THIS AMAZING TOOL WILL HELP YOU PREVENT DEFECTS IN BRICK AND BLOCKWORK, CONCRETE WORK, WINDOW INSTALLATION AND TIMBER DECKS.

BSA
BUILDING SERVICES AUTHORITY

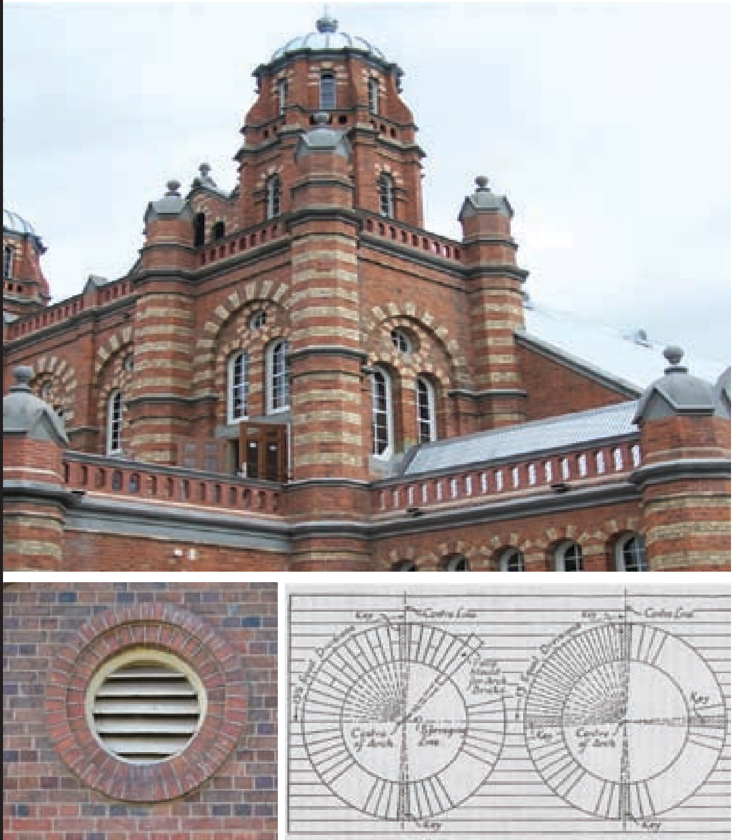
CSQ
CONSTRUCTION SKILLS QUEENSLAND

BETTER BUILDING SHOWS

Queensland Government

Common Defects in BRICK & BLOCKWORK

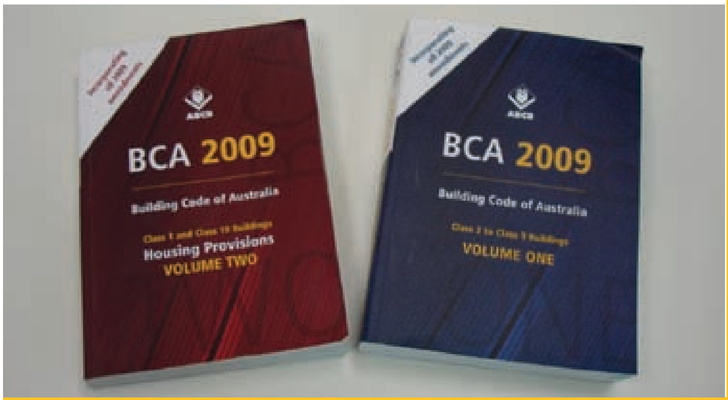
Brick, block and stone has been used to construct buildings for hundreds, if not thousands of years and whilst many of the components used in conjunction with the brick, block and stone may have changed, the basic purpose of the masonry to provide an aesthetically pleasing finish that is structurally sound and watertight is unchanged.



Brick construction has endured.

Given its long history you may expect that very few defective work issues would arise in relation to brick and block work and generally this is the case, however, particularly in more recent years, there appears to have been some increase in the number of defects occurring in the industry. These defects often appear to have been caused by the bricklayer's rush to lay as many bricks as possible in the least amount of time and a lack of care and attention to detail exercised in the process.

This booklet is not intended to provide detailed instructions on how to lay bricks and blocks but rather to identify defects in brick and block work that commonly come to the BSA's attention and to provide general advice on ways of avoiding these defects from occurring.



Building Code of Australia (BCA). An updated edition is published every year.

In providing this advice reference is made to the Building Code of Australia and relevant Australian Standards *AS 3700 2001 Masonry structures and AS/NZS 2699 Part 1 2000 Built in components for masonry construction.*

AESTHETICS

One of the fundamental requirements of brick and block work is to provide a pleasing aesthetic finish, yet this is an area where brick and block work defects commonly occur. Some of the common problems reported to BSA include poor colour blending of bricks, colour variation in the mortar, inconsistent mortar joint widths and poor set out and alignment.

Colour blending of brickwork is an extremely subjective issue, what may be acceptable to one person may be unacceptable to others. The best advice BSA can give in relation to such issues is to clearly discuss any required colour blending with the builder and client prior to commencement of work.

Colour differences in brick work can be a subjective issue

If colour blending of bricks is critical or contentious, the client should be invited to view the work after a small section has been completed to ensure it is consistent with their expectations. There are no winners if whole walls have to be pulled down because the client is unhappy with the appearance and has not been sufficiently consulted during the construction process.

Colour variation in the mortar is another area where disputes often occur particularly where grey or black mortar colours are used. The key to ensuring consistency in the colour is of course consistency in the mix so where colour matching is critical, careful attention should be paid to ensuring the constituents in the mix are used in consistent quantities. This requires the various constituents to be volume batched (using buckets or similar consistent measuring container) rather than the traditional shovel which can easily lead to volume discrepancies in the mix.

In relation to ***joint and perpend widths*** the Building Code of Australia and Australian Standard AS 3700 provide that unless specified otherwise and brickwork designed accordingly, the masonry bed and perpend joints should be 10mm. The Standard however permits a plus or minus 3mm tolerance for deviation from the specified thickness.

Mortar joint of variable width and significantly exceeding 10mm in places.

Once again however, lack of attention to detail or perhaps lack of care with their work has resulted in a number of complaints being lodged with BSA against builders and brick layers in relation to inconsistent mortar bed or perpend thickness.

The only real solution to prevent these defects from arising is for bricklayers to take more care and bricklayers and builders to more closely supervise the work as it proceeds.

Other problems that occur relate to the ***plumb, level and straightness of brickwork.*** Attention to detail and care when laying bricks and blocks will avoid many of these problems occurring, however brick and block layers are often confronted with problems caused by preceding trades and are forced to try and compensate for problems caused by these trades.

For example with flush eaves or gables where brickwork is required to finish just inside the line of the fascia or bargeboard brick layers may be expected to build the brick work out or in to align with an incorrectly aligned fascia or barge. Where such requests are excessive, brick and block layers must refer the issue back to the builder for resolution.

Building a wall out of plumb to accommodate mistakes made by the carpenters in setting out the fascia may result in the bricklayer being required to demolish or rectify defective brickwork that is the result of problems caused by other trades. Similar problems arise when footings are poured out of alignment and brickwork excessively overhangs the edge of the footing.

First course significantly overhanging slab edge

Where such overhang is excessive the issue must be referred back to the builder for resolution prior to laying the first course of bricks. Having to demolish inadequately supported brick walls or to rectify brick walls that subsequently crack or dislodge because they have been inadequately supported is distressing to clients and costly to both builders and bricklayers.

STRUCTURAL CONSIDERATIONS

WALL TIES

Wall ties in brick veneer, cavity brick and at the connection of brickwork to other materials or surfaces are critical to ensuring adequate structural performance of the brickwork, particularly in resisting lateral wind loads.

Correct selection and installation of brick ties is another area where defects commonly occur. The ties must suit the type of framing they are connecting to and need to be fixed with the correct fixings.

Additionally, the spacing of ties must comply with the requirements of the Building Code which for Class 1 buildings are stipulated in Figure 3.3.3.1 of Volume 2 of the BCA.

It is essential the installed ties are kept clean of mortar so that moisture is prevented from travelling along the tie to the inner leaf of masonry or wall frame.

It is also important that the ties are of suitable durability for the exposure conditions in which they are installed. The BCA requirements for Class 1 Buildings are stipulated in Table 3.3.3.1;

Figure 3.3.3.1- Typical Brick Ties Spacing in Cavity and Veneer Construction

NOTE:	
1	Solid masonry ties must be of a size appropriate to the cavity width and built not less than 50 mm into each leaf.
2	Wall tie spacings indicated on the diagram are indicative and may be reduced according to the nature of the wall.
3	Location of wall ties immediately adjacent to ties connecting an intersecting wall may be increased to not more than 600 mm away from the intersecting wall ties.

Diagram A - Spacing for medium duty wall ties - cavity and veneer construction

Table A - Spacing for medium duty wall ties - cavity and veneer construction

DESIGN WIND SPEED (non-cyclonic)	CAVITY MASONRY	CAVITY MASONRY CONSTRUCTION	
		450 STUD WALLS	600 STUD WALLS
N1-N3	600 X 600	600 X 450	600 X 600

NOTE:	
1	Inner leaf masonry thickness 70 to 150 mm for cavity walls
2	Around openings and at control joints, the vertical tie spacings are halved (i.e. the number of ties must be doubled).
3	In veneer construction, masonry must be tied to stud wall framing at all regular stud positions, including gable ends.

Table 3.3.3.1- Corrosion Protection for Wall Ties

Exposure conditions	Tie Specification (minimum corrosion protection)
Areas - • Less than 1km from breaking surf; or • Less than 100m from salt water not subject to breaking surf; or • Within heavy industrail areas.	• Grade 316 or 316L stainless steel • Engineered ploymer
Areas - • 1km or more but less than 10km from breaking surf • 100m or more but less tan 1km from salt water not subject to breaking surf.	• Sheet steel ties galvanised after manufacture- 470g/m^2 on each side • Galvanised wire ties- 470g/m^2_
All other Areas	Ties manufactured from galvanised sheet steel - Z600 Sheet steel ties galvanised after manufacture- 300g/ m^2 on each side

MOVEMENT JOINTS

The BCA Housing Provisions detail the requirements for articulation joints in Class 1 Buildings however, for constructions founded on clay soils the engineer's footing design should also detail any masonry articulation requirements.

Movement or articulation joints are provided in brickwork or block work to accommodate movement associated with brick growth, block shrinkage, differential footing movement and where walls change in thickness or height or adjoin walls constructed of different masonry elements.

Accommodating differential footing movement is especially critical on clay soils where the soils expand and contract significantly with changes in moisture content.

Some common problems encountered with the installation of articulation joints include joints not being installed in accordance with the engineer's design, an inadequate number of joints being installed and joints being installed in locations where they have little effect.

Additionally, joints often fail to be taken through the mortar in brick sills subsequently resulting in cracking of the mortar in the sills and even bricks becoming dislodged.

Articulation joint not carried through sill

Other problems include the joints being breached by mortar or other non-compressible material and joints being cut-in after construction rather than being built-in as construction proceeds. In such cases the joints are seldom the required 10mm minimum width as cutting blades are typically only 3 or 4mm thickness.

Another issue that is becoming more and more prevalent with the increasing number of buildings being finished externally with render or other specialised finishes is that the articulation joints in brick or block work are not being carried through any surface finishes and the expansion and contraction of the joint is consequently being restricted or constrained by such finishes.

CORE FILLING

Core filling of block work is often not given the care and attention it warrants however the consequences of inadequate core filling can result in the wall being structurally unsound.

Core filled pier discovered after Cyclone Larry showing almost non-existent core filling

Common problems include inadequate cleaning out of the block work cores prior to core filling, reinforcing and starter bars being incorrectly located in cores and core filling not fully filling the cores due to inappropriate aggregate size, inadequate slump or inadequate compaction. Problems can also occur with the brick biscuit faces or formwork to clean out blocks 'blowing out' if too great a height of block work core is filled in one pour or alternatively if the biscuit or form is not adequately braced.

To avoid these problems occurring it is essential that block laying and core filling is adequately supervised. to ensure starter bars and reinforcing rods are accurately located and installed in accordance with engineer's recommendations.

This is especially important in relation to reinforcing of bond beams in cyclonic areas where the tie down of the roof frame is dependant upon the tie down straps or rods being cast into the bond beam.
In some instances these tie down fixings are designed to loop around the reinforcing bars whilst other cast in fixings such as rods may only be required to be cast in within a specified proximity of the reinforcing bars.

Work must be adequately supervised to ensure cores are properly cleaned out and biscuits or forms properly positioned and braced. To avoid biscuits or forms 'blowing out' it is also preferable that the height of cores filled each pour does not exceed 2.4 metres.

WATERPROOFING

Two common areas of waterproofing defects are often reported to BSA. The first of these relates to water penetration through brick veneer construction and the second relates to water penetration through single skin masonry such as block work.

In relation to the brick veneer construction the problems usually occur because the cavity has been breached by mortar or service pipe work and cabling or from defective installation of the damproof membrane and other flashings.

Breaching of the cavity is usually a direct consequence of lack of care on the part of the tradesmen involved and poor supervision on the part of the builder. Bricklayers should be constantly aware of the importance of a clean cavity and should exercise care to minimise any mortar that falls into the cavity.

The builder should also be vigilant to ensure cavities are kept clean and that the installation of services such as water pipes, air conditioning pipes and electrical conduits do not breach the cavity.

Good building practice recommends that where services do penetrate the external brickwork and bridge the cavity that such penetrations are properly sealed both externally and where the pipes pass through any sarking and also that the pipes slope marginally towards the outside of the building so that any water or condensation that accumulates on the pipe runs back towards the outside of the building.

Correct installation of the damproof course and flashings around windows and doors and their associated weepholes is also critical to ensure the external wall system is watertight. Too often flashings are incorrectly installed, weepholes are of insufficient size or are blocked by mortar and the damproof course is incorrectly installed. Problems with dampcourses typically occur at corners and laps. A little care during installation can avoid a lot of heart ache and cost after the house is complete and it leaks.

The junction of a lower level roof to a higher level brick wall such as occurs in split level homes also commonly leads to waterproofing issues. The key to solving this problem is to correctly install a stepped flashing into the brickwork and cavity and to ensure the flashing is turned up the inside leaf of the wall and at the higher end of the flashing in its running length.

Problems associated with waterproofing of single skin masonry appear to be on the increase and are particularly prevalent in multi residential units up to three or four storeys in height. Many of these buildings are built close to the foreshore and are subject to strong unimpeded winds during storms. In many cases construction practices appropriate for single storey construction has been used in these buildings even though their additional height will make them subject to higher wind loads.

Buildings in excess of this height are subject to similar and even higher wind loads but are generally built by larger builders experienced in this type of construction and are designed and sometimes supervised by experienced architects and engineers and accordingly a similar level of problem does not generally occur. That said, it is also relevant to note that the single most common defect in commercial building work is water penetration around windows and doors.

The problems typically occur at the floor to wall junction and around windows and doors. They can be caused by a number of issues including inadequate or non existent set-down or water stop angles at the wall to floor junction, inadequate sill set downs or rebate blocks being incorrectly installed or damaged during construction and incorrectly installed sub-sills and flashings.

To avoid these problems occurring block layers should ensure they are familiar with the engineer or designer's requirements particularly in relation to waterproofing of the block work at the wall to floor junction and around windows and doors.

Any concerns should be raised with the builder and designer for resolution prior to commencing with the block work. The block work when being laid at these critical interfaces should be carefully supervised to ensure it is laid correctly in accordance with the engineer or designer's requirements and without damage.

MASONRY FENCES

Masonry fences are at times of particular concern as they often do not require development assessment approval (as they are self assessable if less than 2m high) and can cause significant damage or risk to life should they subsequently collapse or topple over.

Instances have occurred where fences have failed at the bed joint because there was inadequate or no reinforcing in the fence or its engaged piers. Excessive cracking is also often encountered in block fences where cores have been inadequately reinforced or core filling is defective.

Brick work piers in fencing with no vertical reinforcing

RETAINING WALLS

Many problems occur with the construction of brick and block retaining walls and most of these relate to design issues or inadequate or non-existant drainage behind the wall however there are a couple of issues that are directly relevant to the brick or block layer that warrant further discussion.

Correct placement of the starter bars in the footings and reinforcing bars in the wall is critical to the performance of the wall and accordingly should be carried out strictly in accordance with the engineer's design. The starter bars must be correctly placed in the footing so their location closely corresponds with the vertical reinforcing bars and generally the bars should be located in the rear portion of the core closest to the soil being retained.

Considerations mentioned previously in relation to ***correct cleaning and core filling of block work cores applies equally to retaining walls.*** In one example BSA is aware of the block layer did not install clean out blocks in the wall but did hose down the cores to remove mortar dags. The core fill was then poured over the slurry of weak mortar and water that ponded in the bottom of the cores. Five years later the wall collapsed as the reinforcing bars had rusted through at the base of the cores where they had been immersed in the weak mortar slurry.

SUMMARY

As will be evident from this booklet the cause of the majority of defects reported to BSA is simply a lack of care and attention to detail when carrying out work, coupled with inadequate supervision. The result of the defects however is significant requiring time consuming and costly repair.

Reducing defects is good for all in the construction process as less defects means less call backs to repair unsatisfactory work, greater profits for the bricklayer and builder, and a more satisfied client. Quality work enhances your reputation in the industry and BSA research has determined that word of mouth communication is by far and away your best, not to mention your cheapest, marketing tool.

REFERENCES

- Building Code of Australia 2009
- AS 3700 2001 Masonry structures
- AS/NZS 2699 Part 1 Build in components for masonry construction

It is almost impossible to imagine the building industry today without the use of concrete. Concrete has historically been used extensively in structural components of both commercial and residential buildings and in more recent times has been patterned and coloured to also provide an aesthetic aspect to constructions.

As concrete is generally mixed in a batching plant under controlled and quality assured systems few problems usually arise in relation to mixing proportions or materials. A number of common problems do however, routinely occur on site during the installation and curing of the concrete and it is these defects that are the subject of this publication.

This booklet describes a number of common defects encountered by building supervisors, building certifiers and BSA building inspectors during their inspections and provides best practice recommendations to minimise the likelihood of such defects occurring in future.

Large warehouse concrete floor slab pour

DESIGN AND SPECIFICATION

In relation to concrete the Building Code of Australia (BCA) calls up one main standard; AS 3600 Concrete Structures. Two other standards are also relevant in relation to concrete; AS 2870 Residential Slabs and Footings – Construction and AS 1170 Design Loads on Structures.

Compliance with these standards is considered to represent 'Best Practice' when it comes to the design and installation of concrete work on site.

CRACKING

Unplanned cracking is the curse of all concrete. It is difficult to control and has many potential causes. Care, attention to detail, good laying, compaction and finishing practices and a good curing regime can however significantly reduce the likelihood of cracking occurring.

PLASTIC SHRINKAGE CRACKING

Plastic shrinkage cracking

Although they may not become visible until the day after finishing these cracks start to form before the concrete sets and are typically 300 to 600mm long and up to 3mm wide. The primary cause of plastic shrinkage cracking is rapid evaporation of the surface (bleed) water from the concrete leading to premature drying and subsequent cracking of the slab.

Controlling the rate of drying of the concrete surface is the key to minimising plastic shrinkage cracking. The rate of drying can be affected by many factors such as temperature, wind conditions, and humidity, so this may not be a simple task. Site practices that will minimise the likelihood of plastic shrinkage cracking occurring include;

- Dampening the sub-grade and formwork prior to pouring concrete but removing any surface water
- Providing wind breaks
- Spraying evaporative retarders such as aliphatic alcohol over the surface immediately after screeding and whilst bleed water is still present
- Commencing and maintaining curing promptly after finishing for a minimum 7 day period

PLASTIC SETTLEMENT CRACKING

Plastic settlement cracking

Plastic settlement cracking is caused when concrete settles under its own weight often without adequate compaction. As the concrete settles it is restrained by reinforcement or service pipes etc and cracks form. Unlike plastic shrinkage cracking which is often random, plastic settlement cracking usually follows a distinct pattern often mirroring the placement of reinforcement. Site practices that will minimise the likelihood of plastic settlement cracking occurring include;

- Wetting the sub-grade before placing concrete
- Fixing all formwork rigidly to prevent forms moving during compaction and finishing
- Placing concrete in deep sections first and letting settle prior to placing and compacting the top layers
- Thoroughly compacting the concrete
- Curing the concrete promptly and properly

DRYING SHRINKAGE CRACKING

Drying shrinkage cracking is primarily caused by the concrete drying out and shrinking. If the concrete is restrained through formwork, adjoining walls, reinforcement and by sub-grade surface friction cracks may occur.

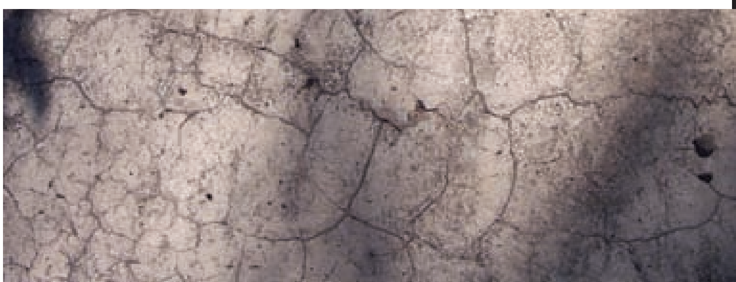
Drying Shrinkage Cracking

Two issues, namely the water content of the mix and the location and timing of installation of joints, contribute significantly to the likelihood of drying shrinkage cracking occurring. Excess water in the mix increases the amount of shrinkage that is likely to occur and inadequate or incorrectly located joints and joints that are cut into the surface too long after the concrete is finished do not provide sufficient ability for the slab to accommodate the shrinkage without cracking. Site practices that will minimise the likelihood of drying shrinkage cracking occurring include;

- Avoiding adding additional water to the mix on site
- Thoroughly compacting the concrete
- Correctly placing reinforcement
- Providing adequate curing
- Ensuring joints are correctly located and if joints are cut into the finished slab are cut in as soon as possible after finishing

CRAZING

Crazing is a form of shrinkage cracking that results in the surface of the concrete exhibiting a network of very shallow fine cracks that become much more obvious when the concrete is wet. Crazing is caused by drying shrinkage of the thin mortar layer created during the finishing process. Other causes include the mix being too wet, being inadequately cured or when cement powder is worked into the surface during the finishing process to dry up excess moisture.



Crazing on concrete surface

Site preventative measures include;

- Using a good curing regime
- Avoid using cement powder or coloured surface hardeners to dry up excess surface moisture
- Avoid adding water to the mix on site
- Avoid working the surface until the bleed water has fully evaporated

DELAMINATION

Delamination of concrete floors occurs most commonly in large industrial floors and results in a thin surface layer (up to 5mm) of concrete initially becoming drummy, then detaching from the rest of the slab. The primary cause of delamination is related to the timing of the final trowel finishing of the slab. Ideally this should start after the initial setting of the concrete. If commenced prematurely bleed water can be trapped under the surface or be worked back into the slab forming a weak surface layer that can delaminate under subsequent loading.

Moving surface concrete during finishing operations to fill low spots can also cause subsequent delamination as the thin layer of repositioned concrete merely sits on top of the remainder of the slab forming a brittle surface layer.

Numerous other factors have an influence on the tendency for concrete floors to delaminate. Some good site practices that may reduce the likelihood of delamination occurring include;

- Correct timing of the final trowel finishing
- Uniform placement, consistent bleed rate and consistent setting time of concrete
- Use of air-entraining and set retarding admixtures should only be used where specifically required (eg where long travel time to deliver concrete is required)
- Properly prepare the sub-base to provide a uniform laying platform including dampening the sub-grade and where plastic membrane is being used ensuring the membrane is free from tears and is properly lapped to prevent uneven loss of moisture.
- Properly and uniformly compact the concrete
- Properly and rigidly fix reinforcing ensuring appropriate cover
- Uniformly place, compact and finish the concrete.
- Attempt to ensure that climatic effects on the concrete such as wind, temperature and humidity are consistent over the entire concrete surface
- On the first pass of the trowelling machine the blades should be as flat as possible, finishing blades can be tilted at progressively greater angles to gradually increase the compaction of the surface layer
- Use a walk behind power floating machine for the first pass to aid surface levelling before subsequent passes using ride on machines.

Ride-on mechanical trowelling machines

DUSTING

Dusting is used to describe the situation where the surface of the concrete becomes non-durable and a fine powder of concrete is continually deposited on the surface. The causes of dusting include the addition of excess water on site and premature finishing of the surface. These and other factors have the effect of weakening the strength of the surface layer of concrete resulting in a low strength surface of poor durability.
Good site practices that reduce the likelihood of dusting occurring include;

- Avoid adding additional water to the mix on site
- Take care to avoid the likelihood of rainwater increasing the water to cement ratio of the surface concrete either by increasing the volume of water in the concrete or by washing the cement powder out of the concrete.
- Correct timing of the final trowel finishing and in particular avoiding premature finishing
- Avoid overworking the concrete
- Properly cure the concrete
- Specify the correct concrete strength for its intended purpose

JOINT LOCATION & INSTALLATION

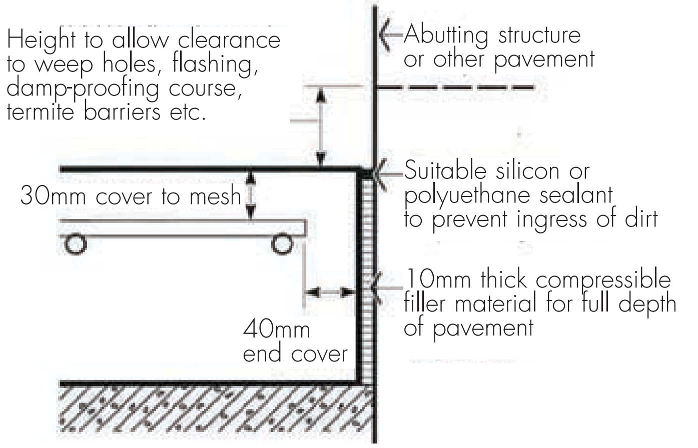
he primary function of joints is to permit movement of the concrete through the use of expansion and isolation joints, to control cracking through control or contraction joints and to accommodate breaks in the concrete placement through the use of construction or 'cold' joints.

The type and location of joints installed on site should be strictly in accordance with the engineer's drawings and specifications.

For example installing joints in house slabs where they are not specified can in fact weaken the slab as well as compromising the termite barrier and installing joints in driveways in the wrong locations can promote rather than limit cracking.

ISOLATION JOINTS

Isolation joints are commonly used at the junction of concrete such as perimeter paths and pavement slabs and vertical restraining elements such as the walls and columns and are designed to permit the concrete to freely expand, contract, heave, settle or rotate thereby reducing the propensity of the concrete to crack. Two common issues of defective work related to isolation joints include failing to install the joints or alternatively failing to adequately seal the top of the joint to prevent water ingress into the sub-grade material.



Isolation Joint

(We gratefully acknowledge CCAA for use of drawing above)

Omitting the joints will often lead to cracking as the concrete surface is excessively restrained by the adjacent elements. Water ingress through the joint can lead to subsidence of the sub-grade or in the case of clay soils, heaving of the underlying soil.

Care should also be taken to ensure that the installation of the isolation joint is consistent with the engineer's drawings and specifications particularly in relation to whether or not the concrete slab should be connected with dowels to the adjacent vertical element (eg footing, slab edge or column) or not.

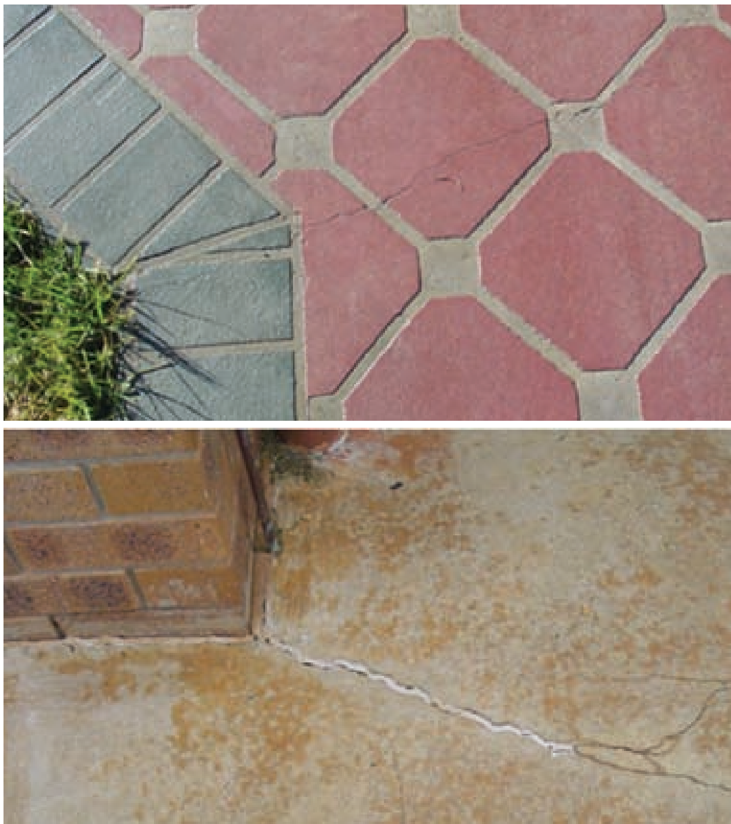
EXPANSION JOINTS

Expansion joints accommodate expansion of the concrete thereby limiting cracking due to temperature or moisture content changes. Expansion joints are usually only used in large areas of external concrete pavement and there are many available proprietary expansion joint systems that allow easy installation and continuous concrete placement. Most expansion joints incorporate dowel bars that connect the slabs and prevent changes in level between the adjacent surfaces.

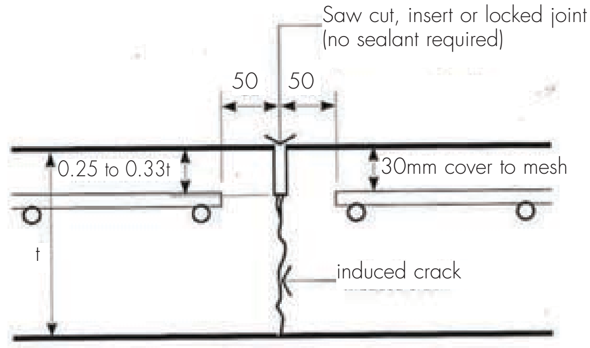
Typical problems associated with expansion joints include failing to install them in the correct locations and failing to install the joint in accordance with the engineer's recommendations or in the case of proprietary jointing systems, in accordance with the manufacturer's installation instructions. The top and sides of joints should be sealed to prevent ingress of moisture and other contaminants that may restrict the performance of the joint.

CONTROL JOINTS

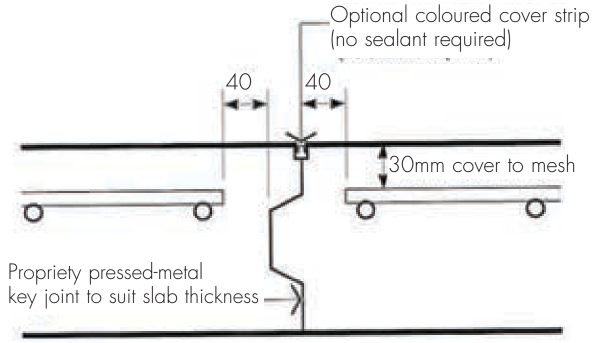
Control joints provide a weak point to encourage the concrete to crack uniformly rather than randomly as it shrinks during the setting and hardening process.



Cracks occurring at change of direction



(a) Crack-induced joint (saw cut, insert or tooled)



(b) Key joint (pressed-metal or formed)

Control Joints

In residential driveways and external slabs control joints should generally be installed at 3m centres in both directions, at any change in direction (eg corners), at change of shape (eg connection of a narrow path to a driveway) and at any rigid structures that may prevent movement and risk cracking (eg protruding column or nib wall).

Control joints can be installed using proprietary plastic or metal strips, using a grooving tool immediately after the concrete has been placed, sawing a groove when the concrete has hardened and by using proprietary metal key joints.
Common problems associated with the installation of control joints include;

- Installing saw cut joints too soon but more often too late after the concrete has hardened. (saw cuts should be installed as soon as practical after finishing the slab but when the slab is hard enough that it does not chip or spall as the joint is cut).
- Failing to cut the reinforcing mesh to weaken the slab at the joint location (usually 50% of the mesh extending across the joint is cut)
- Failing to install proprietary systems to maintain straight lines

CONSTRUCTION JOINTS

Construction joints accommodate concrete to concrete joints where pours are discontinuous. Problems associated with construction joints sometimes occur where unplanned joints are installed due to unforseen delays such as discontinuous supply, pump breakdown or bad weather. In such cases (particularly in the case of a footing and slab system) it is important the engineer is consulted to determine if any special jointing details are required and to ensure the discontinuous joint does not compromise the slab or footing design. Effects on termite barrier systems also need to be considered.

Engineer designed construction joint

SUMMARY

Concrete unlike some other products has a limited time in which it can be worked and is often very expensive to rectify when problems do occur. Accordingly, perhaps the best advice that can be provided to builders and concreters is to ensure they are properly prepared for each concrete pour whether that relates to a domestic driveway slab or a hundred cubic metre warehouse slab.

Experienced industry practitioners recommend the use of check lists to ensure the pour is planned at least the day before it occurs. This includes checking to ensure such things as;

- Access to and around the site is suitable for the pour to proceed
- The concrete has been ordered to be delivered at the correct delivery rate, the correct slump and strength
- The reinforcing, jointing (where required) and formwork are correctly located and rigidly fixed
- Any required membranes are in place, sufficiently lapped and are free from tears
- Sufficient manpower, tools and machinery including fuel and spares are available
- The engineer has inspected and is satisfied that the pour can proceed (if required)
- Adjacent surfaces are protected from concreting operations and slurry (especially where exposed aggregate finishes are installed by water blasting or similar operations)
- Evaporative retarders and spraying equipment is available
- Provision has been made to install any required joints in the concrete
- A curing regime has been devised or contracted out
- Weather reports have been checked to gauge the likelihood of rain or other climatic effects that may impact upon the pour and if significant risks exist, mitigating strategies have been implemented (eg wind breaks installed, pour delayed or additional manpower engaged)

Plastic Film Protection over Roller Grilles

REFERENCES

- Cement Concrete and Aggregates Australia

  Data Sheets:

  - Avoiding Imperfections in Concrete : Plastic Shrinkage Cracks
  - Plastic Settlement Cracking
  - Avoiding Early Cracking
  - Early Age Shrinkage of Concrete
  - Delamination of Concrete Industrial Floors
- Cement Concrete and Aggregates Australia, Guide to Concrete for Housing, 2000
- Building Code of Australia
- Australian Standard AS3600 Concrete Structures 2001
- Australian Standard AS2870 Residential Slabs and Footings – Construction 1996

ACKNOWLEDGEMENTS & FURTHER INFORMATION

- Cement Concrete and Aggregated Australia, www.ccaa.com.au
- Master Concreters Association of Queensland, www.mcaq.com.au

Timber decks, Windows & Door fixings

TIMBER DECKS & BALCONIES

A number of timber deck failures have occurred in Queensland and in other states over recent years that have resulted in injury to those on the deck and in at least one case that BSA is aware of, the death of a person on the deck. The two most recent collapses that BSA has investigated were in Ascot and Morayfield in Brisbane and the cause of these failures will be considered in detail in this publication. Having reviewed the cause of these collapses suggestions will be offered in relation to strategies that builders and building inspectors can consider that may reduce the likelihood of similar occurrences in future.

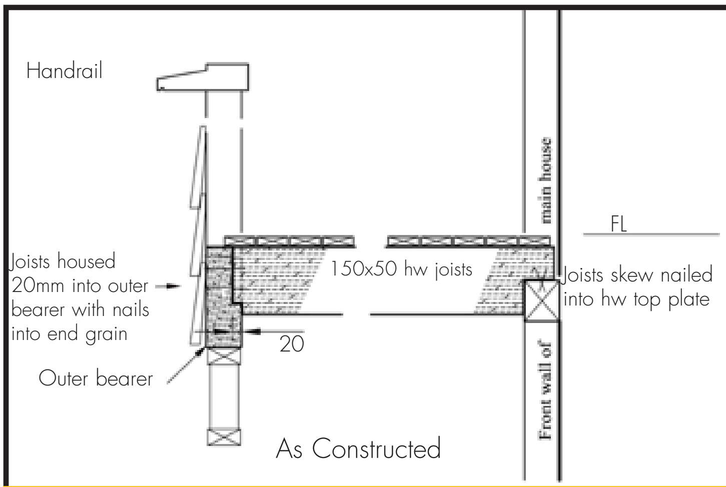
THE ASCOT COLLAPSE

***Description of Construction* -** This residence is a two story timber clad building with sheet metal roof estimated to be in excess of 50 years old. It generally appeared to have been well maintained and the balcony construction generally appeared to be in sound condition for a building of its age. No significant rot or decay to any framing members was observed.

Ascot residence subject to balcony collapse

The balcony that collapsed was located on the front elevation of the dwelling and was a traditional form of timber framed construction utilising hardwood bearers and deck joists with shot edge decking fixed above.

The front balcony measured approx. 6.5 metres x 2.75 metres and appeared to be part of the original dwelling. Deck joists were approximately 145 x 55 hardwood fixed at approximately 500mm centres and were cogged into a check out housing in a deck bearer running across the front of the balcony and cogged over a floor plate where attached to the main residence. The joists were skew nailed to the bearers and many of the nails showed evidence of significant corrosion.



Cross-section of Ascot deck as constructed.

(Drawing provided with generous permission of Peter Wright RPEG

***Cause of Collapse* -** Over a long period of time the external balcony bearer deflected outward due to the inadequate restraint provided by the nail fixings into the bearers. Corrosion of the nails may have contributed to the inadequate restraint. As the bearer deflected outward the joists began to be displaced from their housing in the bearer and this is evidenced by paint on the ends of joists and into the bearer housings.

Housing in the bearer

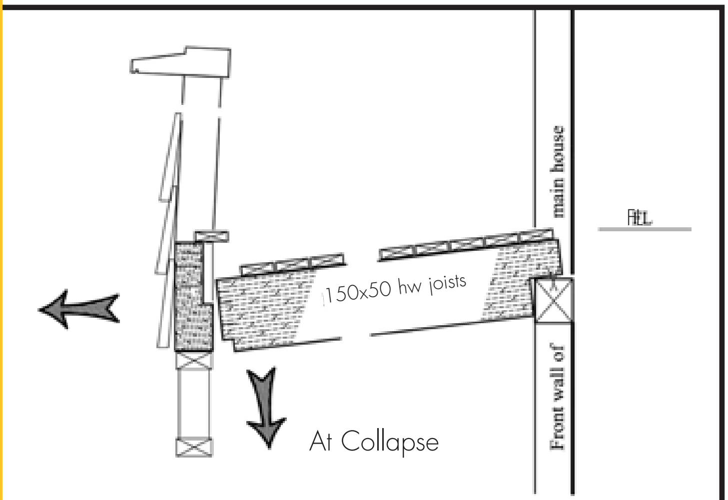
Paint clearly evident inside the cog in the joist.

In fact paint witness marks indicate that on a small number of joists the full depth of cog measured to be approx. 18 to 20mm had disengaged from their housing due to an outward deflection of the main bearer.

The balcony seems to have been sufficiently rigid to withstand the small loads from small numbers of persons that may have congregated on it under normal family usage conditions. The timber decking may have played a part in providing some rigidity and support sufficient to carry these small loads where the deck joists appear to have been almost totally lacking support.

Unfortunately it appears the deck was unable to accommodate the larger number of persons on the deck that were present at the time of failure.

Once one or two deck joist became disengaged they started a progressive collapse of adjacent deck joists due to a probable outward thrust on the bearer as the joists rotated downwards allowing adjacent joists to pull out of their housing in the bearer.



Cross-section of Ascot deck at time of collapse.

(Drawing provided with generous permission of Peter Wright RPEQ)

View at internal wall of home external bearer support

View of external bearer support

View of collapsed deck

Mud wasp nests in bearer housing is evidence that a sizeable gap existed where the floor joist cog was not fully engaging into bearer.

THE MORAYFIELD COLLAPSE

***Description of Construction* -** This residence is a 16 year old two story building, clad with fibre cement boarding with sheet metal roof. The collapsed deck was not part of the original dwelling and is a more recent addition and is approximately 2.5 metres above ground level.

The deck had obvious recent repair work performed to it which included additional timber cleats applied to the sides of the floor joists and steel angle brackets installed under the bearers where connecting to the dwelling. The owner advised that a contractor was engaged to perform the above remedial works sometime after purchase of the property.

***Cause of Collapse* -** It appears that the south-west corner of the deck failed initially where the deck bearer was attached to the main dwelling. It was further found that the deck bearer that failed penetrated the external cladding boards and relied upon support by multiple pine corner wall studs in the wall cavity. The pine wall studs supporting the bearer were found to be totally rotted out due to the ingress of water into the wall frame.

When a substantial load was applied to the deck in the direct vicinity of the south-west corner over the bearer being supported by rotted wall studs, the inadequate support allowed the bearer to rotate downwards and the collapse occurred.

Collapsed corner of the deck is clearly visible in these photographs

Support point for the bearer

Rotted wall studs below the bearer support joint

The ingress of water may have occurred where the bearer itself penetrated the wall cladding and also around the base of a timber veranda post of the main dwelling which was located directly above the location of the bearer. These points of water ingress relied solely upon sealant to prevent penetration of water.

Shrinkage / break-down of the sealant over many years and some shrinkage of timber elements would have occurred allowing water ingress causing the decay to the non-durable pine studs in the enclosed wall.

Gaps around base of veranda post allow water ingress into wall cavity

LESSONS LEARNED

Although not currently required by the Building Code of Australia there are three strategies that can be adopted by contractors and builders that will significantly reduce the risk of future deck and balcony failures;

- All structural framing members and their connections and support points below the floor level of structures such as decks, balconies and patios should be unenclosed and not sheeted to allow full visual inspection of those critical elements.

- When structural framing members and their connections and support points are enclosed and not visible for inspection all framing and connections should be sufficiently durable to accommodate periodic wetting and drying. Alternatively, a method of inspecting the sub-structure to the deck and any building framing to which deck members are connected should be provided.

- No attachments to a dwelling such as patios, decks, balconies or the like should allow structural framing members to penetrate the external fabric of the main building unless the penetrations are flashed and sealed using permanent durable materials to prevent moisture entry.

Additionally contractors should take care to ensure that nail plate connected joists or bearers are not used on external decks or in any location where they are exposed to the effects of weather. This is often contrary to the manufacturer's recommendations that do not recommend the use of nail plates exposed to the weather as they can eventually lose a substantial amount of their nail holding strength as the wetting and drying effects of the weather causes the teeth to gradually withdraw from the timber.

Similarly structural framing members particularly fabricated timber bearers and joists should be of suitable durability if exposed or partly exposed to the weather. Cut ends, joints and notches should be treated strictly in accordance with the manufacturer's recommendations and are particularly vulnerable to degradation if they occur in a weather exposed location. Manufacturer's recommendations may also require a full paint system to be applied to H3 LOSP treated members.

BUILDING INSPECTION

The Ascot and Morayfield collapses make it imperative that building inspectors be particularly diligent when inspecting external decks and balconies.

Any concealed fixing points or areas of concealed framing that are reliant upon sealant to prevent water penetration should receive close attention and may warrant recommending a special purpose inspection report that may include intrusive investigations.

Structural framing members and connections should be inspected and their suitability for external use assessed and reported. Inspections should determine if building movement, weather or other effects have compromised any of the fixing details as occurred in the Ascot residence.

Balcony balustrades and handrails should be carefully inspected to ensure the material used to build them is structurally sound and any joints are rigidly fixed and not deteriorated by weather. In addition to structural adequacey, the balustrade must also be assessed against the dimensional requirements of the Building Code of Australia (heights, gaps etc).

Finally the importance of routine and ongoing maintenance should be impressed upon the current or prospective home owner.

WINDOW & DOOR FIXINGS

The Gap Storms

Following the severe storms that impacted upon The Gap in Brisbane in 2008 inspections by engineers from the James Cook University, Cyclone Testing Station and other regulatory organisations were alarmed to find that window and door frames had blown in as whole units, due to inadequate fixings. This subsequently caused large openings, allowing wind and water inside.

Whole window assembly blown in without breaking the glass

Although the Brisbane storms were severe, the gust wind speeds were only estimated to be about 80% of the design wind speed. What this means is that the actual wind load was a lot less than the design wind loads and so window and door fixings should not have failed.

Further investigation of the 'as installed' details for the failed window and doors revealed that in almost all instances the frames had not been properly fixed. Gaps around the frames were inconsistent ranging from 0 to 30mm, packing was rarely used and nails were typically 50mm in length which was inadequate to extend through the frame, across the often large gap and fix securely into the timber studs.

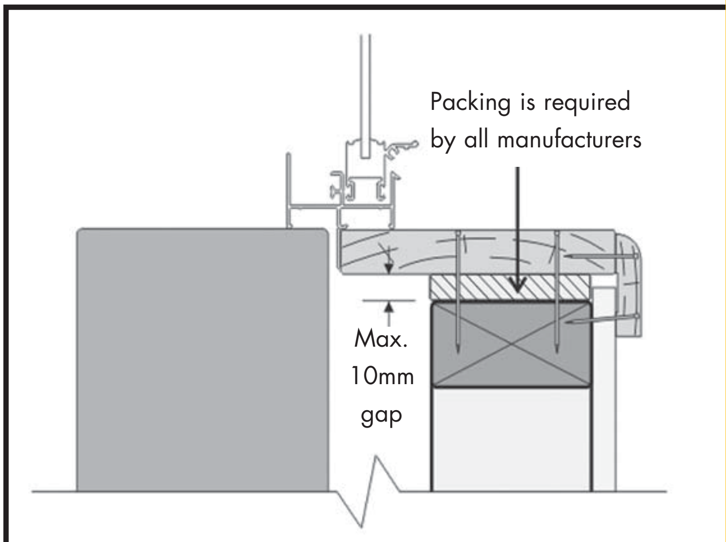
Inadequate fixings - excessive gaps, no packing, nails too short to bridge the gap and securely fix to the frame

Window and Door Fixing Generally

Subsequent site visits by officers of the Cyclone Testing Station to over 300 new houses found a large proportion of windows and doors were not being properly installed. The inadequate fixings were very similar to those identified in The Gap window failures.

Inadequate fixings - excessive gaps, no packing, nails too short to bridge the gap and securely fix to the frame

The window industry requires mandatory packing and a 10mm maximum gap, yet windows are often installed with large gaps and no packing. Nails are often too few, unevenly placed and too short to properly fix the window.



Window packing detail (We gratefully acknowledge the Australian Window Association for use of drawing above)

RECOMMENDED FIXING METHODS

The Building Code of Australia (BCA) references Australian Standard AS 2047 1999 Windows in Building – Selection and installation. In relation to fixing of windows this standard provides that;

- Openings in which windows are to be installed shall be of sufficient size to allow the window to be installed level and plumb,
- Windows shall only be installed in locations for which they are designed,
- Windows assemblies shall be fixed using recognised building practices,
- Fixings shall not deform the window assembly,
- Non-load bearing window assemblies shall not carry building loads, and
- Windows shall prevent water penetration and excessive air infiltration

The Standard also notes that "window manufacturer's installation procedures may need to be followed for particular installations"

A number of other standards are also referenced in the BCA that are relevant to the fixing of windows and doors, namely AS 1170 2002 Wind actions, AS 1684 2006 Residential timber–framed construction, AS 1720 1997 Timber Structures and AS 4055 2006 Wind loads for housing.

The Australian Window Association (AWA) is a cooperative of window manufacturers and suppliers and provides a number of additional recommendations in relation to window and door installation;

- Clearance dimensions vary between manufacturers
- Frame must be packed plumb and square and not twisted
- Aluminium windows should be secured by nailing through the reveal in brick veneer applications
- Nails fixing reveals to the timber frame should be evenly spaced
- In cavity brick installations galvanised building lugs located at 450mm maximum centres should be used
- Sill bricks should be at least 10mm clear of the window frame to allow for settlement
- The sill should be fully supported.

Neither the Building Code of Australia nor the AWA specify particular nail sizes and spacings as these may vary dependant primarily upon the size of the window or door being installed and the location of the site. Accordingly it is important all contractors obtain advice from their window supplier or engineer particular to their installations and the location of their site to determine appropriate nail sizes and spacings.

SUMMARY

This publication aims at increasing your awareness of some of the risks associated with the construction, maintenance and inspection of timber decks and balconies and in doing so hopes to minimise the likelihood of future balcony and deck collapses occurring.

Recent severe storms have highlighted that fixing of windows and doors particularly in brick veneer construction is an area where current work practices are often defective. This is an aspect of construction that will receive greater scrutiny by the BSA in future months and it is hoped that raising awareness of the issue will decrease the instances of defective work and minimise damage when future high wind events occur.

REFERENCES

- Building Code of Australia 2009
- AS 2047 1999 Windows in Building - selection and installation
- Australian Window Association - An Industry Guide to the Correct Installation of Windows and Doors
- Brisbane Coroner Preliminary Report in relation to the Ascot collapse

ACKNOWLEDGEMENTS

- Australian Window Association - www.awa.org.au
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For more tools

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