GOVERNMENT OF WESTERN AUSTRALIA

Department of **Energy, Mines, Industry Regulation and Safety**

Building and Energy Western Australia

WorkSafe Western Australia

Guidance on soil stabilisation by cement grout injection

April 2024

Introduction

This publication is for persons conducting a business or undertaking (PCBUs) and workers involved with designing, approving, procuring and installing permeation microfine cement grout injection. It is also for those neighbouring proposed excavation works where owners are requested to sign a BA20 or BA20A for potentially affected land and for those installing in-ground pools. It highlights issues found when a suitable process was not followed and provides a general overview of the roles and responsibilities for:

- building designers including structural, civil and geotechnical engineers;
- grout injection and earthworks contractors;
- builders and swimming pool installers;
- building surveyors;
- permit authorities;
- other workers on site, including persons with management and control of the work site.

Background

Grout injection involves injecting cement grout under pressure to stabilise soil, enabling excavation and/or underpinning of structures. It does this by permeating into, binding with, and hardening the soil into a cemented sub-soil structure (grout block) with greater cohesiveness and strength. The grouting process permanently alters the soil matrix.

Inadequate or compromised grout injection can leave properties and lives at risk. Significant property damage and personal injury has occurred where grout injection has failed when being used for temporary retention. The use of grout injection for temporary retention at excavations is the primary concern of this publication. Although there are multiple soil retention methods to enable excavation, they are not the subject of this publication.

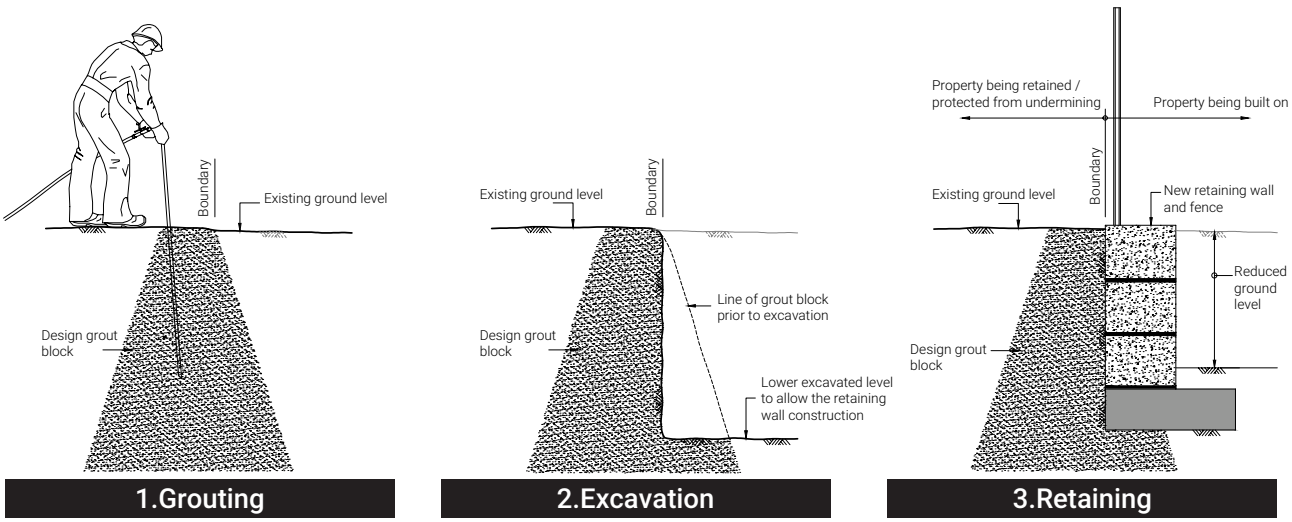

Figure 1: Process of a typical permeation microfine cement injection

Summary of hazard

The Department of Energy, Mines, Industry Regulation and Safety (department) has investigated multiple failures relating to microfine permeation grout stabilised soil blocks. In such instances and through several other inspections, the department noted that details of the grout injection was generally limited to a note on approved plans such as "to specialist contractors' details".

Grout injection contractors in Western Australia (WA) are not required to be registered. Therefore, PCBUs engaging grouting contractors/controlling a work site should establish the competency of parties relied on for design, installation and supervision of grout injection works. Adequate communication must be provided to ensure all parties perform their roles safely, with documentation to demonstrate necessary considerations have been made.

The grout injection design typically requires input from a suitably qualified civil/geotechnical engineer. This engineer should assess that the soil is suitable for grouting operations and provide advice on the grout profile. The project structural engineer typically provides input with respect to loadings for the grout design. The engineered footing drawings, architectural plans (including landscaping) and the builders' construction details help to set levels and extents of the grouting works.

In several instances damage has occurred when individuals carrying out or working around grout injection works had inadequate training/supervision and/or where insufficient grout designs were provided. This resulted in inadequate grout profiles and/or grout blocks that were undermined.

For the latter case, it is essential that all parties clearly understand the levels to which excavation is to occur (including all necessary tolerances) and to ensure that excavation below the design level is prevented. For excavation works, the *Code of practice: Excavation* provides supporting guidance for those operating in WA.

The Work Health and Safety (General) Regulations 2022 (WHS General Regulations) classify work in and around excavations greater than 1.5 metres as "high risk construction work". Mandatory risk assessments are required and safe work method statements (SWMS) must be prepared prior to the work commencing. Refer to the *Code of practice: Construction work* for further information.

Considering the nature of the excavation and where engineering input is usually required, the engineer should be consulted regarding the hazards and risks associated with complex excavations. A safe work procedure should be developed as a result. Part 6.3 of the WHS General Regulations covers safe work method statements (Division 2) and excavation work (Division 3).

Figure 2: Insufficient and undermined grout injection works may result in undermining of land and structures

Actions required

Grout injection must be fit for purpose, whether it is:

- Part of a building or structure, for example where it is used to underpin. In such instances it will also need to comply with the applicable building standards which are generally prescribed by the Building Regulations 2012, being the Building Code (Volumes One and Two of the National Construction Code).
- Stabilising soil for temporary excavations.

The design and construction or installation of grout injection should include:

- design actions, including loading assumptions and assumed exclusion areas in the zone of influence of the excavation works;
- geotechnical information sufficient for the purpose of designing the grout injection system;
- the location of grout injection, including relative location to potentially affected/supported structures and allotment boundaries;
- consideration of water table depth and ground water movement;
- detail of the installation and the materials (composite) proposed including relevant design manuals;
- critical dimensions such as penetration depth, grout block profile, excavation depth;
- plans and specifications of the works to an appropriate level of detail; and
- methods to verify the grout block is of appropriate strength and dimensions.

Every grout injection job is different, and as such, grout injection designs for different sites and final profiles for each site will vary. Workers carrying out the grout injection should have the relevant knowledge and skills to carry out the task.

The worker using the grouting spear should guide its movement through the ground. This is to inject grout at suitable quantity and in the desired locations, and to detect voids (such as soakwells), underground obstructions and differences in soil type. Adjustments will need to be made as appropriate in consultation with relevant persons, such as a geotechnical engineer.

Through the grouting operation, differences in ground condition encountered will also guide what areas should be sampled to ensure that the grout block is free from any inherent weaknesses. As the grout block is created underground and not visible, it is important that the grout injection, soil testing and grouting are performed in a diligent way and under appropriate supervision.

Due to the many unexpected site conditions possible, it is important that construction support is available from the grout injection contractor. This should extend from coordination prior to works, until a permanent retention method replaces the exposed grout stabilised soil block. The grout injection contractor should liaise with the certifying geotechnical engineer as necessary.

To protect against potential damages or injury throughout the grout injection process, careful attention should be given to:

- geotechnical investigations;
- permeation grout injection quality procedures incorporating coordination, construction, inspection and test plans;
- involvement from design through to certification stage by an appropriately qualified and experienced geotechnical engineer; and
- pre and post-construction surveys of all property that is potentially affected by any grouting and excavation works. This process should identify potentially vulnerable structures such as retaining walls that are not sufficiently stable.

A geotechnical engineer asked to certify completed grout injection works for which they had no prior dealings should raise concern with responsible parties, including those responsible for regulating building work where concerns remain.

Grout injection practices and responsibilities

It is noted that grouting operations may be used in various circumstances. When used for fixing settlement of houses where no excavation is to occur, risks may be significantly lower than where the grout block is to support a temporary excavation. Grout blocks retaining soil have to resist active soil pressures pushing both down and sideways on it. A more onerous planning and construction process is typically required where excavation works are to occur.

Under Section 17 of the *Work Health and Safety Act 2020* (WHS Act), PCBU's have a duty to eliminate risks to health and safety, so far as is reasonably practicable. The department has liaised with industry members to develop the following guidance on grout injection practices and to provide a **general overview** of roles and responsibilities of those involved. These practices should be considered as part of safe work methodologies that also consider further relevant areas and include:

Design

Approval design documents should demonstrate how a building solution is fit for purpose and meet applicable building standards. Design documents may include plans and specifications as well as evidence of suitability.

- Local governments (permit authorities) have reported several instances where documentation for grout injection works was lacking, requiring appropriate design details before a building permit for the works was granted.
- When grout injection forms part of works which may affect adjoining land, Part 6 of the *Building Act 2011* (Building Act) must be complied with. In addition to building and demolition work, "work" includes the changing of ground levels of land to an extent that could adversely affect other land, including encroachment. The Building Act also includes definitions for building work, incidental structure and adversely affecting land.
- A competent person (i.e. a geotechnical engineer) should confirm that the soil at the site is suitable for the grout injection product and that a specification for the works and materials is provided and checked by the builder, building surveyor and permit authority as appropriate.
- The structural design drawings should either detail or reference an appropriately designed system where grout injection stabilisation and support is required. Design drawings should be referenced in approved plans, indicating the excavation and grout block relative levels.
- Under Section 22 of the WHS Act, a designer for a structure that could reasonably be expected to be used, as, or at, a workplace must ensure, so far as is reasonably practicable, that it is designed to be without risks to the health and safety of persons.
- The designer must carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary to this extent.
- The designer also has a duty to provide adequate information in relation to the design.

NOTE: All building work is required to comply with the applicable building standards, whether or not a building permit is required.

Site preparation

- Property condition reports should be performed by a competent person prior to starting building works that could or may reasonably be perceived to cause damage. Such works includes grouting operations and planned excavation or construction that relies on soil stabilisation from the grouting works.
- Condition reports by the party responsible for the construction activities, provides an opportunity to identify areas that may already be in a damaged or unstable state. Suitable arrangements can be made in response to this.
- Where grout injection works are to support an existing retaining wall, it is important to note that the retaining wall may not be considered adequate by current standards due to its original design, construction, deterioration over time, changing of levels, changing in loading conditions, or a combination of these factors. Concerns on the stability of existing boundary walls and fencing should be raised with all relevant parties, including the relevant local government.

Construction and installation

- Works are to be performed in accordance with the engineer's design and any other approved plans. Approved plans include those for which the building permit or certificate of design compliance has been granted. Works must also meet work health and safety legislation requirements.
- Under Section 26 of the WHS Act, PCBU's that install, construct or commission structures that could reasonably be expected to be used, as, or at, a workplace; must ensure, so far as is reasonably practicable that this is done without risks to the health and safety of persons.
- The builder and relevant workers, including contractors, should verify the site soil conditions and levels against design details and perform due diligence to ensure that works are correctly executed and meet construction requirements (including for site access and excavation).
- The grout injection process should include quality assurance procedures, such as:
  - ensuring all equipment is serviceable and calibrated;
  - recording installation methodology, aided by flow meters or volume reconciliations, grouting spear injection spacings, withdrawal rates and depth and inclination guides, and checks for signs of grout refusal to verify the grout block is created as expected;
  - using reputed and proven microfine (ultrafine) cements suitable for the specific project;
  - testing the shear strength of core samples as deemed necessary by a suitably competent person; and
  - having the applicable engineers check to ensure that the works meet their design intent.

A building surveyor may inspect and/or request further evidence of suitability.

- Grout blocks often require cutting back (benching). This may occur when the softer cementitious spoil material has encroached into the excavated clearing. The grouting contractor with the input of other competent persons, must outline the methods to safely bench back the grout block. In order to not damage the grout block, safe work methods do not allow bulk earthmoving equipment for the benching operation.

The design and construction process requires collaboration and consultation between various parties at all stages of works.

All design and construction must also comply with the *WHS Act* and supporting regulations. PCBUs must, so far as is reasonably practicable, ensure the health and safety of workers and others who may be affected by the carrying out of work.

Government of Western Australia

Department of Energy, Mines, Industry Regulation and Safety

Building and Energy

1300 489 099

8.30am – 4.30pm
Level 1 Mason Bird Building
303 Sevenoaks Street
(entrance Grose Avenue)
Cannington Western Australia 6107

Online

Website: www.dmirs.wa.gov.au/building-and-energy
Email: be.info@dmirs.wa.gov.au

Mailing address

Locked Bag 100

East Perth WA 6892

Regional offices

Goldfields/Esperance	(08) 9021 9494
Great Southern	(08) 9842 8366
Kimberley	(08) 9191 8400
Mid West	(08) 9920 9800
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