find temporary storage space;

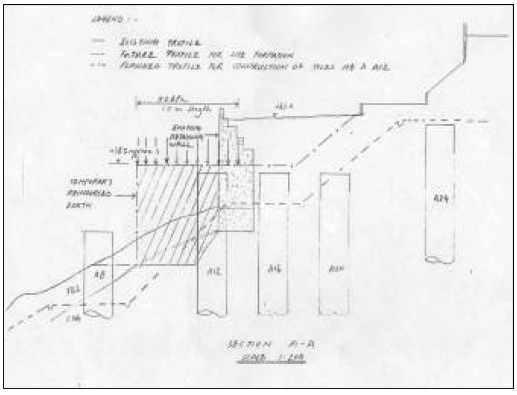

Figure 1. Cross section of temporary platform (Belcher Garden).

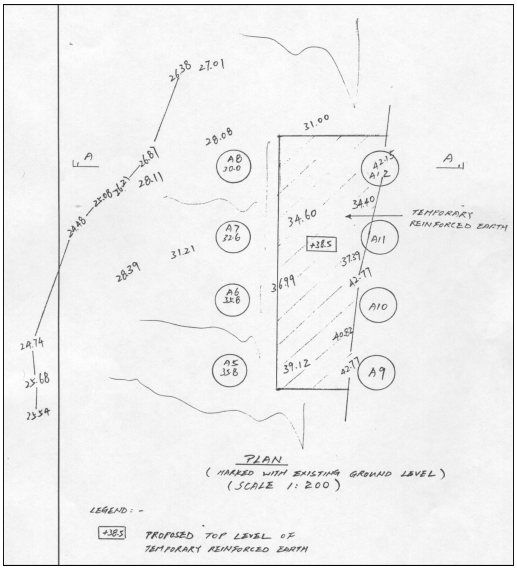

Figure 2. Plan of temporary platform (Belcher Garden).

- The availability of concrete block from completion of temporary surcharge, and;
- A similar platform made from steel structure or reinforced gabion structure would be more expensive and more time consuming to design, construct and dismantle.

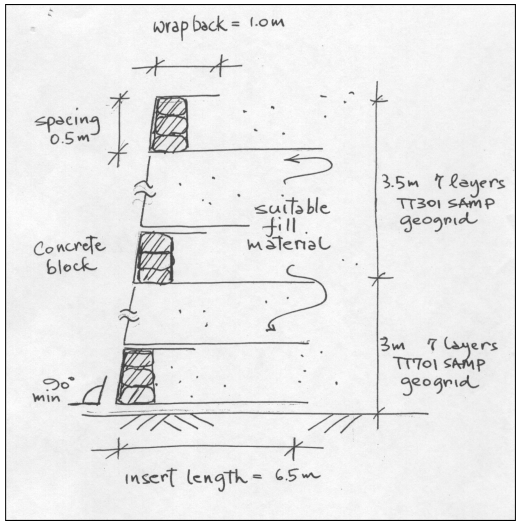

Figure 3. Reinforcement configuration (Belcher Garden).

Photo 1. Temporary work platform with access ramp behind (Belcher Garden).

Table 1. Project details of Belcher Garden.

Contractor	Sunley Engg. & Const. Co Ltd
Client	Sun Hung Kai Properties Ltd
Consultant	JMK Consultant Engineers
Geogrid	HDPE mono directional
Design/Approval period	6 months
Construction Period	8th to 17th October 1998
Period of Usage	About 6 months

3.2 *Po Tat Estate, Po Lam Road*

Public housing blocks were being developed on a terrace 15–20 m below the main road. The future site access was under construction and traffic logistic was insufficient to allow concurrent activities. A temporary haul road was necessary to increase construction traffic capacity before the permanent access road was put into operation.

The two lanes temporary haul road was a reinforced fill embankment built alongside and against the main road down side slope. It was about 80 m long and maximum height of 9 m. To occupy as little space as possible, the slope angle was designed

Photo 2. Construction of haul road (Po Tat Estate).

Photo 3. Estate road occupies early haul road (Po Tat Estate).

to 50° minimum balancing the demarcation limitation and the cost of steeper slope. A wrapped back geogrid method was adopted with 6.5 m wrapped back length. Sand bags were used as facing. The embankment was subsequently hydroseeded, an erosion protection measure.

Reinforced fill slope was taken because:

- Steel frame structure would have taken much too long to come into use. Reinforcement fill construction was quick;
- There was availability of fill material;
- Reinforced fill construction did not require additional heavy equipment thereby overloading already congested space;
- Reinforced fill construction was less expensive to implement and dismantle, and;
- A vegetation facing matched the contractor's environmental friendly motto.

3.3 *Tseung Kwan O Subway South Station*

The site was from reclaimed land on which the main access road of the future residential development lies.

Table 2. Project details of Po Tat Estate.

Contractor	Gammon Construction Limited
Client	Hong Kong Housing Authority
Consultant	Hsin Hieh Architects
Geogrid	HDPE mono directional
Design/Approval period	About 3 months
Construction Period	January to May 1999
Period of Usage	About 12 months

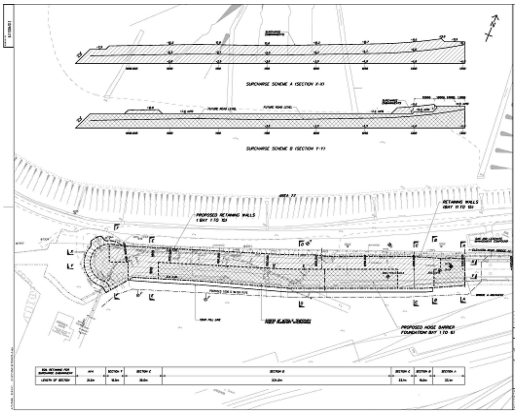

Figure 4. Layout of reinforced surcharge block (Tseung Kwan O).

A design with prefabricated vertical drain and temporary surcharge was sought to encourage ground consolidation. The surcharge required a 24,000 m^3 volume of fill. Reinforced fill construction was considered a good option to build this surcharge embankment.

The geometry of this rectangular embankment was 2.0 m to 8.5 m high, 20 m width and ran 150 m long with a facing angle of about 85 degree. Reinforcement was applied to all sides of the structure. Concrete blocks were placed at the base in certain locations for retaining surcharge fill, primarily because of its early availability to meet a tight program. In this area, no geogrid was applied (refers to Figure 4).

The reinforced fill embankment was constructed with wrap-around facing. Steel wire mesh and woven geotextile were used at the face to retain fill material. The vertical spacing of the primary geogrid was 500 mm and the reinforcement length was between 3.0 m to 7.5 m. A facing set back of 50 mm had been introduced to each layer of construction (refer to Figure 5).

Why reinforced fill was chosen:

- Ground consolidation was only required in a close defined proximity. Reinforced fill technique beings the rectangular surcharge block within this boundary. Typical fill construction would have to have toe line extended far beyond this boundary;

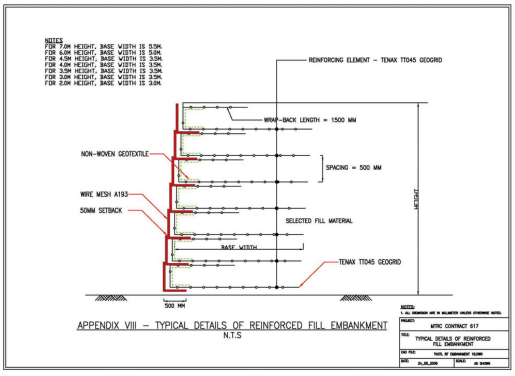

Figure 5. Cross section of reinforced surcharge block (Tseung Kwan O).

Photo 4. End view of reinforced surcharge block (Tseung Kwan O).

- Geogrid reinforcement was a simple and efficient method even to vertical facing;
- Unavailability of large quantity of concrete block (estimate 3,500 m^3), the handling, logistics and its disposal were unmanageable, and;
- Expensive option of gabion buttress, mechanical stabilized wall and reinforced concrete construction, in particular their disposal.

4 OVERVIEW

The three projects utilized reinforced fill as a "construction convenience" to provide temporary facilities, a working platform, a haul road and a surcharged containment. All took the advantages of construction simplicity (no particular skill and equipment), cost effectiveness (no expensive steel frame structure and concrete fabrication), overall time saving (as fast as any fill and compaction work) and less construction

Photo 5. Vertical facing along site boundary (Tseung Kwan O).

Photo 6. Surcharge embankment at site boundary (Tseung Kwan O).

waste (many of the fill material were reusable for landscaping). Site conditions were also favorable such as space for laying reinforcement and the availability of fill material.

Permanent reinforced fill design methodologies are well established and design soft wares are abundant. The same is applicable for designing temporary works. However, the design, acceptance, testing and approval can be undertaken with less stringent submission procedures. Two examples are the exemption of pull out test and the necessity of full submission to the Authority. The Contractors are made responsible for their design and endorsed by an Independent Checking Engineer. Therefore design can be more aggressive, taking advantage to maximize the reinforcement spacing and width and optimize the full design strength

Photo 7. Surcharge embankment under construction (Tseung Kwan O).

Table 3. Project details of Tseung Kwan O Subway South Station.

Contractor	Maeda Corporation
Client	Mass Transit Railway Corp.
Consultant	Maunsell Consultants Asia Ltd
Geogrid	HDPE mono directional
Design/Approval period	About 2 months
Construction Period	November 2006 to March 2007
Period of Usage	About 9 months

without taking into the effects of temperature and creep, thereby minimize the cost of the geogrids, with the stability design and reinforcement configuration conforms fully the statutory practice.

One of the attractiveness with reinforced fill is the flexibility in change of design geometry during construction. An access ramp or a platform can be widened, steepened and turned, where structures are often too massive to change at ease. In Belcher Garden, the work platform can be extended larger simply by building it wider, using more fill material and geogrid. In Po Tat Estate, the haul road widening can be made possible with altering the crest alignment. And in Tseung Kwan O Station, the reinforced block can be built over layers of concrete blocks, catching a tight program. This type of temporary construction can be considered as a valuable tool in site management. It is, therefore, to the interest of contractors, to look into reinforced fill method whenever site constrains, access requirement or other complications are encountered.

Temporary application is viewed as a catalyst to bring forward the experience, to build up the confidence and to exercise the practicality of employing reinforced fill techniques. It is through more accustomed applications that engineering will excel.

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