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Wind Resistance of External Overhead Roller and Sectional Doors

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1. Introduction

Another category which suffered badly was that of large roller shutter doors.

JCU Report on Cyclone Althea, 1972 [1]

In general, roller doors to all classes of buildings performed poorly.

CTS Report on Tropical Cyclone Larry, 2006 [2]

Cyclone Althea and Cyclone Larry were 34 years apart, yet the observed behaviour of roller doors was similar. In between, other tropical cyclones that impacted populated areas of Australia caused similar damage, as had Cyclone Ada two years before Cyclone Althea.

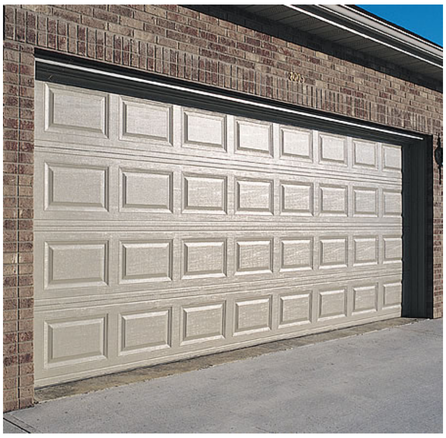
After the impact of Cyclone Tracy on Darwin in 1974 had revealed fundamental weaknesses in Australian buildings in respect of wind resistance, there was a major overhaul of the wind design of all types of buildings in Australia, including housing. In Darwin most of these improvements in wind design were implemented within a year of Cyclone Tracy occurring, in Queensland they were implemented in the early 1980's and by the early 1990's they had been implemented in most of Australia. When Cyclone Larry hit the Innisfail region in 2006 the general performance of most buildings reflected these changes [2]. One exception was the performance of overhead roller and sectional doors. Many modern buildings suffered much greater damage, to structure or contents, than they would have done if the overhead roller and sectional doors had been as wind resistant as the remainder of the buildings.

If another major tropical cyclone hits a coastal populated area of Australia it can be confidently predicted that, with the possible exception of the Northern Territory, there will be similar reports of the performance of this class of doors unless some action is taken. Why is this so? Can anything be done about it? These are the two main questions this Information Bulletin tries to answer.

2. Scope and Definitions

The type of doors addressed in this report are those described generically as rolling curtain doors, rolling shutter doors and sectional overhead doors in AS/NZS 4505:1998 [3]. This report will also consider curtain doors that are not wound onto a roller, since these are expected to perform similarly to a curtain roller door with respect to wind loading.

The most common use of these types of doors in residential buildings is for garage doors, but they are also widely used in commercial and industrial buildings where large doors are required for access, often by vehicles, for delivery and despatch of goods and equipment. They are usually found on the external walls of buildings. While they can also be used internally in some buildings, this report only considers external applications such as those shown in Figure 1 below.



(a) Sectional Door

(b) Roller Door

Figure 1 – Typical doors considered in this report

A characteristic feature of overhead roller and sectional doors is that the vertical edges of the door slide in guides fixed to the building. The mechanisms are generally fitted with a spring or other device which partly counteracts the weight of the door to reduce the force needed to open the door and to hold it place when it is open. The doors may be opened manually or by using an electrically driven mechanism.

Tilting doors, hinge-mounted doors, folding doors and sliding doors such as those shown below are outside the scope of this report, even though they use the same design principles with respect to wind loading.

(a) Tilting Door

(b) Hinged Door

(b) Sliding Door

(d) Folding Door

Figure 2 – Doors outside the scope of this report

3. Wind Problems

Although different in their design principles and mechanism of operation, overhead roller doors and sectional doors resist wind in a similar manner. Both can have similar modes of failure under wind loads, as discussed below. Sectional doors, however, often have greater out-of-plane stiffness and are more likely to resist wind loads in bending, while roller doors and other curtain-type doors have lower stiffness and may rely largely on membrane action for wind resistance.

Wind forces are applied to the doors in the form of wind pressures on both the outer and inner surfaces of the doors. These combined wind pressures may be positive or negative (suction) depending on the wind direction and geometry of the building. External pressures will be positive on windward wall doors, and negative on doors on leeward and side walls. Internal pressures may be positive or negative depending of the relative size and location of any wall or roof openings relative to the wind direction.

In cyclonic areas, similar wind forces can arise from a combination of positive external pressures and negative internal pressures, or negative external and positive internal pressures, so it is usually necessary to evaluate door performance in both directions. Even in non-cyclonic areas, there is not a great difference between the highest combination of external and internal pressures in each direction, so once again the ability of the door system to resist wind loading may need to be evaluated in both directions.

The four principal modes of failure of overhead roller and sectional doors are:

i) Dislodgement of door from guides;

ii) Bending failure of door itself;

iii) Guide failures including failure of any wind lock mechanisms or failure of the attachment to the door frame;

iv) Failure of the door frame under the wind loads transferred from the door.

3.1 Dislodgement From Guides

This is the most frequent cause of failure of roller doors due to their out-of-plane flexibility (see Figure 3). These doors generally deflect a large amount before they fail, resisting the wind forces by a combination of horizontal bending and membrane action. These deflections can cause an effective shortening of the door span, which can in turn result in the doors disengaging from their side supports with the result that the doors are blown in or out. This mode of failure can be resisted by adequate door stiffness, by the provision of what are known as wind locks, which restrain the sides of the door in the guides, or by the use of sufficiently large guides. Wind locks are a common form of solution as they increase the proportion of the load transferred by membrane action, potentially resulting in lower costs.

Sectional doors can also fail by this mechanism depending upon their out-of-plane stiffness and the design of their guides.

3.2 Door Bending Failure

If the doors have deeper profiles and therefore higher out-of-plane stiffness, any shortening of the span due to wind loading is less likely to occur, thus reducing the susceptibility to failure by dislodgement from the guides. In this case most of the load transfer will be by bending.

In these cases the door is normally designed with sufficient bending strength to resist the estimated pressures under extreme wind loads. This could mean that little consideration has been given to membrane forces occurring in the door system. If the door does fail in bending, it may then be dislodged from the guides due to the large deflections following failure. Adequate wind locks may provide a mechanism to ensure that the door stays in place if bending failure occurs, but once a bending failure occurs the door is likely to be inoperable until failed sections are repaired.

3.3 Guide or Fastener Failure

Another common reported mode of failure of roller and sectional doors is the guides failing, usually by separating from the door frame to which they are attached. The guides are usually attached to the door frame with metal fasteners of one form or another. A door can produce two types of reaction forces on the guides; transverse forces directly proportional to the wind force, and indirect in-plane tension forces arising from the membrane action if wind locks are used to restrain the deflection of the door (see Figure 3 below). These forces in turn are transferred to the door frame by the fasteners or other fixing methods and these must be adequate to resist the relevant transverse and in-plane forces.

Figure 3 – The door will try to pull away from the guides as shown under wind loading. If the guides offer some form of restraint, the door may resist the wind forces by membrane action. In this case the forces in the plane of the door (shown here as black arrows) can be extremely high. These forces must be accounted for in design, or failure can occur in the guides, the fasteners or the surrounding structural frame of the building.

Most failures of this type arise from either inadequate fastenings having been used to resist the estimated transverse wind loads on the door, or because the membrane reactions have either not been taken into account or have been underestimated. In the latter case failure can occur in the fastener, the guide or the door frame.

Guides can also fail themselves by deforming so much, either elastically or plastically, that the door is no longer restrained. To avoid this, material thickness, strength and cross-sectional shape of the guides must be adequate to ensure that the guide can transfer any transverse bending forces and membrane forces to the door frame.

3.4 Door Frame Failure

If the door frame is an integral part of the building structure then this form of failure is unlikely, providing that the building structure has been designed for wind, and the wind speeds experienced do not exceed the design wind speed. A problem can arise if the door frame is not an integral part of the building structure and it has not been adequately designed to resist the anticipated wind forces.

Possible modes of failure are either in bending in a direction transverse to the plane of the door, bending in the plane of the door under the membrane forces if wind locks are used, or dislodgement of the door frame from the building structure due to connection failures.

4. Standards and Regulations

The Australian Standard directly relevant to the wind strength of overhead roller and sectional doors for residential applications is AS/NZS 4505:1998 – Domestic garage doors [3]. This Standard in turn refers to AS/NZS 4504.2:1998 – Domestic garage doors – method of test [4]. This latter Standard provides a standard test procedure for determining the wind resistance of domestic garage doors, including overhead roller and sectional doors. These documents have existed for over 10 years and offer guidance on methods to be used to evaluate the performance of doors.

AS/NZS 4505:1998 [3] also includes an informative appendix with an example of a label that could be used on the garage door or its packaging to demonstrate compliance with the Standard. An informative appendix is not a mandatory part of the Standard and therefore it is possible to claim compliance with the Standard without using such a label. However, the proposed label would appear to be useful to provide all parties, including specifiers, designers, builders, regulators and home owners with confidence that a door is fit for purpose with respect to performance in a wind event.

There does not appear to be a comparable Australian Standard for commercial and industrial overhead roller and sectional doors. These doors still need to be evaluated for compliance with regulatory requirements. There is no reason, in principle, that the methods included in AS/NZS 4505:1998 [3] and AS/NZS 4504.2:1998 [4] should not be used for this purpose. Unfortunately, however, wind pressures derived from AS/NZS 4505 are lower than those obtained from either AS 4055:2006 [5] or AS/NZS 1170.2:2002 [6]. This would result in any door designed in accordance with AS/NZS 4505:1998 [3] failing at a lower pressure than the remainder of the building envelope.

The Cyclone Testing Station has written to Standards Australia to express concern about this inconsistency. Standards Australia have in turn written to members of the three relevant committees and it is understood that they agree with CTS's view that AS/NZS 4505 needs to be amended to be consistent with other Standards. At the time of writing a proposal has been submitted to amend AS/NZS 4505 such that it is consistent with both AS 4055 and AS/NZS 1170.2, thereby introducing the possibility that AS/NZS 4505 could apply to external overhead roller and sectional doors in any type of building. In the interim, the Cyclone Testing Station has advised the industry to derive design and test pressures for all doors from AS/NZS 1170.2.

The Building Code of Australia [7] makes no specific reference to overhead roller and sectional doors but it does require all aspects of a building to be designed for the specified wind loads, and this requirement is adopted by all the States and Territories. Given that they are not specifically excluded, this also applies to overhead roller and sectional doors.

In 2005 the Northern Territory Building Advisory Committee adopted a specific policy indicating that roller doors and 'the like' 'are required to be adequate for the design wind loads applicable to the building or structure in which the roller door is installed'. An exception to this policy is granted to doors used at ground level in houses, flats and associated outbuildings which are required to be designed to resist a lateral pressure of 1.8 kPa. While this is far more explicit than requirements in other states, the cladding and structure adjacent to the door may be subject to pressures greater than 1.8 kPa. Furthermore, the surrounding cladding and structure must also be evaluated using a cyclic regime, whereas the NT door requirement is a static pressure.

Therefore, while a specific door requirement is commendable, it should be noted that a door evaluated in this way may still fail at less than the design wind pressure for the building.

5. Common Current Practice

A perusal of the web sites of manufacturers and suppliers of overhead roller and sectional doors offers limited information in regard to the wind resistance of the doors they manufacture and sell, even in cyclone-prone regions. An exception to this is for doors intended for use in Darwin, with at least one manufacturer having a specific model designed to meet the wind code requirements as specified by the Northern Territory Building Advisory Committee, and other manufacturers indicating they could supply such doors.

Apart from this the best has a table of design wind speeds, which decrease with span, for their standard model, plus information that door locks, which they claim are cyclone-rated, can be fitted as an optional extra. At least one supplier provides no information at all on wind resistance, while another claims their doors have been tested to ‘typhoon pressures’ but gives no other information. None of the product brochures reviewed or web sites visited make any direct reference to the tests for wind resistance specified in AS/NZS 4505:1998 [3] or AS/NZS 4504.2:1998 [4].

This lack of specific reference to wind resistance ratings raises concern that (apart from perhaps NT), unless specifically requested, overhead roller and panel doors as generally supplied may not be wind rated. Similar designs appear to be often marketed all over Australia, irrespective of the design wind speed for the building or structure in which they are to incorporated. In cyclone areas and other high wind areas wind locks may be provided as an optional extra, to improve their wind resistance. In some cases these wind locks are claimed to be wind rated in accordance with the relevant Standard, but it is not clear whether this refers just to the wind lock, or to the whole system including the connections to the door frame.

This suggests that there is a significant risk of roller and panel doors or the surrounding structural frame of the building failing in wind events which are less than the design wind event that should apply to the building in accordance with building regulations.

6. Comparison With Current US Practice

Like Cyclone Tracy in Australia, Hurricane Andrew in 1991 had a major impact on wind resistant building design in the US, particularly residential buildings. Based on the major damage that occurred in each event, Australia concentrated on ensuring the integrity of roof systems, while the US has concentrated on ensuring the integrity of the wall systems.

One consequence of the US approach is the following two related standards:

- ASTM E1889-05 – Standard test method for the performance of exterior windows, curtain walls, doors, and impact protective systems impacted by missiles and exposed to cyclic pressure differentials [8].

- ASTM E1996-09 – Standard specification for the performance of exterior windows, curtain walls, doors, and impact protective systems impacted by windborne debris in hurricanes [9].

The first of these describes the test methods and the second is concerned with the test criteria. The testing requirements were first incorporated in the US International Building Code in 2006 and are now incorporated in the building codes used by most states and municipalities in hurricane prone areas. There is also a static pressure differential test which is commonly specified in non-hurricane regions.

The testing procedure, which is designed to evaluate the complete system including the supporting frame and connections, has been widely used by overhead roller and sectional door manufacturers to obtain approval for their products to be used in hurricane areas. The tests for the hurricane areas require a combination of missile impact, fatigue tests and static tests. It should be noted that all wall and door systems to be used in hurricane-prone areas have to meet this criteria, with no relaxation of the debris impact criteria if buildings are designed for full internal pressurisation. A number of commercial testing laboratories have built facilities to enable them to undertake these tests.

7. Issues

The disconnect between the regulations in the Building Code of Australia and practice in all parts Australia (other than perhaps the Northern Territory) in regard to the wind design of overhead roller and sectional doors raises a number of issues.

First and foremost is why this has happened. Australian wind engineers are very proud of the way that the Australian building industry has responded to the need for greater reliability in the wind resistance of buildings following the destruction caused by Cyclone Tracy. The continued use of overhead roller and sectional doors which may not meet the Building Code of Australia's requirements is a black spot on this otherwise excellent record. The reasons for it are not very clear. There have been a number of suggested reasons put forward.

- One common suggestion is that manufacturers and building certifiers have assumed that because the Building Code of Australia [7] does not specifically mention overhead roller and sectional doors then its requirements do not apply to them. It is further suggested that this is the reason the Building Code of Australia does not call up AS/NZ 4505:1998 [3]. However there is nothing in the Building Code of Australia [7] to suggest that anything not specifically mentioned is excluded from its requirements. It is quite the reverse. Everything is covered unless specifically excluded. However it is very probable that the Northern Territory published its policy note to counteract this suggestion.

- Another suggested reason is that since the Building Code of Australia's [7] requirements are only concerned with human safety they are only applicable to the occupied part of buildings, and providing the occupied space is sealed off from the space at risk from a door failure, and the roof is designed for the resulting internal pressure, then it is acceptable for the door to fail under wind loads. Again this is based on a misconception about the role of building codes. Human safety is definitely the first priority, but health and amenity are also key goals of the Building Code of Australia [7]. Failure of overhead roller and sectional doors may not appear to pose a significant risk to human safety in general, unless of course they are dislodged from their supporting structure and become flying debris. Flying debris such as a failed door is a safety hazard and even a door that is not totally dislodged can lead to further structural damage on the building as it flaps in the breeze. This secondary damage is a key reason for ensuring that the door remains intact, even though the building may be designed for full internal pressurisation. Failed doors can also result in a significant loss of amenity, particularly if this leads to significant water ingress, for example. The Building Code of Australia [7] does allow failure of the outer envelope including windows and doors, by debris impact if the building is designed for full internal pressures, but still requires the wall system, including the windows and doors, to be designed for the design wind pressures. This recognises that debris damage is rare except in very extreme events, and if all elements are designed for wind, the probability of failure in all but the most severe events is small.

- It has also been suggested that although required by a strict interpretation of the Building Code of Australia [7], the complexity of the structural analysis due to the large deflections and the combined bending and membrane action, and a possible lack of suitable testing facilities to justify wind ratings by testing, has been accepted as a valid reason by certifiers for not providing wind rated doors. However the fact that the industry can supply doors in Darwin which meet the wind loading criteria, and that in the US the overhead roller and sectional door manufacturers are meeting much more stringent wind resistance requirements than those required by the Building Code of Australia [7] makes this argument unsupportable. Facilities do exist in Australia for testing and/or modelling door performance.

In reality the reason can probably be more easily explained by human behavioural science than by technical reasoning. It is probable that when the regulations were first introduced the industry was not in a position to meet them and certifiers were somewhat lenient towards them assuming that the position would be corrected with time. However it would seem that without any real effort being made by anyone to enforce the regulations, apart from in the Northern Territory, nothing has changed.

"If everybody else is permitting it why should I not allow it" has probably been the attitude of the certifiers.

"If certifiers allow it, why should I supply only wind rated doors and put myself at a competitive disadvantage" has probably been the attitude of the suppliers.

"I can supply wind rated doors if requested but why should I make an issue of it in my promotional literature if it is not a concern of buyers" has probably been the attitude of the manufacturers.

If this anomaly in the wind resistant design of buildings in Australia is to be corrected it will be necessary to change these attitudes.

Of course it could be argued that the present requirements of the Building Code of Australia are too stringent, and that even after considering the risk of economic loss and loss of amenity, there is a case for changing the requirements of the Building Code of Australia requirements based on a sustainability analysis of lifetime costs and benefits. However the likelihood of such an argument being successful for buildings in general seems small and this should not be an excuse for ignoring the current requirements, particularly in cyclone regions where the community wide consequences of extensive failures of such doors can have significant social and economic consequences. Even if there was a case to suggest that current requirements are too stringent, this would not explain why doors should be treated differently to the surrounding elements of the building.

7.1 Cyclonic vs Non-Cyclonic Areas

While much of the focus tends to be on the consequences for buildings in cyclone regions, the lack of wind rating can be even more serious in non-cyclone regions. The reason for this is that in cyclone regions C and D, as defined in AS/NZS 1170.2:2002 [6], unless all elements of the building, including doors and windows, have been evaluated for impact resistance, then the building must be designed to allow for full internal pressures. In such cases if a door fails, it should not lead to overall structural failure of the building, even though there may be significant damage to contents.

In regions A and B however, there is not a requirement to design the building for full internal pressures in such cases. The argument for this is that because the design wind speeds are significantly lower, the level of wind borne debris will be much lower, so that there will only be a small risk of the building envelope, including doors and windows, being punctured by debris. Since these elements are designed for wind pressures, the risk of a dominant opening arising from wind damage is very small. If, however, the overhead doors are not designed for wind, they pose a significant risk of a dominant opening arising. If this occurs then there is a very significant risk of failure of the overall structure due to the resulting internal pressure which has not been considered in the design of the building. This is borne out by the relatively frequent reports of relatively new buildings failing in thunderstorm winds in non-cyclone regions, usually as a consequence of door failures. If an argument justifying the use of doors which do not comply with the wind code requirements could be maintained in non-cyclone regions, then it is likely it would need to be accompanied by a requirement that buildings using them would need to be designed for full internal pressures.

8. Implications of Current Situation

Whatever the reasons for the present situation, it exists and needs to taken into account by all the key stakeholders including property owners and occupiers, builders, certifiers, manufacturers and insurers.

8.1 Owners and Occupiers

It is very important that owners and occupiers recognise that any overhead roller and sectional doors they have in their building may have significantly less resistance to wind than the rest of the building. Indeed there is a high probability that this will be the case. This may be the case even if they have purchased or had constructed a house or other building with a specified wind rating.

A first step in addressing the issue would be to determine the make and model of individual doors and inquire from the supplier of such doors whether they are wind rated and what the rating is. Any such rating can then be compared with the wind rating of the building. If the door is not wind rated this means that if there is an extreme wind warning, the owner or occupier may need to consider what is at risk if the door fails, and whether they should take precautions to reduce the loss risk by relocating contents or strengthening the door. In regard to strengthening, there are some relatively simple things that can be done. Some of these are the outlined in a later section.

If purchasing a new building then potential owners should ask specific questions about the wind rating of any proposed overhead roller and sectional doors and whether they comply with the requirements of the Building Code of Australia [5] in respect of wind resistance. The public needs to be aware of the issue and demand compliant doors.

8.2 Builders

Builders need to be aware of the situation for two reasons.

- They need to be aware that if a door does not have a wind rating, or has a wind rating less than that required by the Building Code of Australia [7], they will not be complying with the building regulations and hence be putting themselves at risk from legal liability.
- If they are providing a building to meet a specified wind rating and the door does not meet this specification, they need to ensure that the owner is formally advised of this. Otherwise they put themselves at risk of being sued for damages in the event of failure of the door in a severe wind event, which may cause losses to the owner or occupier.

It would seem to be incumbent on builders to advise potential building owners of the situation and to provide quotations for wind rated doors meeting the specified wind rating for the building, as well as warning them of the possible consequences of using a non-wind rated door.

8.3 Certifiers

It is not clear why certifiers permit major elements of the external envelope of a building that do not comply with the building regulations. In doing this, they must significantly increase their liability risk.

It would seem to be a relatively simple task to require the manufacturers to supply a certificate of compliance for each of their standard models, which would include the certified wind rating and which seems to be the practice in the US. In many ways the certifiers seem to have the most to lose from a major incident arising from the present practice and are in the best position to take action. This would quickly remove the anomaly in regard to future construction in a way that would ensure a level playing field for all participants.

There are existing Standards that adequately describe the testing requirements for residential doors. Having said this, Standards Australia are currently addressing a concern about the reduced wind pressures obtained from AS/NZS 4505 [3] when compared to those obtained from AS 4055 or AS/NZS 1170.2 [6]. A test certificate indicating that doors are capable of resisting the relevant wind pressures derived from AS/NZS 1170.2 [6] would alleviate this problem immediately.

8.4 Manufacturers

It would seem to be a responsible action for the manufacturers to rate their doors in terms of design wind speed or the wind rating, and to publish this in their technical product information. It is acknowledged that this will involve some design and testing costs that may have to be passed on. However this is not an issue of the impact of new regulation. Rather, it is an issue of ensuring compliance with both existing regulations and consumer expectations.

In a modern developed country like Australia, the community should be able to take it for granted that the products they purchase have been properly tested for compliance with the regulations. This may introduce some short-term challenges but should also create an incentive to invest in the development, production and testing of new or enhanced models which meet the regulations.

A number of the manufactures are international companies and are probably already supplying doors to the US market which meet their more stringent requirements. They should be able to capitalise on this experience.

It is important to also acknowledge that some existing products may meet current regulatory requirements. Those manufacturers and suppliers who already have compliant products should be supportive of any initiative to ensure compliance across the industry. As discussed above, it may be prudent to design and test to wind pressures derived from AS/NZS 1170.2 [6] until there is resolution on variations in wind pressures from different Standards.

8.5 Insurers

Most of the losses arising from the failure of overhead roller and sectional doors in strong winds are paid for by the insurance industry. The cost to the insurance industry in meeting the claims arising from these losses is reflected in the insurance premiums. Buildings designed to meet the building regulations should attract much lower premiums than those which are less wind resistant. Ever since the building regulations were dramatically revised in response to the damage from Cyclone Tracy, there have been demands on the insurance industry for reduced premiums for newer buildings built to comply with regulations. There have been some moves in this direction but unfortunately the continued losses attributed to newer buildings apparently built to comply have meant that the reductions have not been as great as might have been expected. One cause of these continuing losses in newer construction has been overhead roller and sectional door failures.

The insurance industry could make a significant contribution towards decreasing the relative level of these losses over time by either offering significant reductions in premiums for buildings for which a certificate of compliance with the relevant wind code requirements is provided, including the compliance of any overhead roller and sectional doors, or by making the premium for those complying the standard rate, and having a loading for those which don't comply. Although the numbers may be the same there seems to be a stronger negative attitude to loadings than positive attitude to discounts!

9. Upgrading Existing Installations

There are measures that can be taken to reduce this risk when extreme winds are forecast, whether in a cyclone-prone region or not. General literature is currently available [10] on the CTS web site at www.jcu.edu.au/cts and also on the web sites of the Queensland, Northern Territory and Western Australian Governments to help home owners and others to prepare for cyclones and other high wind events.

9.1 Residential Doors

The most common use of overhead roller and sectional doors in residential buildings is as garage doors. The height of these rarely exceeds 3 m, although they may be much wider. The strength of these doors can be greatly enhanced by temporarily placing one or more timber, aluminium or steel stanchions against the inside of the door and holding them in place in some way during the period of strong winds. For sectional doors the stanchions can be held in place by brackets temporarily bolted to the floor and to the top of the door frame. For roller doors it is not possible to fix them to the top of the door frame because of the roller. One simple solution that has been used is to back vehicles into them, although this does little to prevent a door failing outward. An alternative would be to fix the top of the stanchion to a temporary horizontal beam attached to the side of the door frames and wedged under the roller so that it is restrained by the roller as well.

A slightly more complex but better solution is one where the door is attached to such a stanchion at several points. This has the advantage of protecting the door from blowing in or out. It also means that the stanchion could be located on the outside of the door if necessary, to avoid the roller on the inside.

Figure 4, Diagram of temporary brace as discussed above. This is a proprietary version marketed by Secure Door® in Florida. It has been tested for compliance with relevant regulations.

It should be possible to produce some standard solutions for common door geometries which could be included in disaster preparedness leaflets and publications.

It is also possible that manufacturers could include such temporary strengthening as an integral part of their individual door assemblies. If designed to meet the regulatory requirements and sold on the condition that they are installed when severe wind warnings are issued, and when occupants are away for extended periods of time, this could be an alternative solution to the doors being designed to meet the wind requirements without such support. Manufacturing such systems for existing doors might also be commercially viable.

It is known that at least one such system is commercially available in USA but it is not known whether any such system is available in Australia.

9.2 Commercial and Industrial Doors

Because commercial and industrial doors are often much wider and higher than those used for residential garage doors and are often customised to the particular geometry, simple standard solutions may not be practical. However it should be possible to use the same approach as suggested for residential doors using customised solutions developed by a structural engineer.

Again there may be scope for manufacturers to produce such systems as a solution to the wind problem under similar conditions of use to those outlined for residential doors.

10. Conclusion

Overhead roller and sectional doors should be designed to resist the same wind forces as the surrounding structure and cladding, whether they are used in residential, commercial or industrial buildings.

Standards exist that include test methods for residential doors, but there is little evidence to show that many current doors comply. Investigations following high wind events suggest that many may not. While the Standards are not directly referenced within the Building Code of Australia [7], a failure to demonstrate compliance with the appropriate wind loading requirements would be deemed as non-compliance with regulatory requirements.

There is currently no Standard that provides test methods for commercial or industrial doors and it is therefore left to the supplier to determine how to demonstrate that these doors meet regulatory requirements with respect to wind loading. It is suggested here that the same Standards that apply to residential doors (ie AS/NZS 4505:1998 [3] and AS/NZS 4504.2:1998 [4]) could equally apply to commercial and industrial doors for the establishment of test methods.

It is strongly recommended that test pressures for all doors are established using AS/NZS 1170.2 at present, [6] as the pressures derived from AS/NZS 4505 [3] are considered to be incorrect and are currently under review.

When a door fails in bending it can be dislodged from the guides. If a device such as a wind lock has been included to restrain the door in the guides, this can then result in high in-plane forces. If not allowed for in design, these high forces may fail the guides, wind locks or connections to the structural frame of the building. All of these elements should therefore be included in any testing program, not just the door itself. Doors should also be evaluated in both directions, as the combined external and internal pressures are of a similar magnitude in both directions. That is, a door can be either blown in or blown out.

There are many reasons why it is important that doors do not fail. In non-cyclonic areas any such failure can pressurise the building and lead to other structural failure such as failure of the roofing system. In cyclonic areas this internal pressure may already be allowed for but door failure can either result in further damage from the flapping door or the door itself can become a danger to life and property if it fully disengages. Another key issue from a door failure is water ingress that can lead to loss of amenity or damage to contents.

It is recommended that once tested, the performance of a door is identified on either the door itself or the packaging, as proposed in Appendix B of AS/NZS 4505:1998 [3].

11. References

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[2] Cyclone Testing Station Technical Report No 51 "*Tropical Cyclone Larry - Damage to buildings in the Innisfail area*", www.jcu.edu.au/cts or www.abcb.gov.au.

[3] Australian/New Zealand Standard AS/NZS 4505:1998 "*Domestic garage doors*" Standards Australia/Standards New Zealand, 1998.

[4] Australian/New Zealand Standard AS/NZS 4504.2:1998 "*Domestic garage doors – Methods of test Method 2: Wind pressure test*" Standards Australia/Standards New Zealand, 1998.

[5] AS/NZS 1170.2:2002 "*Structural design actions – Part 2: Wind actions",* Standards Australia/Standards New Zealand, 2002.

[6] AS 4055:2006 "*Wind loads for housing"*, Standards Australia, 2006.[7] Building Code of Australia, Volumes 1 and 2, Australian Building Codes Board, 2009

[8] ASTM E1889-05 – "*Standard test method for the performance of exterior windows, curtain walls, doors, and impact protective systems impacted by missiles and exposed to cyclic pressure differentials*".

[9] ASTM E1996-09 – "*Standard specification for the performance of exterior windows, curtain walls, doors, and impact protective systems impacted by windborne debris in hurricanes*".

[10] www.jcu.edu.au/cts *"Is your House Prepared for a Cyclone? Advice for the Homeowner",* Pamphlet prepared by Cyclone Testing Station with support from Queensland, Northern Territory and Western Australian Governments – also available via relevant State Government web sites.