



Best practice design for support of precast panels during construction (considerations for building designers)

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Abstract

This paper aims to assist those involved in the design and construction monitoring of projects that require temporary propping schemes for precast concrete panels. Its purpose is to highlight key issues and common misconceptions regarding temporary support of buildings during construction, with the goal of improving the consistency of panel propping designs across New Zealand and reducing risk in the industry.

The paper covers the following issues related to the support of panels during construction:

- Existing standards, guidance, and compliance pathways for panel propping.
- Design action requirements (wind, seismic, and others).
- Prop requirements.
- Anchor design requirements (including seismic design).
- Load path and hold-down requirements.

This paper serves as a companion document to the Technical Guidance Note: TGN03:22 – Precast Panel Propping Design, which was authored by the New Zealand Engineering Temporary Works Forum (TWfNZ). Although there is some duplication between this paper and the guidance note, we recommend that the reader familiarize themselves with the guidance and that contractors involved in concrete construction are made aware of the relevant recommendations.

Existing standards and guidance relevant to panel propping

1. Temporary Works Forum NZ (2019), TWfNZ GPG01:19 Temporary Works Procedural Control: Good Practice Guideline.
2. WorkSafe NZ (2018), Safe work with precast concrete: Handling, transportation, and erection of precast concrete elements.
3. Health and Safety at Work Act 2015 (HSWA).
4. Technical Guidance Note: TGN03:22 – Precast Panel Propping Design

Compliance pathway for structural design of propping

Temporary works are subject to additional structural requirements to permanent works, temporary works designers use the same loadings and materials codes as permanent works designers, but they must also be aware of Work Safe NZ documentation and the wide-ranging powers of the HSWA.

Permanent works typically fall under the definition of a "Building," and all building work must comply with the Building Code (s.17). Among other things, the Building Code requires that buildings have a low probability of collapsing (B1.3.1). Verification Method B1/VM1 deems compliance with the Building Code if the NZ Loadings and materials codes (AS/NZS 1170, NZS 3101, NZS 3404, etc.) have been followed.

In contrast to the Building Act, the HSWA does not have a Health and Safety Code with Verification Methods and Acceptable Solutions that deem compliance with the Act. However, the Act (s.20) provides for the Minister, through Ministry of Building Innovation and Employment (MBIE) and its predecessors, to produce Approved Codes of Practice (ACOP) for many aspects of temporary works. ACOPs have also been issued through Worksafe, NZ, and although the wording is cautious, the message is that these documents meet the requirements of the HSWA (cover of "Prevention of Falls," April 2000).

Since precast panel propping generally supports a building during construction, most propping is bound by both acts, and the most onerous requirements should be complied with. The relevant codes (AS/NZS 1170, NZS 3101, NZS 3404, etc.) should therefore be referenced.

The precast panel propping design technical guidance and the summary in this paper are not intended as an acceptable solution or to contradict any current guidance. Rather, they serve as a roadmap through the relevant standards

Recommended design requirements for propping

All propping systems must be designed by an engineer who is suitably competent. It's recommended that an assessment of the propping's design complexity and the risk it poses in the event of failure be carried out to determine the temporary works category of the scheme and the competency requirements of personnel involved in design and verification.

This section covers the minimum requirements for designing temporary panel supports that will be in service for less than six months. For temporary works that will remain in place for more than six months or where there is an interface with high importance level structures or infrastructure, the loadings should be adjusted accordingly (the APE minimum may need to be a 1/250 or 1/500 event in some cases). Additionally, if the propping is to remain in place for longer than originally intended, the designer should be notified, and the propping system should be reassessed.

Wind loadings must be calculated in accordance with AS/NZ 1170.2 for a 1/100 APE event in the appropriate region. Seismic loadings must be calculated in accordance with NZ 1170.5 for a 1/100 event, with the appropriate seismic coefficient for panels on the ground. Other loading requirements, such as supported structural elements or backfill against panels, must also be considered for construction purposes.

Anchors used to support the panels should comply with the manufacturer's requirements, including embedment, substrate depth, and installation instructions. The seismic capacity of

post-installed anchors should be calculated based on EOTA TR045 to comply with Amendment 3 to NZS 3101, Clause 17.5.5. Drop-in and impact-setting anchors should not be used for panel propping, and anchors that rely solely on chemical adhesion should not be used as bracing anchors unless each fixing is individually proof-tested to the working load limit (WLL). The appropriate concrete strength at the time of propping should also be considered.

It is important to note that propping suppliers commonly exclude anchors and seismic loadings from their designs, it is therefore crucial to verify that the bolt capacity is congruent with the prop design and that the risk of seismic load is considered. This may be outside of the expertise of the prop supplier and may require verification by a third-party engineer.

Prop capacities are generally presented as Working Load Limits (WLL), and it is necessary to understand how the supplier defines their specific prop capacities. Comparing ultimate load strength (ULS) loads to WLL capacities is on the safe side but conservative. A comparison of ULS loads to ULS capacities can be made if the designer has sufficient information to determine the prop ULS capacity whilst making allowance for the potential 'used' condition and 'repeated-use' nature of the props. The effect of prop length on its design capacity should also be considered as some props provide varying WLLs depending on extension.

Consideration of load-paths into ground and permanent elements

The propping designer must ensure that there is sufficient hold-down to maintain the equilibrium of the propping system. However, this crucial step can often be overlooked, as propping suppliers may explicitly exclude it from their designs. Additionally, it is commonly assumed that unreinforced site concrete can tolerate the load due to the temporary nature of the structure. When reviewing propping designs, several factors should be considered:

- Sliding or overturning are likely to be the governing factor in the ballast design (note that any uplift force on the ballast may have significant effect on the sliding and overturning resistance).
- Buried ballasts or footings should be checked in accordance with B1:VM4.
- The appropriate coefficient of static friction should be used for the given situation. Recommended static friction coefficients for propping design are included below. Friction coefficients for other material combinations can be found in Friction in Temporary Works (Gorst et al., 2003).
- For robustness and redundancy, it is recommended that panel bases should not be solely restrained by friction. Ideally, panel bases should be secured by bolts, starters, or secondary props in conjunction with friction.
- When using concrete ballasts, the designer should consider the need for reinforcement.
- Concrete ballasts that are not continuously poured should be reinforced.
- When piles are utilized, the design must include an analysis of the shear and rotational effects of the props loading on the pile.

To advise this paper, a test was performed to verify the capacity of a 1200 mm x 600 mm x 600 mm concrete ballast block buried in compacted gravel and loaded at 45 degrees in tension.

The theoretical nominal capacity of the block was calculated to range between 5-10 kN; however, during the test, minimal deflection was noted under loading over 20 kN. It should be noted that B1/VM4 provides strength estimates but does not indicate movement onset or magnitude. Further investigation is recommended in this area. Regarding the test, the following should be noted:

- The test was very limited in scope, and few statistically significant conclusions can be drawn from it. One test is not sufficient to draw definitive conclusions.
- The block was subject to a specific compaction specification, which may not necessarily reflect the conditions on site.
- The test was 'mono-tonic' or 'quasi-static' and does not reflect seismic loading.



Figure 1: Testing arrangement of concrete ballast test

Often, the base props supporting panels will need to be tied to existing structures. Once again, it is important that the load-paths are followed to the ground, and that the permanent structure can resist the localised applied loads. Smaller panels can be fixed to the concrete floor slab, whereas larger multi-storey panels may need to be secured to reinforced ground beams. It is important that when props are tied to a concrete permanent structure, it is confirmed that the structure has sufficient strength and reinforcement to engage the required hold-down weight and resist the effects of an imposed load.

Conclusions

This paper is intended to assist anyone involved in the design and construction monitoring of projects requiring temporary propping schemes for precast concrete panels. It is also intended to highlight some key issues and common misconceptions regarding temporary support of building during constructions. The issues identified are:

- Propping of precast elements for buildings during construction is bound by both the HSWA and the Building Act with the most onerous requirements governing the design. The relevant codes (AS/NZS 1170, NZS 3101, NZS 3404 etc.), should therefore be the main point of reference for design.
- It should be verified that all elements and load paths required for the propping are considered. It is common practice for propping suppliers to provide designs that specifically exclude anchors, footings and seismic loadings and this has the potential to result in oversights. Any temporary propping design therefore needs these to be undertaken.

- Specification of any post installed anchors based on EOTA TR045 to comply with Amendment 3 to NZS 3101, Clause 17.5.5 for seismic action.
- There is an opportunity to reduce significant risk to the construction industry and to buildings in construction in New Zealand in this field. The following research and investigation could be undertaken:
 - Investigation of extent of risk and cost associated with failure of propping and other temporary works.
 - Confirmation of suitably conservative design procedures for anchors used for temporary propping.
 - Clearer requirements and guidelines for the design of temporary footings.

References

European Organisation of Technical Approvals (2013), TR045 Design of Metal Anchors For Use In Concrete Under Seismic Actions.

Gorst, Williamson, Pallett & Clark (2003), Friction in Temporary Works.

Ministry of Business, Innovation and Employment (2017), Verification Method B1/VM4: Foundations.

NZS 3101.1&2:2006 Concrete structures standard. The design of concrete structures.

Standards New Zealand (2002), AS/NZS 1170.0:2002 Structural Design Actions, Part 0: General Principles.

Standards New Zealand (2002), AS/NZS 1170.1 Supplement 1:2002 Structural design actions - Part 1: Permanent, imposed and other actions - Commentary (Supplement to AS/NZS 1170.1:2002).

Standards New Zealand (2004), NZS 1170.5:2004 (A1 excl.) Structural Design Actions - Part 5: Earthquake design actions - New Zealand.

Standards New Zealand (2019), AS/NZS 1576.1:2019: Scaffolding - Part 1: General requirements.

Standards New Zealand (2021), AS/NZS 1170.2:2021 Structural Design Actions, Part 2: Wind Actions.

Standards New Zealand. (2018). NZS 3404 Parts 1 and 2: Steel structures standard.

Temporary Works Forum New Zealand (2019), TWf(NZ) GPG01:19 Temporary Works Procedural Control: Good Practice Guideline.

Temporary Works Forum New Zealand (2022), Technical Guidance Note: TGN03:22 - Precast Panel Propping Design.

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WorkSafe NZ (2018), Safe work with precast concrete: Handling, transportation, and erection of precast concrete elements.