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ASESSMENT OF CORRIDOR, DOOR & STAIR WIDTHS IN PATHS OF EGRESS

Fire and Security Consulting Services (FSCS) is frequently asked about the BCA requirements for corridor, doorway and stair widths and whether there is any relief available in a fire engineering process.

An assessment may be required to justify reduced widths in existing buildings or to rationalise building dimensions in structures such as sports stadia or theatres.

Corridors and Doorways

Part D1.6 of the BCA requires buildings to have certain minimum widths of corridors and doors forming a path of travel to an exit so that occupants can evacuate the building within a reasonable time and not undergo undue queuing and crowding. They are 1.0m for corridors and 0.75m for doorways.

Analysis of movement in corridors can be found in “Emergency Movement”, by Harold E. “Bud” Nelson and Frederick W. Mowrer in the SFPE Handbook of Fire Protection Engineering (Third Edition) [1].

Nelson (et al) consider that the Effective Width must take into account obstructions and the natural tendency for evacuating persons to seek clearance between walls and their person.

Persons moving through the exit routes of a building maintain a boundary layer clearance from walls and other stationary obstacles they pass. This clearance is needed to accommodate lateral body sway and assure balance.

Discussion of this crowd movement phenomenon is found in the works of Fruin [2], Pauls [3] and Habicht and Braaksma [4]. The useful (effective) width of an exit path is the clear width of the path less the width of the boundary layers. Figure 1 depicts effective width and boundary layer. The effective width of any portion of an exit route is the clear width of that portion of an exit route less the sum of the boundary layers.

Clear width is measured

1. From wall to wall in corridors or hallways;
2. As the width of the treads in stairways;
3. As the actual corridor width of a door in its open position;
4. As the space between the seats along the aisles of assembly arrangement;
5. As the space between the most intruding portions of the seats (when unoccupied) in a row of seats in an assembly arrangement;

The intrusion of handrails is considered by comparing the effective width without the handrails and the effective width using a clear width from the edge of the handrail. The smaller of the two effective widths then applies.

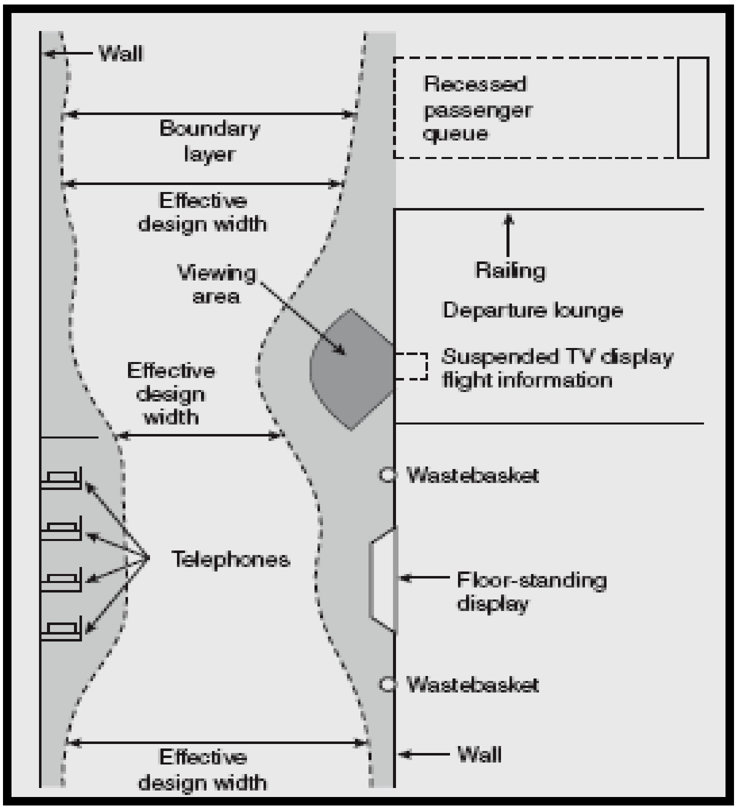

Figure 1 – Boundary Layers

Nelson has researched various boundary layers and Figure 2 provides the results.

Exit Route Element	Boundary Layer (in.)	(cm)
Stairways—wall or side of tread	6	15
Railings, handrails[a]	3.5	9
Theater chairs, stadium benches	0	0
Corridor, ramp walls	8	20
Obstacles	4	10
Wide concourses, passageways	<18	46
Door, archways	6	15

[a]Where handrails are present, use the value if it results in a lesser effective width.

Figure 2 – Boundary Layers

This research concluded that persons moving through corridors or doorways would try to maintain the boundary layers nominated in Figure 2. Note that in corridors, the boundary layer is greater (20cm) that in a doorway (15cm) or stair (15cm). It is understood that this is because the walking speed along a corridor (~1.0 to 1.2m/s) is considered to be twice the speed of ascending or descending a stair or passing through a doorway (~0.5m/s). Faster walking speeds result in a swinging gait requiring greater boundary layers as evidenced by the wide concourse boundary layer of 46cm.

Consequently an assessment by a Fire Engineer can justify reduced width of corridors and/or doorways and that the reduced will not unduly compromise evacuation of the building and will provide equivalent egress to a DtS (Deemed to Satisfy) building under the allowable BCA Volume 2 Clause 1.0.9 “expert judgement” provisions.

Generally the justification of reduced widths will be based on the premise that neither a 1.0m wide corridor nor a 0.75m wide doorway will accommodate more than one person across its width because the width of a 50% percentile Caucasian man carrying a bag is 635mm as shown in Figure 3 below.

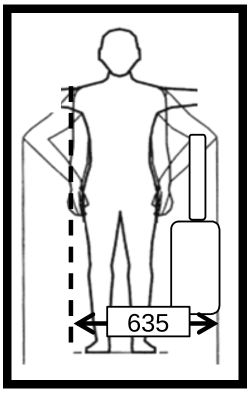

Figure 3 – Width of Person

Stairs

The BCA requirement for stairs in Parts D1.6 and D2.9. In brief, these contemplate either minimum widths of 1.0 or 2.0m (dependant on population) and then pro-rata increases in width.

It is this minimum width and pro-rata calculation that FSCS finds flawed.

When persons ascend or descend stairs as shown in Figure 4 below, a natural gait occurs where a person will occupy two steps and will maintain a clear step in front, thus occupying three steps. Therefore with an average "going" of 350mm (from BCA Table D2.13), the space occupied by a person will be 1,050mm in length.

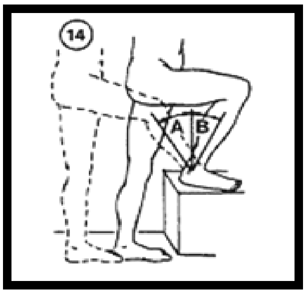

Figure 4 – Stair Gait

When assessing the capacity of a stair and based on the above, a person will try to maintain a 150mm (15cm) boundary layer either side. Therefore the occupied width will be 935mm. However a common 150mm between persons can be said to be sufficient and therefore Figure 5 below shows the space required for two persons at 1,720mm and Figure 6 shows the space required for three persons at 2,505mm.

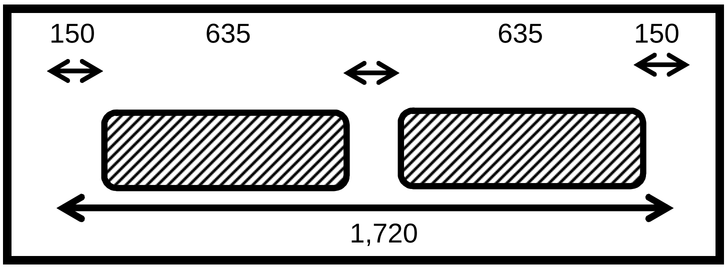

Figure 5 – 2 Persons Width

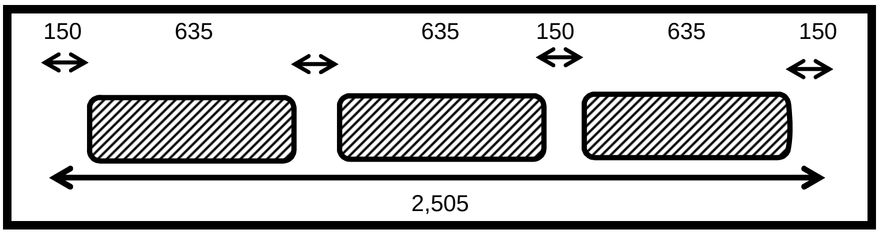

Figure 6– 3 Persons Width

With the side boundary layer addressed, a 2.0m wide stair can accommodate two persons side by side but a 1.5m wide stair can only accommodate one person in the width.

With both the gait and boundary layer addressed, a 2.0m wide stair can accommodate 6 persons within a 2.8m long stair as shown in Figure 7. It would be natural to assume that a 1.5m wide stair could only accommodate 3 persons in the same stair length but because persons are naturally averse to walking directly behind another, they will naturally move to one side. This allows them to walk closer behind as shown and therefore a 1.5m wide stair can accommodate 4 persons in a 2.8m length of stair.

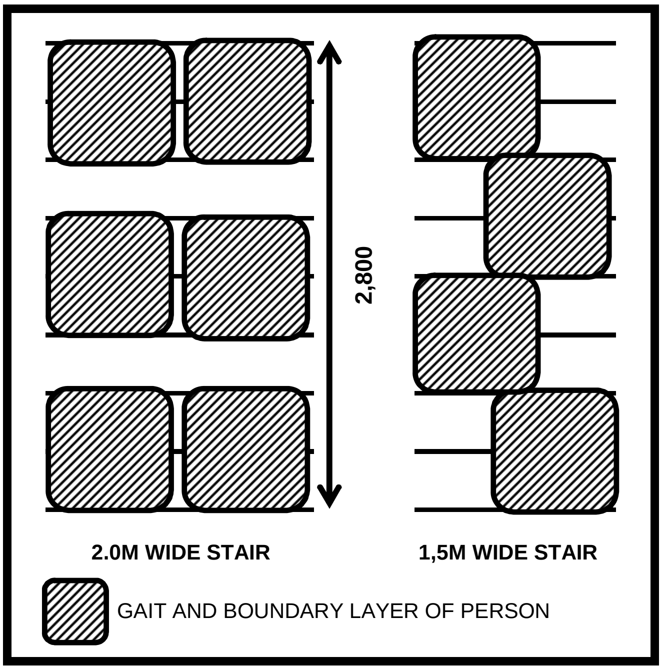

Figure 7 – Stair Capacity by Width

Accordingly a 1.5m wide stair has 67% of the capacity of a 2.0m wide stair; this is less than the mathematical width (1.5/2.0) calculation of 75% but more than the 50% calculation for following persons as shown in Figure 7.

Seating Row Feed

When persons traverse a seating row they cannot face the direction of travel and therefore the "sideways" shuffle can result in very slow walking speeds. However the ultimate constraint is the ability to merge into the stair queue.

At the start of egress the stair will be rapidly filled with persons nearest the stair after which, and subject to orderly merging, the seating rows will empty from the lowest row of seats with those persons in the top row waiting the longest.

Merged feed into the stair from seating rows can be mathematically calculated after which further calculations can be carried out for the stair and onwards travel time.

Ultimately the capacity of the stair is governed by the exit capacity at the top. With a 0.5m/s travel speed a stair will discharge one person per 0.935m of width each 2 seconds, say 0.5 persons per second per metre width of each stair. This cannot be calculated as "part thereof".

Note however that comparison calculations between say a DtS 2.0m wide stair and a 1.5m wide stair will <u>always</u> give approximately 50% longer egress time to the last person emerging at the top of the stairs.

I trust that this paper provides appropriate and sensible advice regarding egress path widths.

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References

1 “Emergency Movement”, by Harold E. “Bud” Nelson and Frederick W. Mowrer in the SFPE Handbook of Fire Protection Engineering (Third Edition).

2. J.J. Fruin, *Pedestrian Planning Design,* Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York (1971).

3. J.L. Pauls, “Effective-Width Model for Evacuation Flow in Buildings,” in *Proceedings, Engineering Applications Workshop,* Society of Fire Protection Engineers, Boston (1980).

4. A.T. Habicht and J.P. Braaksma, “Effective Width of Pedestrian Corridors,” *Journal of Transportation Engineering,* 110, 1 (1984).

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