Attachment H7

Rapidwall British Standard Guidelines

RAPIDWALL

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ENGINEERING DESIGN GUIDELINES

BRITISH STANDARDS SUPPLEMENT

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1 Introduction

This document has been developed so that the previous research and development work undertaken on Rapidwall panels in accordance with the Australian Standards can be used in areas under the jurisdiction of the British Standards.

This document is to be read in conjunction with *Rapidwall Engineering Design Guidelines* by consulting structural engineers Dare Sutton Clarke. *Rapidwall Engineering Design Guidelines* is available online at www.rapidwall.com.au under Home > Rapidwall > Downloadable Content.

The *Guidelines* and the information in this document are for use by appropriately qualified and experienced structural engineers who should satisfy themselves as to the relevance of this information.

This information is appropriate only for those Rapidwall panels manufactured using the woven glass fibre technique as capable from the Mark IV Rapidwall plant developed by Rapid Building Systems and licensed to Horizon Industrial Development Company LLC (HDIC) in Oman.

The presented information is supplied in good faith. Neither PT Design Associates Pty Ltd nor Rapid Building Systems Pty Ltd will accept responsibility for the incorrect use or interpretation of the data and guidelines presented.

2 Safety Factors

2.1 Australian Standards Approach

Structural design to the Australian Standards is done in accordance with limit states design. Design for the strength of Rapidwall elements is done for the ultimate limit state case.

In limit states design the design load, or design action effect (S*), is calculated by multiplying the various loads expected to act on an element (self weight, dead load, imposed loads from occupants, storage, wind, earthquake and the like) by combination factors and combining them.

Structural elements are proportioned such that the design capacity, ϕR_u, is not exceeded by the design action effect, S*, i.e. $\phi R_u \geq S^*$. Refer below for calculation of design capacity of elements.

2.1.1 Design Capacity of Elements

The design capacities given in *Rapidwall Engineering Design Guidelines* have been determined in accordance with the Australian standards and in conjunction with a significant testing program. These capacities include strength reduction factors which are used to account for local weaknesses in materials, inaccuracies in the determination of resistance of sections and the like.

The following strength reduction factors were used (Table 2.1):

Design action	**Strength Reduction Factor (ϕ)**
Axially loaded walls in compression	0.6
Out of plane bending without axial load	0.8
In plane bending	0.7
Shear strength	0.6
Axially loaded walls in tension	0.8

Table 2.1: Strength Reduction Factors to Australian Standards

2.2 Adaptation to British Standards

Design of Rapidwall elements may be undertaken in accordance with the British Standards using limit states design. Design for the strength of Rapidwall elements is to be done for the ultimate limit state.

2.2.1 Design Loads

Determination of the design loads or design action effects is the responsibility of the local engineer and is to take into account local conditions. Partial safety factors for load (γ_f) are to be applied.

2.2.2 Design Capacity of Rapidwall

The equivalent British Standards design capacity of Rapidwall is presented in Section 3 of this document. The Australian Standards based design capacities have been modified to remove the capacity reduction factor (ϕ), above, and to apply the British Standards partial safety factor for strength of materials (γ_m).

The following partial safety factors were used (Table 2.2).

Design action	**Strength Reduction Factor (ϕ)**
Reinforcement	1.05
Concrete in flexure or axial load	1.50
Shear strength without shear reinforcement	1.25
Others	1.50

Table 2.2: Partial Safety Factors for Strength of Materials to British Standards

3 Design Capacities of Rapidwall Elements

This section is to be read in conjunction with the equivalent section in *Rapidwall Engineering Design Guidelines*. Only design capacity information that differs from that outlined in the original *Guidelines* is presented below.

Section 3.1 below corresponds to *Guidelines* Section 1, Section 3.2 corresponds to *Guidelines* Section 2 and so on.

3.1 Introduction

No additional information.

3.2 Notation

No additional information.

3.3 Design Philosophy

No additional information.

3.4 Product Dimensions

No additional information.

3.5 Mechanical Properties of Rapidwall

Amended values from *Guidelines* Table 5.1:

Unreinforced and unfilled Rapidwall

Uni-axial compressive strength = 100 / 0.6 / 1.5 = 111 kN/m

Uni-axial tensile strength = 28.8 / 0.8 / 1.5 = 24 kN/m

Concrete filled (C25) Rapidwall in all cells

Uni-axial compressive strength = 890 / 0.6 / 990 kN/m

3.6 Fire Resistance

No additional information.

3.7 Sound Transmission

No additional information.

3.8 Thermal Insulation

No additional information.

3.9 Out of Plane Bending of Unfilled Rapidwall Panels

Amended values from *Guidelines* Table 9.1:

Design bending moment capacity with ribs/cells parallel to span = 1.6 / 0.8 / 1.5 = 1.33 kN/m

Design bending moment capacity with ribs/cells perpendicular to span = 0.7 / 0.8 / 1.5 = 0.58 kN/m

3.10 Lintel Design

3.10.1 Unfilled Lintels

Amended values interpolated from *Guidelines* Figure 10.2:

Design bending moment capacity of 300 mm deep section = 1.1 / 0.8 / 1.5 = 0.59 kN/m
Design bending moment capacity of 400 mm deep section = 2.4 / 0.8 / 1.5 = 1.3 kN/m
Design bending moment capacity of 500 mm deep section = 3.7 / 0.8 / 1.5 = 2.0 kN/m
Design bending moment capacity of 600 mm deep section = 4.8 / 0.8 / 1.5 = 2.6 kN/m
Design bending moment capacity of 700 mm deep section = 5.9 / 0.8 / 1.5 = 3.1 kN/m
Design bending moment capacity of 800 mm deep section = 7.0 / 0.8 / 1.5 = 3.7 kN/m

3.10.2 Concrete Filled Lintels

3.10.2.1 Flexural Strength

Flexural strength design to be done by rectangular stress block method in accordance with BS 8110 with maximum rectangular stress block of 150 mm depth.

Note that for lintels under uplift, top reinforcement is required in addition to bottom reinforcement, with 150 mm deep compression zone provided in bottom of lintel in addition to top.

3.10.2.2 Shear Strength

Design shear capacity at any shear plane = 25 / 0.6 / 1.5 = 28 kN

3.11 Axial Load Capacity of Rapidwall

Amended values interpolated from *Guidelines* Figure 11.1 (unfilled, 3.0 metres high, one end fixed and one end pinned):

Design axial compression capacity for 5 mm eccentricity = 65 / 0.6 / 1.5 = 72 kN/m
Design axial compression capacity for 10 mm eccentricity = 62 / 0.6 / 1.5 = 69 kN/m
Design axial compression capacity for 15 mm eccentricity = 61 / 0.6 / 1.5 = 68 kN/m
Design axial compression capacity for 20 mm eccentricity = 59 / 0.6 / 1.5 = 66 kN/m

Amended values interpolated from *Guidelines* Figure 11.2 (25 MPa concrete filled, 3.0 metres high, both ends pinned):

Design axial compression capacity for 5 mm eccentricity = 500 / 0.6 / 1.5 = 560 kN/m
Design axial compression capacity for 10 mm eccentricity = 400 / 0.6 / 1.5 = 440 kN/m
Design axial compression capacity for 15 mm eccentricity = 310 / 0.6 / 1.5 = 340 kN/m
Design axial compression capacity for 20 mm eccentricity = 220 / 0.6 / 1.5 = 240 kN/m
Design axial compression capacity for 25 mm eccentricity = 170 / 0.6 / 1.5 = 190 kN/m
Design axial compression capacity for 30 mm eccentricity = 150 / 0.6 / 1.5 = 170 kN/m

Amended values interpolated from *Guidelines* Figure 11.3 (25 MPa concrete filled, 3.0 metres high, one end fixed and one end pinned):

Design axial compression capacity for 5 mm eccentricity = 590 / 0.6 / 1.5 = 660 kN/m
Design axial compression capacity for 10 mm eccentricity = 540 / 0.6 / 1.5 = 600 kN/m
Design axial compression capacity for 15 mm eccentricity = 480 / 0.6 / 1.5 = 530 kN/m
Design axial compression capacity for 20 mm eccentricity = 430 / 0.6 / 1.5 = 480 kN/m
Design axial compression capacity for 25 mm eccentricity = 380 / 0.6 / 1.5 = 420 kN/m
Design axial compression capacity for 30 mm eccentricity = 340 / 0.6 / 1.5 = 380 kN/m

3.12 Shear Strength of Rapidwall

Amended values from *Guidelines* Table 12.1:

Design shear capacity for unfilled Rapidwall panel = 10.5 / 0.6 / 1.5 = 11.7 kN/m
Design shear capacity for 25 MPa concrete filled Rapidwall panel = 28.5 / 0.6 / 1.5 = 31.7 kN/m

3.12.1 Frictional Shear at Wall Slab Joint

No additional information.

3.13 In Plane Flexural Strength of Rapidwall

No additional information.

3.14 Design Procedure for Rapidwall Buildings

No additional information.

4 Design Capacities of Rapidwall Elements (Out of Plane Bending)

For particularly tall panels or panels in high wind load regions it is possible for the out of plane bending capacity of Rapidwall panels to be a critical load case.

Currently there is no design model to account for any shear connection between the concrete filling of a panel and the panel cell walls themselves. At the time of writing, research is underway to quantify this.

It has been conservatively assumed that provided the reinforced concrete cell infill has sufficient ductility, the ultimate capacity of unfilled Rapidwall and the ultimate capacity of the reinforced cell (designed as a discrete reinforced concrete element) may be summed.

The ultimate bending capacity of unfilled Rapidwall has been determined by physical testing (refer Section 3.5, above, and Section 5 of the *Guidelines*). The ultimate bending capacity of the reinforced concrete cell infill has been determined using the rectangular stress block method.

Table 4.1 below outlines the out of plane bending moment capacity of reinforced concrete filled Rapidwall. In the calculation of bending moment capacity the strength of concrete infill was assumed to be 25 MPa with γ_m = 1.50 and strength of steel reinforcement was assumed to be 460 MPa with γ_m = 1.05.

	Number of Bars	**Reinforcement Diameter**	**Bar Position**	**Ultimate Bending Capacity**
1	1	12 mm	Central	2.0 kNm per cell
2	1	12 mm	Each Face 8 mm cover to cell wall	3.7 kNm per cell
3	2	12 mm	Each Face 8 mm cover to cell wall	6.2 kNm per cell
4	1	16 mm	Each Face 8 mm cover to cell wall	6.2 kNm per cell

Table 4.1: Out of Plane Bending Capacity of Filled and Reinforced Rapidwall

Care must be taken to ensure the position of the bars for central and each face reinforcement.

Reinforcement placed each face is not commonly used. As cover to reinforcement is less than that recommended for concrete cover, adequate measures to protect the reinforcement from corrosion must be taken.