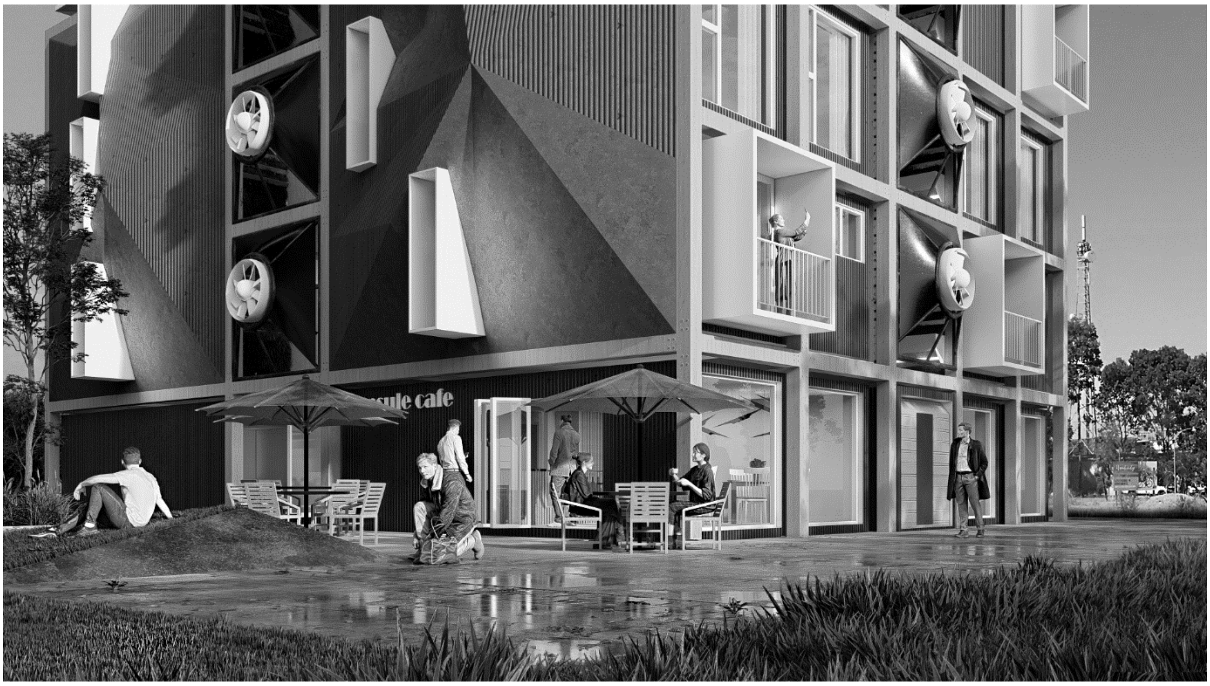

CONCEPT DESIGN VALIDATION REPORT

A Conceptual Overview

Abstract

An overview of the key considerations addressed by the design in relation to the brief produced by Fleetwood Cup Challenge 2022

CONTENTS

Introduction

This project embodies many design ideals that collectively work in unison to deliver Architecture wholistically, with an aim to address current and future issues surrounding social housing for the homeless and demands for more affordable living. Seeking to respond to this ever-growing housing crisis that our nation is facing, the proposal utilises modular construction and sustainable design with a strong focus on implementing innovative thinking to develop new possibilities for a NET Zero future. The development presents itself as a 4 Story mixed use apartment that makes use of adaptable modular design principles to achieve a unique aesthetic, celebrating the many elements of innovation fused within the building's fabric. With sustainability and practicality the focus for design, a series of key components was developed, each with an intent to achieve a more sustainable outcome for the day to day operation of the building. Renewable power generation and storage is an integral part of the sustainability aspect for this project, as such, a prefabricated renewable power generating module was developed that integrates both Solar PV and wind power to generate electricity for residents and onsite amenities. In addition to the technological features of the building, there is also the great adaptability aspect made possible by utilising innovative modular construction methods, making site relocation and future expansion possible.

NET Zero

As NET Zero is one of multiple key considerations for this project, a significant effort has been made to address this subject matter. In terms of meeting this crucial aspect of the brief, a wholistic design approach has been followed, ensuring a multifaceted inclusion of components that address current and future implications faced within the construction industry.

During concept inception, a collective of design components was established, all with the intent of addressing a particular facet of NET Zero. Whilst each component can be considered an individual entity, they all come together to work in unison. This collective of components is very much a 'kit of parts' approach to tackling a complicated issue. It is a technique that makes it possible to break down a complex aggregate of important considerations by addressing them individually.

In the early concept design phases, analysis of conventional buildings was undertaken to gather insight into the main componentry they comprised of.

In essence, most buildings consisted of:

- A roof
- A façade
- A structure
- Circulatory features (stairs/lifts/corridors

From this, an attempt was made to design each of these elements as modular, prefabricated components, with the combined purpose of achieving NET Zero.

The Roof

A roof was developed with two elements in mind, rainwater harvesting and protection. With an inverted parachute style design, the roof typology is ideal for collecting rainwater. The water collects at the centre of the roof in box gutters that then feed water down a central downpipe connected to tanks at ground level where it is stored. The purpose of this harvested water is to serve as irrigation to the onsite, waterwise landscaping. The secondary purpose of the roof system is to simply act as a barrier against unwanted heat gain and other climatic conditions.

The Facade

The façade was designed with both aesthetic and practical purpose in mind. With the ability to accommodate various appearances relating to context of site, it acts as an element of uniqueness for the buildings design. Practicality is also considered. The façade acts as an acoustic and thermal barrier that improves living qualities and the overall functioning of the building.

Structure

The structure of the building was designed to accommodate all key design elements/components to eliminate the need for additional structural systems. The host structure is a CLT frame, engineered to support the living modules of various sizes, layouts and configurations, making it an adaptable system for future changes. The host structure was designed for easy assembly and disassembly making it a versatile component that can be transported anywhere.

Circulatory Features

The features necessary for circulating and traversing the building are modular and prefabricated to enable convenient installation, replacement and maintenance. These features are directly integrated/attached to the CLT host frame.

Social Housing

Various social housing ideologies have been implemented within the design scope of the building. With flexible areas to facilitate activities such as volunteering, social support services, work and interaction, the building hosts many opportunities for community and client value.

As a social housing complex, attention has been given to issues regarding homelessness and shortages of places to live. With this in mind, there is potential for implementing a strategy whereby home seekers can work in the onsite facilities in exchange for accommodation and other living benefits. This would bring value to the community and also provide opportunity for those in need.

Affordability

With the housing shortage crisis at the forefront of issues that need addressing in current agendas, it has been a crucial part in the concept design of this project. Modular design aims to address this issue as it is considered to have the necessary qualities needed such as reduced construction times, efficient planning and reduced costs.

The design comprises of small but smart module configurations reducing costs by limiting the materials required. Recycled materials are used where possible and standard sizes are abided by for efficiency and waste reduction. Sustainable design is also factored in, with NET Zero aiding in the reduction of day to day running costs faced by residents.

Innovation

Driving innovation within the construction industry is a necessary obligation for addressing current and future problems. This is why effort has been made to develop a distinct response, unique to the design concept of the building.

To enhance NET Zero capabilities, a modular, prefabricated component has been designed that combines both solar PV and wind power generation to achieve renewable power for residents. The component integrates with the host structure as a technology add on, creating a unique façade with a practical purpose.

The addition of this technology encourages innovation and adds client value by reducing living costs, associated with reliance on the grid.

Appendix A – Engineers Calculations

1.5 Vertical and horizontal load path

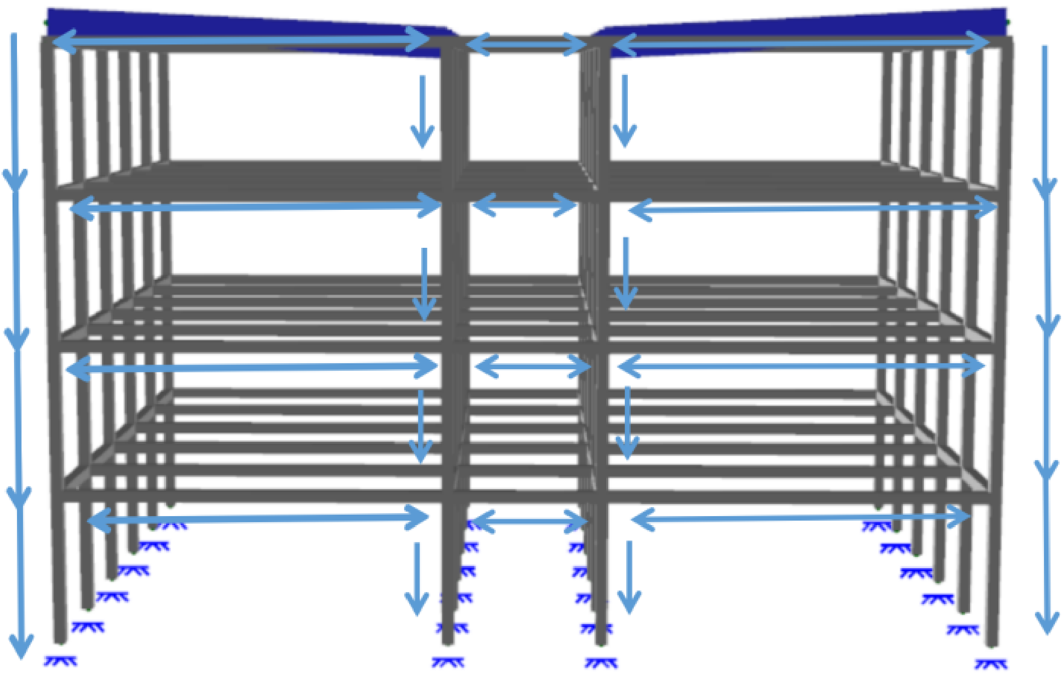

Figure 1 - Load path for vertical and horizontal

2.0 Design Details

2.1 Wind load

The required information to calculate the wind action will be shown below.

The building has level 2 structure importance

It has a design work life of 50 years

Annual probability of 1/500

Regional wind speed (VR) - 45 m/s

The building is to be built in 47 victoria St, midland WA 6056 which is located in the

Region A1.

2.1.1 West

From < AS/NZS 1170.2 Table 3.2(A) > the wind direction multiplier (Md) for cardinal direction (West) in Region A1 was obtained.

Cardinal directions	Region A0	Region A1	Region A2	Region A3	Region A4	Region A5	Region B1	Regions B2, C, D
N	0.90	0.90	0.85	0.90	0.85	0.95	0.75	0.90
NE	0.85	0.85	0.75	0.75	0.75	0.80	0.75	0.90
E	0.85	0.85	0.85	0.75	0.75	0.80	0.85	0.90
SE	0.90	0.80	0.95	0.90	0.80	0.80	0.90	0.90
S	0.90	0.80	0.95	0.90	0.80	0.80	0.95	0.90
SW	0.95	0.95	0.95	0.95	0.90	0.95	0.95	0.90
W	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.90
NW	0.95	0.95	0.95	0.95	1.00	0.95	0.90	0.90

NOTE In Region A0 non-synoptic winds are dominant. In Regions A1 and A4, extra-tropical synoptic winds are dominant. Extreme winds in Regions A2, A3, A5 and B1 are caused by a mixture of synoptic (extra-tropical large-scale pressure systems, or tropical cyclones in the case of B1) and non-synoptic (thunderstorm) events. In Regions B2, C, and D, extreme winds from tropical cyclones are dominant.

Figure 2 - Wind direction multiplier

$M_d = 1.0$

Terrain multiplier

Average roof height,

Z = 12810 mm, which was obtained from the architecture drawing

The location of the project, 47 victoria St, midland WA 6056 is found to be located in

Terrain category 3 area.

From AS/NZS 1170.2 < Table 4.1 >

Mz,cat = 0.86

Shielding multiplier

From AS/NZS 1170.2 < Clause 4.3.1 >

Ms = 1.0 (Conservative)

Topographic multiplier

From AS/NZS 1170.2 < Clause 4.4 >

Mt = 1.0 (Conservative)

Hill shape multiplier

From AS/NZS 1170.2 < Clause 4.4.2 >

Mh = 1.0 (Conservative)

Design Wind Speed

From AS/NZS 1170.2 < Clause 2.2 >

$V_{des,\theta} = V_{sit,\beta} = V_R\ M_d(M_{z,cat}M_sM_t)$

$V_{des,\theta} = V_{sit,\beta} = V_rM_c\ M_d(M_{z,cat}M_sM_t)$

$V_{des,\theta} = V_{sit,\beta} = 45 \times 1 \times 1 \times (0.86 \times 1 \times 1)$

$V_{des,\theta} = V_{sit,\beta} = 38.7$ m⁄s

$V_{des,\theta} = 38.7$ m⁄s > 30 m⁄s

(acceptable)

Area reduction Factor

From AS/NZS 1170.2 < Clause 5.4.2 >

Tributary area: 19.738 × 14.273 = 281.720 m2

$P_{air} = 1.2$

kg⁄m3 (constant)

$V_{des,\theta} = 38.7$ m⁄s

$C_{shp} = -0.05$

$C_{dyn} = 1.0$ (for normal structure with natural frequency > 1 Hz)

p = (0.5 × 1.2) (38.7)

2 × −0.05 × 1

= −0.045 kPa (outwards)

Internal Pressure

$C_{shp,i} = C_{p,i}\ K_{c,i}\ K_v$

Cpi = internal pressure coefficient

Kci = combination factor applied to internal pressure

Kv = Open area / internal volume factor for internal pressure

Windward wall:

West have 6 windows

Dimension of the window = 1500mm × 2100mm = 3.15 m2

Area of the whole building = 12810mm × 14790mm = 189.46 m2

Ratio:

With 6 windows = 3.15 × 6 = 18.9 m2

18.9

189.46

× 100 = 10% > 0.5%

Area Reduction factor, Ka does not apply to the stained glass window on the windward wall

Ka = 1.0

Since the area of the window is more than the limiting area for local pressures, the local pressure factor.

Kt = 1.0

External pressure coefficient for windward wall where h < 25m and z = h,

Cp,e = +0.7

Cp,i = Ka Kt Cp,e

= 1 x 1 x 0.7

= 0.7

A combination of internal and external pressure will allow the use of the Combination Factor, Kc.

From AS/NZS 1170.2 < Table 5.5 > for lateral pressure on external positive wall pressures and negative internal pressures on 2 effective surfaces,

Kc,i = 0.9

Area = 1.5m × 2.1m = 3.15 m2

Volume = 7.83m × 5.42m × 3.1m = 131.56m2

Kv = [100 ×

(

A

3

2

⁄)

Vol]

= 4.25 < 3

So, take Kv = 1.085

Cshp,i = Cp,i Kc,i Kv

$C_{shp,i} = 0.7 \times 0.9 \times 1.085$

$C_{shp,i} = 0.68$

External Pressure

External Pressure Coefficient , $C_{p,e}$ for roof:

$C_{shp,e} = C_{p,e}\ K_a\ K_{c,e}\ K_l\ K_p$

$C_{p,e}$ = external pressure coefficient

K_a = area reduction factor

$K_{c,e}$ = combination factor applied to external pressures

K_l = local pressure factor

K_p= porous cladding reduction factor

Windward wall:

External pressure coefficient for windward wall where $h < 25m$ and $z = h$,

$C_{p,e} = +0.7$

Area Reduction factor, K_a does not apply to the stained glass window on the windward wall

$K_a = 1.0$

From AS/NZS 1170.2 < Clause 5.4.4 >

a = minimum of [h, 0.2d, 0.2b]

= minimum of [3.1m, 0.2 × 26m, 0.2 × 25m] = 3.1 m

Therefore, the limiting area is 0.25a

2 = 2.4 m2

The area of the stained glass window is 1.5m × 2.1m = 3.15 m2

Since the area of the window is more than the limiting area for local pressures, the local pressure factor, K_l applies.

$K_l = 1.0$

The external surface is steel which is not a permeable cladding, therefore

$K_p = 1.0$

A combination of internal and external pressure will allow the use of the Combination Factor, K_c.

From table 5.5 AS/NZS 1170.2, for lateral pressure on external positive wall pressures and negative internal pressures on 2 effective surfaces,

$K_{c,e} = 0.9$

$C_{shp,e} = C_{p,e}\ K_a\ K_{c,e}\ K_l\ K_p$

$C_{shp,e} = 0.7 \times 1 \times 0.9 \times 1 \times 1$

$C_{shp,e} = 0.63$

Combined Pressure Coefficient: $C_{shp} = 0.63 - 0.68$

$= -0.05$

[Same method of calculation is applied to the rest directions]

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2.1.2 East

From < AS/NZS 1170.2 Table 3.2(A) > the wind direction multiplier (M_d) for cardinal direction (East) in Region A1 was obtained.

$M_d = 0.85$

Terrain multiplier

Average roof height,

Z = 12810 mm, which was obtained from the architecture drawing

The location of the project, 47 victoria St, midland WA 6056 is found to be located in Terrain category 3 area

From AS/NZS 1170.2 < Table 4.1 >

$M_{z,cat} = 0.86$

Shielding multiplier

From AS/NZS 1170.2 < Clause 4.3.1 >

$M_s = 1.0$ (Conservative)

Topographic multiplier

From AS/NZS 1170.2 < Clause 4.4 >

$M_t = 1.0$ (Conservative)

Hill shape multiplier

From AS/NZS 1170.2 < Clause 4.4.2 >

$M_h = 1.0$ (Conservative)

Design Wind Speed

From AS/NZS 1170.2 < Clause 2.2 >

$V_{des,\theta} = V_{sit,\beta} = V_R \, M_d(M_{z,cat} M_s M_t)$

$V_{des,\theta} = V_{sit,\beta} = V_r M_c \, M_d(M_{z,cat} M_s M_t)$

$V_{des,\theta} = V_{sit,\beta} = 45 \times 1 \times 0.85 \times (0.86 \times 1 \times 1)$

$V_{des,\theta} = V_{sit,\beta} = 32.9$ m⁄s

$V_{des,\theta} = 32.9$ m⁄s > 30 m⁄s

(acceptable)

Area reduction Factor

From AS/NZS 1170.2 < Clause 5.4.2 >

Tributary area: 19.738 × 14.273 = 281.720 m2

$P_{air} = 1.2$

kg⁄m3 (constant)

$V_{des,\theta} = 32.9$ m⁄s

$C_{shp} = -0.05$

$C_{dyn} = 1.0$ (for normal structure with natural frequency > 1 Hz)

$p = (0.5 \times 1.2)\ (32.9)$

$2 \times -0.05 \times 1$

$p = -0.032$ kPa (outwards)

2.1.3 North

From < AS/NZS 1170.2 Table 3.2(A) > the wind direction multiplier (Md) for cardinal direction (East) in Region A1 was obtained.

$M_d = 0.90$

Terrain multiplier

Average roof height,

Z = 12810 mm, which was obtained from the architecture drawing

The location of the project, 47 victoria St, midland WA 6056 is found to be located in Terrain category 3 area

From AS/NZS 1170.2 < Table 4.1 >

$M_{z,cat} = 0.86$

Shielding multiplier

From AS/NZS 1170.2 < Clause 4.3.1 >

$M_s = 1.0$ (Conservative)

Topographic multiplier

From AS/NZS 1170.2 < Clause 4.4 >

Mt = 1.0 (Conservative)

Hill shape multiplier

From AS/NZS 1170.2 < Clause 4.4.2 >

Mh = 1.0 (Conservative)

Design Wind Speed

From AS/NZS 1170.2 < Clause 2.2 >

Vdes,θ = Vsit,β = VR Md(Mz,catMsMt)

Vdes,θ = Vsit,β = VrMc Md(Mz,catMsMt)

Vdes,θ = Vsit,β = 45 × 1 × 0.90 × (0.86 × 1 × 1)

Vdes,θ = Vsit,β = 34.83 m⁄s

Vdes,θ = 34.83 m⁄s > 30 m⁄s

(acceptable)

Area reduction Factor

From AS/NZS 1170.2 < Clause 5.4.2 >

Tributary area: 19.738 × 14.273 = 281.720 m2

Pair = 1.2

kg⁄m3 (constant)

Vdes,θ = 34.83 m⁄s

Cshp = −0.05

Cdyn = 1.0 (for normal structure with natural frequency > 1Hz)

p = (0.5 × 1.2) (34.83)

2 × −0.05 × 1

p = −0.036 kPa (outwards)