



# Eliminating the Risk of Air Voids in Concrete Walls



---

By eliminating the need for vibration, SCC (self-compacting concrete) reduces human error and removes a key risk factor in the placement process, leading to more consistent and defect-free concrete walls.

---

## **Introduction**

Voids in concrete walls are a pervasive issue in the construction industry. These air pockets pose significant risks to the overall structural integrity of a building. Left unchecked, they can lead to a range of complications, from weakened load-bearing capacity to the eventual failure of the structure itself. Understanding the factors contributing to void formation is essential to addressing the problem at its root.

Even minor voids can significantly compromise the strength and durability of a concrete wall. These gaps create points of weakness that interrupt the uniform distribution of stress and load, making the structure more susceptible to cracking under pressure. Furthermore, voids often facilitate water ingress, which can cause moisture-related problems such as the development of mould, mildew, and harmful bacteria. Over time, these factors contribute to the accelerated deterioration of the wall, requiring more frequent maintenance and raising overall costs.

This whitepaper offers a detailed, objective analysis of the causes and effects of voids in concrete walls, aimed at providing architects with practical insights into mitigating this issue. Through a technical lens, it explores how voids impact both small and large-scale construction projects and presents best practices for reducing their occurrence.



## Understanding voids

A void in concrete refers to an air pocket or empty space that can affect the structural integrity of a wall. These voids typically result from several factors. For example, a poorly balanced concrete mix, such as one containing too much water or an unsuitable aggregate size, can also hinder proper compaction, leading to trapped air pockets. When these air bubbles are not expelled, they remain within the concrete mass, ultimately forming voids.

Without proper vibration, the air is not adequately dispersed, resulting in the formation of voids within the concrete. Additionally, pouring concrete too quickly or without layering care can exacerbate this issue, particularly in deep or narrow formwork particularly walls where the flow of concrete is restricted by the presence of horizontally laid reinforcing bars. In some cases, porous or rough formwork materials may also contribute to air accumulation, as they allow air to remain on the surface of the concrete as it cures, leading to surface-level voids.

Voids compromise more than just the structural strength of a concrete wall. They can lead to significant issues such as water ingress, which causes moisture damage and accelerates corrosion in reinforcing steel. Over time, voids can cause surface defects like cracking and honeycombing, which detract from the wall's aesthetic quality and require costly repairs.

These air pockets also reduce fire resistance, acoustic performance, and waterproofing capabilities. Voids can compromise fire performance by creating pathways for smoke and flames to spread more rapidly. In terms of acoustics, voids disrupt the concrete's density and uniformity, allowing sound to travel through these gaps more easily. In addition, voids reduce moisture resistance by creating channels through which water can infiltrate, leading to potential structural weakening and increased susceptibility to mould and corrosion.

Ultimately, the presence of voids can result in premature building life, building code non-compliance, forcing project delays or expensive remediation efforts.





## Issues with common walling systems

### Core-fill block walls

Core-fill blocks, commonly used for reinforced wall construction, typically come in thicknesses of 140mm and 190mm. These blocks feature porous hollow cores, with thick internal webs connecting their faces. When these porous blocks are stacked in a brick-like pattern, the internal webs effectively reduce the size of the hollow cores, impeding the free flow of concrete during filling. Without adequate flow, particularly in cases where vibrators are not used, concrete can fail to fully occupy these spaces, leading to the formation of air pockets within the wall. This issue is more prevalent in narrower block walls, where the webs further limit the movement of the concrete mix.

Another challenge arises from the presence of reinforcement bars—both horizontal and vertical—within the block wall. These reinforcement elements often crowd the space within the cores, making it difficult for vibrators to be used effectively. In addition, mortar from laying blocks falls inside the walls, landing on the horizontal reinforcement bars. These “mortar-dags” set and remain, further inhibiting the flow of concrete. As a result, air pockets can form during the concrete filling process, particularly in areas where the concrete is unable to flow smoothly around the reinforcement bars.

### Conventionally formed concrete walls

Formwork plywood is widely used in construction for creating moulds into which concrete is poured. To ensure proper concrete flow and minimise the risk of voids, the plywood should be oiled before use, reducing friction between the concrete and formwork. Adequate space is also necessary to allow for the proper placement of steel reinforcements and to ensure the concrete is properly confined. Vibration of the concrete during placement is crucial to eliminate trapped air, but over-vibration must be avoided to prevent segregation of the concrete mix, which can result in uneven strength distribution and potential weak points in the wall.

An additional consideration when using plywood formwork is the maximum free fall distance for pouring concrete. Allowing concrete to fall from a height greater than two metres can cause the mix to segregate, leading to inconsistent material distribution within the wall and the potential for voids to form. Careful control of both the concrete pouring process and vibration technique is essential to avoid these issues and ensure the structural integrity of the wall is maintained.

## Fibre-cement sheet-based permanent formwork systems

Fibre-cement formwork is a porous material that tends to absorb moisture, creating friction between the concrete and the formwork surface. This friction can restrict the smooth flow of concrete, increasing the likelihood of void formation. Additionally, fibre-cement sheets are often glued to metal frames, and under the pressure of the concrete, these sheets are prone to detachment. Inappropriate use of vibrators exacerbates this issue, potentially causing serious blow-outs, particularly during inclement weather when the material's moisture absorption is heightened.

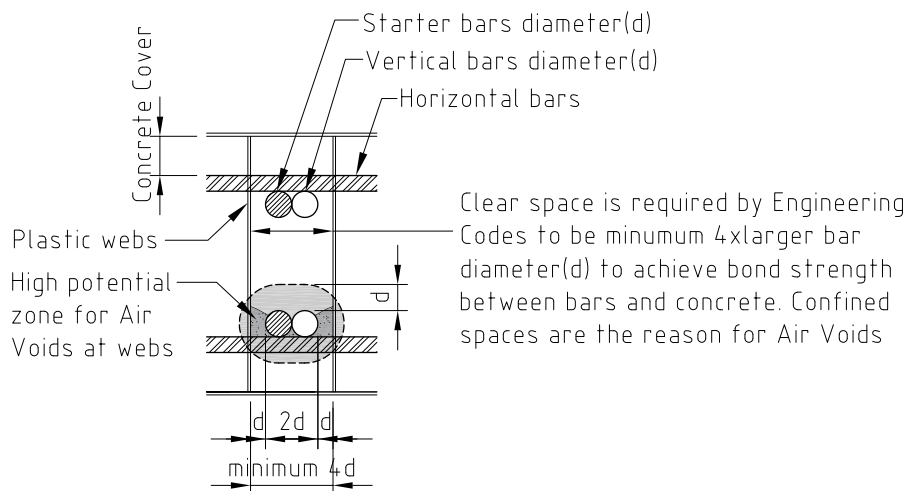
Furthermore, the structural integrity of fibre-cement sheets can be compromised under concrete pressure, leading to failures within the formwork system itself. So, to minimise the chance of formwork failure pour pass heights must be limited, lower slump concrete is used and vibration must be minimised. All of these processes significantly increase the chances of introducing voids and defects such as cold joints into the wall. Proper handling, highly skilled installers and careful application of vibration are essential to avoid these common problems.

There are other issues with fibre cement faced permanent formwork. The NCC is particularly concerned about preventing the potential for building façade elements falling for public safety reasons. The fibre-cement sheets of about 1.2m x 3m in size glued to metal frames can detach during a building façade fire and also during concrete placement. This could be prevented if these sheets are mechanically fixed to metal frames. The 1.2m x 3m size panels can weigh up to 50kg which can create WHSE issues particularly when panels have to be lifted above starter bars during panel placement.

## PVC/plastic-based permanent formwork systems

PVC and plastic-based permanent formwork systems offer a distinct advantage, due to their light weight nature only require one man to install which improves construction site safety and speed of installation. Unlike more traditional formwork materials, the design of these systems allows for the concrete to be poured from heights greater than the conventional two metres. The unique shape of the PVC forms includes webs that retard the speed of free fall of aggregates, which reduces the risk of segregation during the pour. However, to accommodate these greater drop heights and the use of vibrators, the formwork must be robust enough to withstand the pressure exerted by the concrete.

One critical factor in minimising air voids and ensuring proper bond strength between reinforcing bars and concrete in PVC-based formwork systems is the spacing between the supporting webs as shown in the below diagram. These distances must be wide enough to permit unimpeded concrete flow and provide space for optimum bond strength, particularly in areas where dual vertical bars overlap at each face and starter bars are placed at the top and bottom of the walls. According to international concrete codes, the optimal web spacing is at least four to five times the diameter of the vertical reinforcement bars, ensuring adequate concrete flow and reducing the likelihood of void formation at critical points in the wall and ensuring optimum bond strength.



PVC/PLASTIC BASED WALL

## Challenges in detecting air voids in walls

Air voids can occur in any type of formwork system. Conventionally formed walls can visually show surface air voids when the forms are removed, however this does not mean that there are no air voids within deep in the concrete away from visible concrete surfaces in and around steel reinforcement. Internal air voids usually are connected to surface by the presence of shrinkage and thermal cracks which are usually adequate to start the concrete cancer process if the concrete surfaces are not protected by impervious surface protection such as in the case of waterproof PVC/plastic-based formwork systems.

Detecting air voids in concrete walls is a complex task, and traditional methods like thermal imaging present several limitations. Thermal cameras are primarily designed to detect surface-level temperature variations, meaning they are less effective at identifying voids deep within the concrete, particularly around areas with dense reinforcement or when the concrete has set and is cold. The effectiveness of thermal scanning depends heavily on the camera's resolution and quality, which may not always capture smaller voids or inconsistencies.

Furthermore, the interpretation of thermal images requires a skilled operator who can correctly analyse heat signatures, introducing the potential for human error. Thermal imaging relies on external heat sources, such as curing concrete or sunlight, to create temperature differentials, and in the absence of these, the results can be inconclusive or misleading. That said, thermal image cameras can be useful at the time of concrete pour to

track concrete flow paths (setting concrete gives off heat) to assist in prevention of voids—in the same way as “tapping walls” during fill.

Most voids in concrete walls tend to form in areas where reinforcement is congested and deep within the structure—regions that thermal cameras are unlikely to penetrate effectively. Consequently, while thermal imaging may be helpful for identifying surface anomalies, it falls short when it comes to detecting voids that pose a greater risk to the structural integrity of the wall.

Ground Penetrating Radar (GPR), by contrast, is the most reliable system for detecting air voids within concrete post pour. GPR uses high-frequency radio waves to penetrate concrete and locate objects or anomalies within the structure. It can penetrate deeper, locate reinforcement, and provide precise information on the size and position of voids without relying on temperature differences. A GPR analysis therefore offers a more accurate representation of potential voids and addresses the limitations associated with surface-focused technologies like thermal imaging.

Repairing voids post-construction involves labour-intensive processes like coring and cutting, which are both expensive and time-consuming. Considering these factors, preventative measures, including proper concrete compaction, high-quality mix, and skilled placement techniques, remain the most effective approach for avoiding these costly problems.

Voids compromise more than just the structural strength of a concrete wall. They can lead to significant issues such as water ingress, which causes moisture damage and accelerates corrosion in reinforcing steel.

## Eliminating voids in walls using conventional high-slump concrete

Achieving a void-free concrete wall is highly dependent on using precise construction techniques and materials. A 220 +/- 40 mm slump concrete mix is recommended, which offers an optimal balance between fluidity and stability, allowing for efficient filling of the formwork while reducing the risk of air pockets. To further enhance compaction and eliminate voids, vibration and tapping techniques should be applied throughout the pouring process. Proper vibration helps settle the concrete uniformly, filling any potential gaps and ensuring a solid, cohesive structure. Tapping, in conjunction with vibration, aids in dislodging trapped air from around reinforcements and formwork

surfaces. To validate the integrity of the pour, thermal scanning may be used to detect any remaining voids or inconsistencies within the structure.

Note that highly skilled operators are essential to executing these steps effectively, as their expertise ensures that each step—from slump testing to vibration and scanning—is performed with precision. Following these prescribed methods significantly reduces the likelihood of voids. As discussed next, self-compacting concrete can further minimise risks inherent in conventional concrete filling methods due to its superior flow and self-levelling properties.



# Reducing the risk of voids in walls with self-compacting concrete (SCC)

## What is SCC?

Self-compacting concrete (SCC) has become a widely adopted solution in Australian Government projects, addressing many of the issues associated with improper concreting practices that can lead to voids.<sup>1</sup> SCC is engineered to flow easily into formwork and fully compact under its own weight, eliminating the need for mechanical vibration. This ability to completely fill all spaces, even in complex or confined areas, significantly reduces the likelihood of air pockets and voids within concrete walls.

SCC differs from traditional concrete by possessing three enhanced properties: filling ability, passing ability, and segregation resistance.<sup>2</sup> Its filling ability ensures that it flows smoothly into the formwork, reaching all corners and crevices without requiring vibration. Passing ability allows the SCC to move easily through tight spaces, such as those between densely placed steel reinforcement bars, without segregating or becoming blocked. Finally, its segregation resistance ensures the mix remains uniform throughout transportation, placement, and curing, preventing material separation that could lead to weaknesses in the finished concrete.

A common issue in conventional concrete practices is the addition of excessive water to a low-slump mix on-site, to make it more workable. This practice compromises the strength and durability of the concrete. SCC, on the other hand, flows easily without the need for extra water, mitigating this risk and providing greater assurance for structural engineers, concrete suppliers, and project stakeholders. Additionally, by eliminating the need for vibration, SCC reduces human error and removes a key risk factor in the placement process, leading to more consistent and defect-free concrete walls.

## SCC cost considerations

While the initial supply cost of SCC may appear higher, it proves to be more economical when considering several key factors. The increased speed of concrete placement significantly reduces labour costs, as fewer workers are required, especially since SCC eliminates the need for vibration. This reduction in manpower—removing at least two labourers per pump outlet—further lowers expenses.

Additionally, the use of SCC reduces the need for extensive scaffolding and prevents the formation of voids, which in turn eliminates the costly rectification work typically associated with void repairs. In the Sydney metropolitan area, the additional cost of SCC is generally less than \$7/m<sup>2</sup> within 200 mm thick wall, a small price compared to the cumulative savings in labour, scaffolding, and remedial work, making SCC the more cost-effective solution overall than conventional concrete.

## SCC and Dincel formwork

SCC has proven to be a highly effective solution in modern construction, particularly when used in conjunction with Dincel formwork systems. SCC is designed to flow into and fully fill formwork without the need for mechanical vibration. This characteristic is particularly advantageous when used with Dincel permanent formwork, which has been engineered for rapid installation and long-term durability.

Dincel forms evolution has gone through various formwork thickness iterations up to the current 2.5 mm formwork skin thicknesses to handle construction mishandling and adaptation of the NZ earthquake requirements in 2018. Dincel further improved the robustness of the product 3 years ago to handle the SCC pressure.

The Dincel formwork system is specifically designed to add strength to concrete walls, sometimes even eliminating the need for steel reinforcement. When SCC is introduced into the Dincel system, it further enhances the speed and efficiency of construction by removing the need for vibration, which not only reduces labour but also mitigates the risk of human error. The Dincel team's research, including rigorous testing in collaboration with the various industry experts and institutions, has demonstrated that SCC can travel throughout the formwork, even in challenging configurations with high levels of reinforcement beyond the engineering code limitations (i.e. significantly over reinforced), without creating voids or segregation.

The results of these tests confirm the advantages of pairing SCC with Dincel formwork, offering a void-free, high-quality concrete finish. The system has been proven to provide enhanced structural, fire, acoustic, and waterproofing compliance, which is critical in building in civil applications. Moreover, the ability of the Dincel snap-lock joints to effectively contain the pressure exerted by SCC highlights the robustness of the formwork. Together, SCC and Dincel formwork deliver significant time and cost savings, increased durability, and the assurance of void-free construction, making them an ideal solution for modern concrete wall construction.

In a groundbreaking move for the Australian market, Dincel offers a "Void Free Warranty." This warranty guarantees void-free results when SCC is used to pour Dincel walls, if installation follows Dincel's specified guidelines. This commitment further reinforces the quality and reliability of Dincel's formwork systems, offering engineers, architects, and builders' greater peace of mind in their projects.

## REFERENCES

- <sup>1</sup> For more information, view the assessment of SCC in Dincel walls by Mahaffey Associates Pty Ltd here:  
[https://www.dincel.com.au/theme\\_dincel/static/resources/compliance/self\\_compacting\\_concrete\\_trial\\_with\\_dincel\\_walls.pdf](https://www.dincel.com.au/theme_dincel/static/resources/compliance/self_compacting_concrete_trial_with_dincel_walls.pdf).
- <sup>2</sup> Elsevier. "Self Compacting Concrete." ScienceDirect.  
<https://www.sciencedirect.com/topics/materials-science/self-compacting-concrete> (accessed 14 October 2024).

All information provided correct as of November 2024