

BUILDING
COMMON GROUND



Best Practice

A Good Practice Guide for
Pecafil® permanent foundation
formwork systems



Introduction

Permanent formwork systems offer a time saving and cost effective method of constructing reinforced concrete foundations compared to traditional erect, prop & strike shuttering methods.

They were first developed in the 1980s and the technology gained popularity in the UK from the mid-1990s.

This document is a reference guide for consulting engineers, site inspectors, main contractors, project managers, QA teams, and groundwork subcontractors to help ensure that

the permanent formwork system selected is fit for purpose and installed in accordance with the relevant British Standard and existing industry guidelines.

It sets out a minimum standard for all installations; highlights the problems which can occur if the formwork has insufficient stiffness; and demonstrates how a substructure's durability can be affected through the use of unsuitable materials.

The object of this guide is to ensure that...

- ...foundations are constructed to a minimum standard and meet specification
- ...there is increased awareness of common construction defects in substructures
- ...specified cover is achieved using spacers which are not detrimental to the structure
- ...relevant aspects of Temporary Works are considered
- ...a suitable formwork system is selected by the contractor to meet the above requirements
- ...installations are independently inspected before concrete is poured

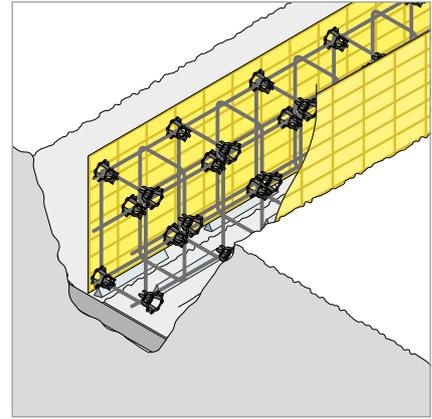
System components & concept

All permanent formwork systems comprise of:

- Formwork panels
- Reinforcement cover spacers
- Proprietary accessories e.g. tapes, tie-rods, girders, pins etc

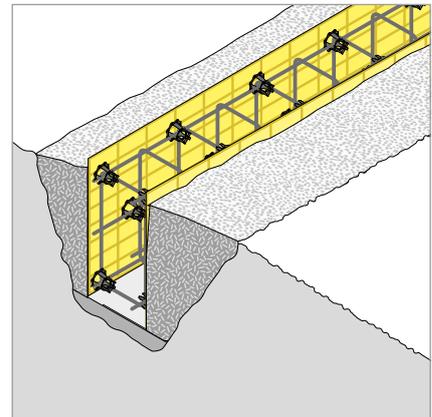
The concept is simple and universal:-

Formwork panels are spaced off the reinforcement to maintain cover and provide support when the system is backfilled which, in turn, resists the concrete pressure.



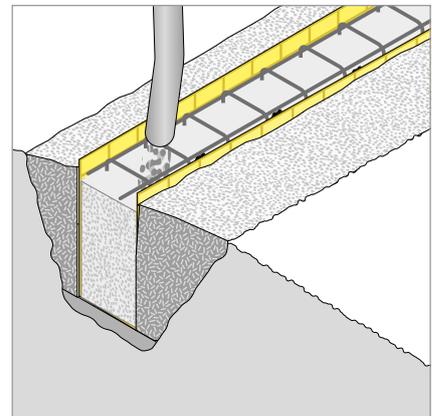
Benefits of permanent formwork

- Reduced working space requirements
- Minimal overdig and cartaway
- Offsite fabrication
- No specialist trades
- Concrete volume savings
- Potential to eliminate the need for concrete blinding
- Faster construction



Good Practice requires that...

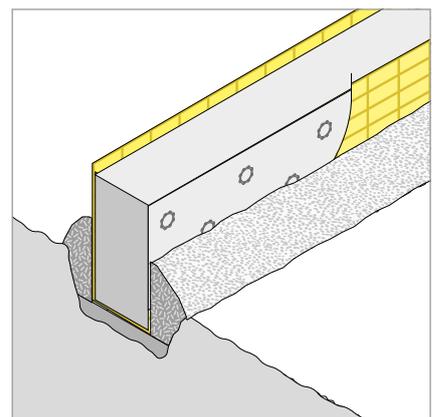
- ...foundations should be consistent and true to line & level
- ...design cover to the reinforcement should be achieved through the use of BS7973 compliant spacers
- ...structural integrity is not compromised
- ...formwork should be clean and free of debris
- ...concrete wastage is avoided



Permanent formwork is sacrificial and the finished concrete surface is usually hidden, which sometimes means **latent** defects e.g. loss of cover, honey-combing and voids may go undetected.

Insufficient concrete cover and voids around reinforcement bars have severe effects on long-term durability and structural integrity by increasing the rate of corrosion and affecting bond strength.

If British Standard compliant spacers and a suitably strong formwork material are used the likelihood of such defects is greatly reduced. However, it is advisable to perform visual inspections by exposing random parts of the substructure to rectify any defects at an early stage.



Common defects associated with some permanent formwork systems



Low strength formwork failing to maintain a neat finished concrete line



Concrete is wasted if formwork splays outwards during the pour



Flexible formwork panels collapsing onto reinforcement bars



Timber spacers leave voids when extracted



Loss of cover - even with an excessive quantity of spacers - due to inadequate formwork rigidity



Loss of cover caused by surcharge loads from site traffic around excavations



Plastic line spacers are known to cause compaction problems and when used in long lengths may act as a crack inducer

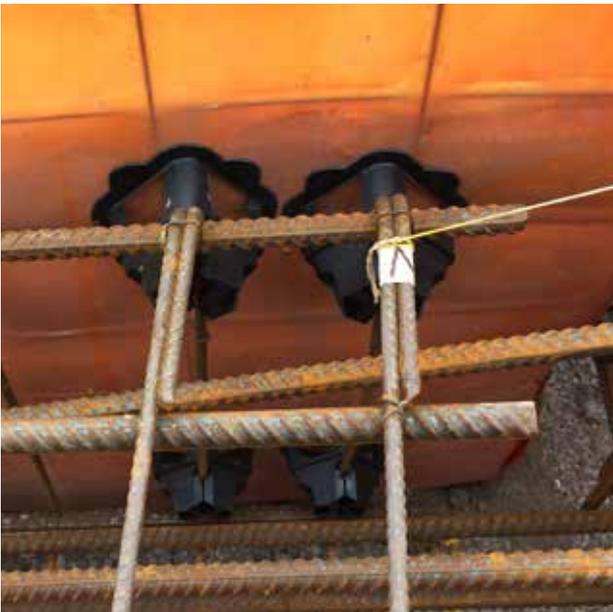


Plastic line spacers were designed for use under fabric reinforcement in flat slabs, not vertical formwork. When turned on their side the concrete is often not able to flow into the channel, creating voids

Common defects associated with some permanent formwork systems



Evidence of voids caused by plastic line spacers. Here, the building inspector insisted on the formwork being stripped to check compaction. The foundations were subsequently condemned.



Spacers installed at centers < 300 mm increase the risk of voids and loss of cover because the concrete cannot flow freely.



Honeycombing resulting from spacers installed at centers < 300 mm



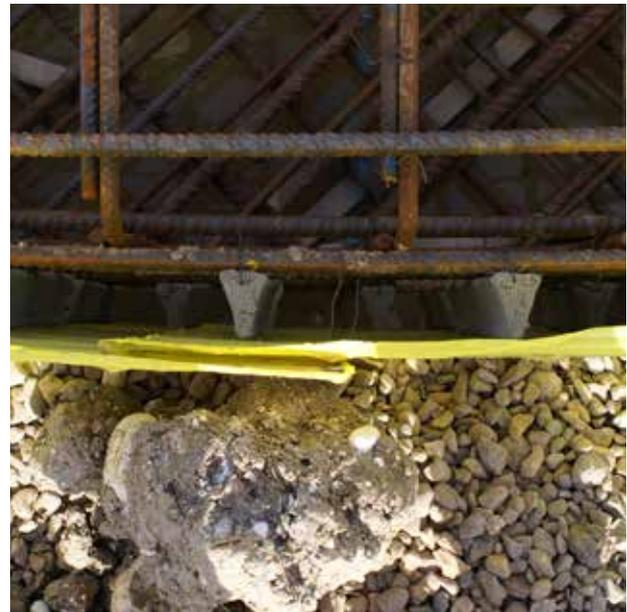
Spacers with small apertures are likely to cause "aggregate lock", preventing adequate compaction and leaving voids around reinforcement bars



Suitable plastic spacers, like those supplied as part of the Pecafil system, have large apertures to enable coarse aggregate to penetrate and achieve good grout flow



Spacer failure: Compressive strength exceeded by soil pressure, resulting in loss of cover



Heavy duty cementitious spacer bars have increased compressive strength and resist crushing

Importance of suitable spacers: British Standard BS7973 & Concrete Society / NHBC guidance

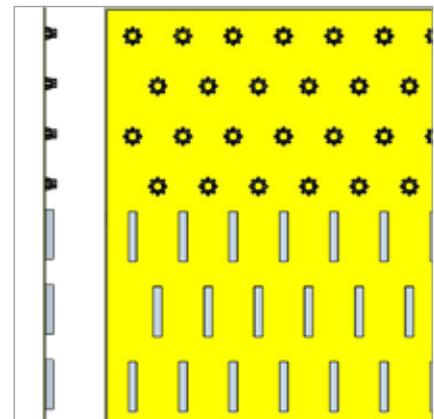
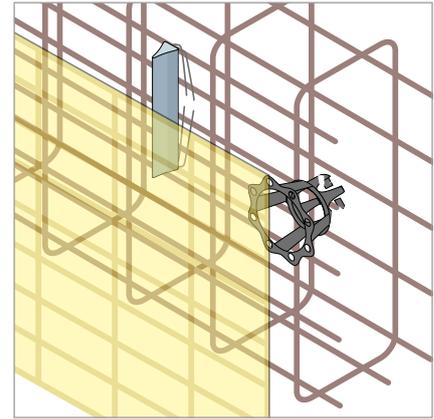
All permanent formwork systems rely on spacers for support, but it is crucial for durability that they are not detrimental to the concrete.

The specification and use of suitable compliant spacers is strongly advised to avoid defects e.g. voids, insufficient cover, cracking etc. BS 7973:2001 “Spacers and chairs for steel reinforcement and their specification” contains the performance requirements for both plastic and cementitious spacers.

Permanent formwork systems will typically require ‘medium duty’ & ‘heavy duty’ spacers, with minimum individual load capacities of 0.5 kN (plastic) & 3.0 kN (fibre concrete) respectively to resist the forces imposed from backfill material. It is vital the spacers are able to support the pressure of backfill without crushing to ensure the specified cover is achieved.

Supplementary guidance from the Concrete Society / NHBC recommends plastic line spacers should not be used in lengths greater than 350 mm; and individual spacers should not be installed at centers less than 300 mm, nor in straight lines on **adjacent** parallel bars.

This limits the number of spacers to a maximum of 11 No. per m² (shuttered face) and they should be installed in a staggered arrangement.



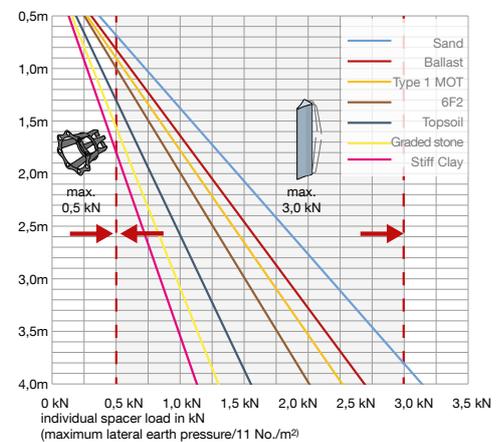
Temporary works considerations

Lateral earth pressure should be considered when selecting an appropriate formwork material and number / type of spacers.

Spacer compressive strength must be adequate to resist the soil pressure

Formwork stiffness must be adequate to limit deflection to within acceptable tolerance

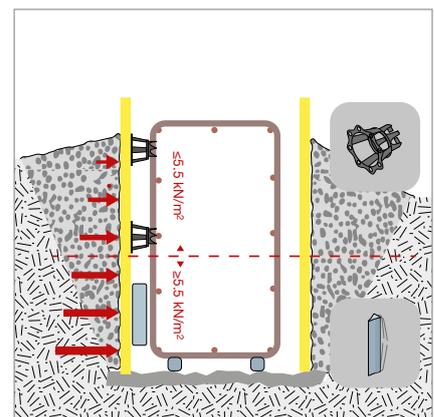
Reinforcement cages must be securely tied (or welded) to provide support against soil pressure. In recent years “basket” reinforcement cages have become popular due to value engineered design, but these open to cages are often not robust enough to support the formwork.



Spacer load capacity / excavation depth limits

If the lateral earth pressure exceeds the rated load capacity of the spacers then a heavier duty type should be selected.

- If lateral earth pressure ($< 5.5 \text{ kN/m}^2$) / 11 No. spacers $\text{m}^{-2} \leq 0.5 \text{ kN}$ then **‘normal duty’** spacers can be used
- If lateral earth pressure ($> 5.5 \text{ kN/m}^2$) / 11 No. spacers $\text{m}^{-2} > 0.5 \text{ kN}$ then **‘heavy duty’** spacers are required
- A mixture of normal & heavy duty spacers can be used within a form

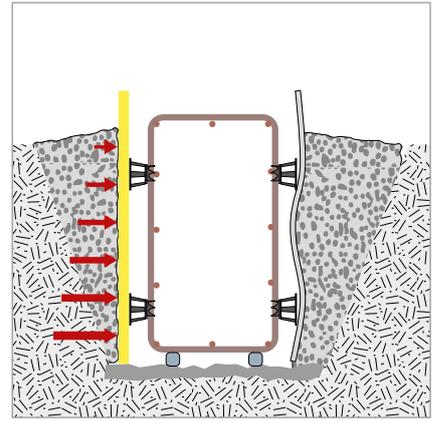


Formwork deflection due to backfill pressure

Permanent formwork materials deflect when a backfill load is applied, but the amount of deflection which occurs will depend upon:

- formwork stiffness
- excavation depth
- backfill material density (Ka value)
- whether the ground is dry or waterlogged

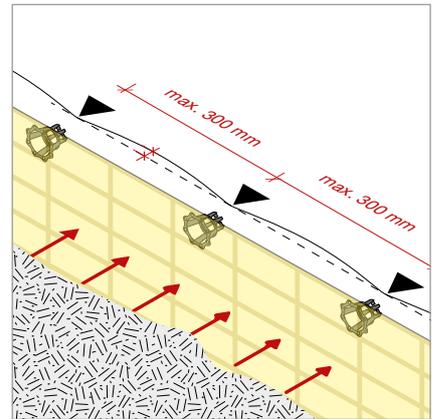
Important: Excessive deflection will result in loss of cover to the reinforcement.



If the formwork distorts excessively under the pressure of backfill it is not acceptable to increase the frequency of spacers above the minimum recommended 300 mm spacer centers.

If the formwork cannot span a minimum of 300 mm without excessive distortion it is not suitable for the application and a stiffer material (or higher grade) should be selected.

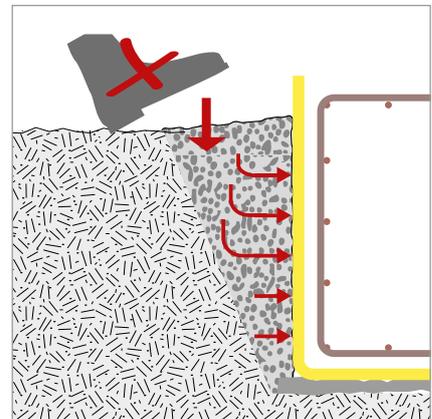
Careful consideration should therefore be given when selecting a permanent formwork system. It is advisable to seek the advice of a reputable manufacturer.



Backfilling

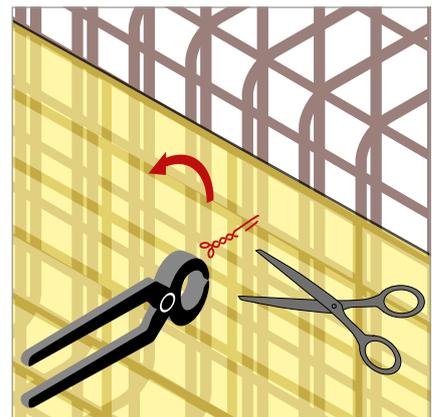
Care must be taken when backfilling, with spoil being placed loosely and evenly around the excavation to avoid damaging spacers or shifting the reinforcement cage out of position.

It is not generally possible to compact fill material until after the concrete has cured. Backfill is ideally placed within approx. 150 mm of T.o.C. to prevent the formwork splaying outwards and subsequent concrete wastage. Surcharge loads will increase earth pressure acting on the formwork so plant and foot traffic must be kept away from excavations.



Bridging the cover zone

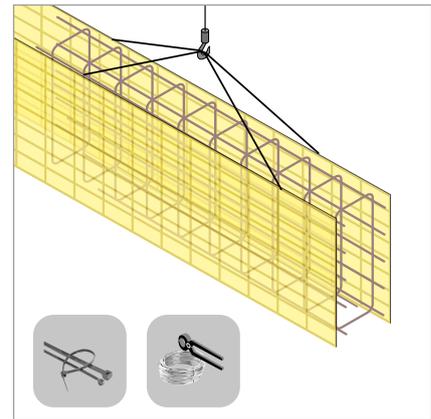
Whilst this may be necessary during installation to keep the formwork panels in position, it is important to remember that any mild steel tying wire in the cover zone should be removed prior to placing concrete.



Deep trenches

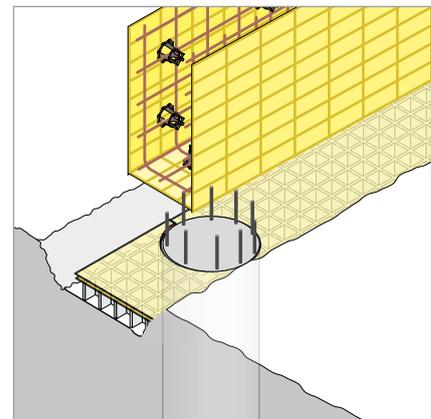
For deep trenches permanent formwork can be fixed onto a prefabricated reinforcement cage and craned into position to avoid site personnel entering deep, unsupported excavations.

The formwork panels must be secured using stainless steel tying wire or nylon zip ties so not to encourage corrosion.



Heave protection void formers

Permanent formwork systems must be grout tight when used in conjunction with void formers, and not allow concrete to leak into cellular systems or around pile penetrations. U-section forms are recommended. If the contractor prefers side panels then they should extend down to the trench blinding, or return on top of the void former as an 'L-section' profile.



Quality Management System

It is advisable that permanent formwork installations are checked by a competent and independent inspector. A checklist is included at the end of this guide as an aid.

If unsuitable materials have been used and/or the installation has not been carried out in accordance with this best practice guide it is reasonable for the inspector to suspect concrete cover defects may be present.

Most standard form construction contracts contain provisions for reasonable inspection to ensure no such defects exist. In the case of permanent formwork, inspection would involve excavating alongside random parts of the substructure, stripping of the formwork to expose the concrete surface and visually checking there are no voids in the cover zone. A "cover meter" could also be used to check the specified cover has been achieved, or core samples could be taken.

By way of illustration, JCT provides that the employer may issue instructions requiring the opening up for inspection of any work covered up or tests of materials or goods or executed work. The cost of opening up or testing is added to the contract sum, unless the inspection shows that the materials, goods, or work are not in accordance with the contract – whereby the contractor then bears those costs.

1.0 Reinforcement spacers		YES	NO
1.1	Has the contractor used BS2013 compliant spacers for side and bottom cover? If not, also complete section 2?	<input type="checkbox"/>	<input type="checkbox"/>
1.2	Has the manufacturer's BS2013-1 Declaration of Performance been provided?	<input type="checkbox"/>	<input type="checkbox"/>
1.3	Do the side & bottom cover spacers supplied match the specified cover detail?	<input type="checkbox"/>	<input type="checkbox"/>
1.4	Have fibre cement bars been limited to a 300mm in length?	<input type="checkbox"/>	<input type="checkbox"/>
1.5	Have spacers been installed at a 300mm horizontal & vertical centers (max. 10 per m ²)?	<input type="checkbox"/>	<input type="checkbox"/>
1.6	Are the spacers arranged in a staggered layout?	<input type="checkbox"/>	<input type="checkbox"/>
1.7	Confirm that spacers have not been stacked or nested to increase cover?	<input type="checkbox"/>	<input type="checkbox"/>
1.8	Confirm that spacers are not crushing under weight of backfill? If spacers are crushing and cover is being lost, see section 2.2.	<input type="checkbox"/>	<input type="checkbox"/>
2.0 Non-compliant spacers, reducing risk		YES	NO
2.1	The use of non BS2013 compliant spacers means that the contractor has not been compliant in accordance with BS2013-1.	<input type="checkbox"/>	<input type="checkbox"/>
2.2	Has the project manager / consulting engineer been made aware?	<input type="checkbox"/>	<input type="checkbox"/>
2.3	Has a 40mm cover inspection been planned to check for non-compliant? If it is, specify which formwork panels to inspect the concrete surface.	<input type="checkbox"/>	<input type="checkbox"/>
2.4	Excessive fine spacers were used, have their lengths been limited to a 300mm?	<input type="checkbox"/>	<input type="checkbox"/>
2.5	Embedded plastic spacers were used, do these side spacers to smallest dimension of 1.5x cover aggregate diameter to not compress?	<input type="checkbox"/>	<input type="checkbox"/>
2.6	The use of metal steel chairs as side cover spacers has been avoided?	<input type="checkbox"/>	<input type="checkbox"/>
2.7	The use of timber been temporarily as side cover spacers has been avoided?	<input type="checkbox"/>	<input type="checkbox"/>
3.0 Formwork systems: Prior to concreting		YES	NO
3.1	Did the contractor undertake a temporary works design to ensure a formwork system that meets the performance requirements was assembled?	<input type="checkbox"/>	<input type="checkbox"/>
3.2	Has the contractor complied with the manufacturer's recommendations for material grade & spacers type (open or recessed depth) & not compressed?	<input type="checkbox"/>	<input type="checkbox"/>
3.3	Have heavy duty non-ribbed side spacers been used where necessary?	<input type="checkbox"/>	<input type="checkbox"/>
3.4	Once installed, formwork deflection between spacers is limited to a 5mm?	<input type="checkbox"/>	<input type="checkbox"/>
3.5	Has a 40mm cover inspection been planned to check for non-compliant? If it is, specify which formwork panels to inspect the concrete surface.	<input type="checkbox"/>	<input type="checkbox"/>
3.6	Formwork is not 'locking under' at the bottom of the excavation?	<input type="checkbox"/>	<input type="checkbox"/>
3.7	Formwork panels to at least 10°C level?	<input type="checkbox"/>	<input type="checkbox"/>
3.8	Formwork joints are not allowing spill to enter the structure?	<input type="checkbox"/>	<input type="checkbox"/>
3.9	Formwork is free of standing water and contaminants?	<input type="checkbox"/>	<input type="checkbox"/>
3.10	Formwork will not allow grout to escape into compressible void former cells?	<input type="checkbox"/>	<input type="checkbox"/>
3.11	All tying wires and metal steel clips bridging the cover zone have been removed?	<input type="checkbox"/>	<input type="checkbox"/>



1.0 Reinforcement spacers

		YES	NO
1.1	Has the contractor used BS7973 compliant spacers for side and bottom cover? If no, also complete section 2	<input type="checkbox"/>	<input type="checkbox"/>
1.2	Has the manufacturer's BS7973-1 Declaration of Performance been provided?	<input type="checkbox"/>	<input type="checkbox"/>
1.3	Do the side & bottom cover spacers supplied match the specified cover dims?	<input type="checkbox"/>	<input type="checkbox"/>
1.4	Have fibre cement bars been limited to ≤ 350 mm in length?	<input type="checkbox"/>	<input type="checkbox"/>
1.5	Side spacers have been installed at ≥ 300 mm horizontal & vertical centers (max. 11 per m ²)?	<input type="checkbox"/>	<input type="checkbox"/>
1.6	Are the spacers arranged in a staggered layout?	<input type="checkbox"/>	<input type="checkbox"/>
1.7	Confirm that spacers have not been stacked or nested to increase cover?	<input type="checkbox"/>	<input type="checkbox"/>
1.8	Confirm that spacers are not crushing under weight of backfill? If spacers are crushing and cover is being lost, see section 3.3	<input type="checkbox"/>	<input type="checkbox"/>

2.0 Non-compliant spacers, reducing risk

		YES	NO
2.1	The use of non-BS7973 compliant spacers means that the works have not been conducted in accordance with NSCS Ed 4. Has the project manager / consulting engineer been made aware?	<input type="checkbox"/>	<input type="checkbox"/>
2.2	Has a QA post-pour inspection been planned to check for cover defects? e.g. stripping random formwork panels to expose the concrete surface?	<input type="checkbox"/>	<input type="checkbox"/>
2.3	If plastic line spacers were used, have their lengths been limited to ≤ 350 mm?	<input type="checkbox"/>	<input type="checkbox"/>
2.4	If individual plastic spacers were used, is their side aperture's smallest dimension $\geq 1.5x$ coarse aggregate diameter to aid compaction?	<input type="checkbox"/>	<input type="checkbox"/>
2.5	The use of mild steel chairs as side cover spacers has been avoided?	<input type="checkbox"/>	<input type="checkbox"/>
2.6	The use of timber (even temporarily) as side cover spacers has been avoided?	<input type="checkbox"/>	<input type="checkbox"/>

3.0 Formwork system: Prior to concreting

		YES	NO
3.1	Did the contractor undertake a temporary works design to ensure a formwork system that meets the performance requirements was selected?	<input type="checkbox"/>	<input type="checkbox"/>
3.2	Has the contractor complied with the manufacturer's recommendations for material grade & spacer type based on excavation depth & soil properties?	<input type="checkbox"/>	<input type="checkbox"/>
3.3	Have 'heavy duty' cementitious side spacers been used where necessary?	<input type="checkbox"/>	<input type="checkbox"/>
3.4	Once backfilled, formwork deflection between spacers is limited to ≤ 5 mm? If No, a stiffer material should be selected to prevent excessive loss of cover	<input type="checkbox"/>	<input type="checkbox"/>
3.5	Formwork is not "kicking under" at the bottom of the excavation?	<input type="checkbox"/>	<input type="checkbox"/>
3.6	Formwork extends to at least T.o.C level?	<input type="checkbox"/>	<input type="checkbox"/>
3.7	Formwork joints are not allowing spoil to enter the shutter?	<input type="checkbox"/>	<input type="checkbox"/>
3.8	Formwork is free of standing water and contaminates?	<input type="checkbox"/>	<input type="checkbox"/>
3.9	Formwork will not allow grout to escape into compressible void former cells?	<input type="checkbox"/>	<input type="checkbox"/>
3.10	All tying wire and mild steel clips bridging the cover zone have been removed?	<input type="checkbox"/>	<input type="checkbox"/>

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Project

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Checked by

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Date



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