REPORT

ĀLIA - BLOCK I

HONOLULU, HI

CLADDING WIND LOAD STUDY
RWDI # 2203689
May 4, 2022

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI was retained to assess the wind loads for designing the exterior envelope of the proposed Ālia - Block I development at the Kaka'ako district in Honolulu, Hawaii. The proposed project is a mixed-use, residential development, comprised of one tower that consists of approximately 39 stories, with 6 story podium and a recreation deck at level 6.

Key Points

- The wind tunnel test procedures met or exceeded the requirements set out in the ASCE 7-16 Standard.
- A 700-year return period effective wind speed of 135 mph (3-second gust) at 33 ft height in open terrain was adopted for wind loading predictions. This wind speed is specified for the site in the IBC 2018 which references ASCE 7-16 Standard.
- All predictions were derived using a statistical wind climate model developed for the area.
- Recommended cladding design wind pressures are provided in Figures 4 to 19.
- The wind pressures provided in this report are the ***ASCE 7-16 ultimate state wind loads <u>multiplied by 0.6, as such they are applicable for the Allowable Stress Design approach.</u>*** The provided wind pressures are to be applied to the building's cladding system in the same manner as would wind loads calculated by code analytical methods.
- The largest recommended negative cladding wind pressure was -85 psf, which occurred on the protruding sun-shade / canopy element at the very top of the building on the south-west corner of the roof plan (Figure 10). Note that this localized high negative cladding wind load is a net pressure acting on the protruding element and was determined by measuring the instantaneous pressure difference across it. This localized large negative pressure region is primarily due to the building geometry, and alignment of the tower edge with the strongest wind direction (southeast). The majority of the negative wind pressures were in the range of -35 psf to -50 psf.
- The largest recommended positive cladding wind pressure was +60 psf, which occurred on the roof parapet of the West and South Elevations (Figures 13 & 14). Note that this localized high positive cladding wind load is a net pressure acting on the parapet and was determined by measuring the instantaneous pressure difference across it. The majority of the positive wind pressures were in the range of +35 psf to +45 psf.
- The recommended cladding wind pressures are in line with expectations based on RWDI's experience of wind tunnel studies on similar buildings and surrounding conditions.
- The recommended design wind pressures either include an internal pressure allowance or represent the instantaneous differential pressures across protruding elements exposed to the wind on opposite sides.
- The design wind pressures in this report may be combined with appropriate tributary area reduction factors provided in Image 2 from Section 3.4.

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1 INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by Kobayashi Group to conduct an analysis of the wind loads for designing the exterior envelope of the Ālia - Block I development in Honolulu, Hawaii. This report presents the project objectives, background, approach, and provides a discussion of the results from RWDI's assessment. A summary of the overall recommendations from the assessment is presented in the Executive Summary.

1.1 Project Description

The proposed project is a mixed-use, residential development, comprised of one tower that consists of approximately 39 stories, with a 6-story podium and a recreation deck at level 6. The west and east ends of the base consist of solar panels laid out horizontally.

1.2 Objectives

The objective of this assessment was to determine the wind loads for design of the exterior envelope of the structure, including the cladding, components, and secondary cladding systems.

2 BACKGROUND AND APPROACH

2.1 Methodology

Appendix A provides additional background information on the testing and analysis procedures for this type of assessment.

In performing the Cladding Wind Load Study (the "Assessment"), RWDI confirms that the assessment was performed by RWDI in accordance with generally accepted professional standards at the time when the Assessment was performed and in the jurisdiction of the Project. No other representations, warranties, or guarantees are made with respect to the accuracy or completeness of the information, findings, recommendations, or conclusions contained in this Report. This report is not a legal opinion regarding compliance with applicable laws.

2.1.1 Study Model and Surroundings

A 1:300 scale model of the proposed development was constructed using the architectural drawings listed in Appendix B. The model was instrumented with pressure taps and was tested in the presence of all surroundings within a full-scale radius of 1200 ft, in RWDI's 12 ft x 7 ft boundary-layer wind tunnel facility in Guelph, Ontario, Canada for the following test configurations:

Configuration 1 – Proposed study model with existing surroundings;

Configuration 2 – Proposed study model with existing and future surroundings.

The cladding wind loads presented in this report are a result of combining the data from the two test configurations into one consolidated set of cladding design wind loads.

Photographs of the scale model in the boundary layer wind tunnel are shown in Figure 1a and 1b, corresponding to test configurations 1 and 2, respectively. An orientation plan showing the study site and immediate surroundings is given in Figure 2.

The findings and recommendations set out in this report are based on the following information disclosed to RWDI:

- architectural information listed in Appendix B, and
- the construction phasing as reflected in the test configurations ("Project Data").

The recommendations and conclusions are based on the following assumptions:

1. The Project Data are accurate and complete; and
2. The surroundings model used for the wind tunnel tests reflected the current state of development at the time of testing and include, where appropriate, known off-site structures that have received planning approval and/or been agreed upon with the design team. (collectively "Project Specific Conditions').

2.1.2 Simulation of Upwind Terrain

Beyond the modeled area, the influence of the upwind terrain on the planetary boundary layer was simulated in the testing by appropriate roughness on the wind tunnel floor and flow conditioning spires at the upwind end of the working section for each wind direction. This simulation, and subsequent analysis of the data from the model, represented terrain conditions similar to the ASCE 7 Exposure C as appropriate for the particular wind direction. Wind direction is defined as the direction from which the wind blows, measured clockwise from true north.

2.1.3 Wind Climate

For the determination of the recommended wind loads, it is important to account for the impact of the local wind climate. A statistical wind climate model was created based upon local surface wind measurements taken at Honolulu International Airport and a Monte Carlo simulation of hurricanes. The Monte Carlo simulation produced 100,000 years of tropical cyclones to determine the strength and directionality of the hurricane wind climate and was provided by Applied Research Associates of Raleigh, NC.

A graphical representation of the statistical wind climate model is provided in Figure 3. The top two plots show the directionality of common winds on the left and design winds on the right. The common winds correspond to a return period of approximately 1 month, and the design winds correspond to a return period of 700 years. Design winds are the strongest from the southeast. The lower plot shows the wind speeds from each data set as a function of return period. It is clear from the plot that the common events (i.e., lower return periods) are dictated by the extra-tropical winds whereas at longer return periods, the hurricanes generate the most significant wind speeds for strength design.

The resulting statistical wind climate model was combined with the wind tunnel results using the Upcrossing Method to produce the recommended full-scale wind pressures. Therefore, while the directional wind speeds shown in Figure 3 are illustrative of the directionality of the local wind climate, they were not and should not be used directly for predictions of wind pressures.

2.1.4 Determination of Cladding Design Wind Pressures

For design of cladding elements, the differential wind load acting across an element must be considered. For elements exposed to wind on the external surface only, an internal pressure allowance (determined through analytical methods and the wind tunnel test data) must be applied to the measured external pressure in order to determine the differential pressure applicable for design. In strong winds, the internal pressures are dominated by air leakage effects. Important sources of air leakage include uniformly distributed small leakage paths over the building's envelope and larger leakage paths if applicable. These larger leakage paths might include loading dock doors, operable doors or windows in residential units, or envelope breaches during extreme events.

To obtain the differential peak negative cladding pressures, the negative exterior pressures are augmented by an amount equal to the positive internal pressure. Likewise, the differential peak positive pressures are obtained by augmenting the exterior positive pressure by an amount equal to the magnitude of the negative internal pressure. "Negative pressure" or suction is defined to act outward normal to the exterior surface and "positive pressure" acts inward.

For single-surface elements exposed to wind on opposite sides, such as glass parapets, balcony guardrails and canopies, the differential pressure acting on the element is determined by measuring the instantaneous pressure difference across the element. In cases where the design details of these protruding elements are uncertain, the recommended design wind pressure is based on the worse case between the instantaneous differential pressure and the external pressure augmented by an appropriate internal pressure.

The cladding design wind pressures presented in this report are localized values intended for the design of small elements and do not necessarily occur simultaneously. The simultaneous application of the provided wind pressures will result in conservative forces.

2.2 Criteria

The governing code for this project is the IBC 2018, which references the ASCE 7-16. For this reason, the ASCE 7-16 is referred to hereafter to define the design wind speed and other project-related criteria, where applicable.

The recommendations for wind loads provided in this report are based on wind tunnel tests employing procedures that meet or exceed the requirements set out in the American Society of Civil Engineers (ASCE) 49-21 Standard on Wind Tunnel Testing for Buildings and Other Structures as well as Chapter 31 of the ASCE 7.

The recommended wind pressures provided in this report are based on a 3-second gust wind speed of 135 mph at a height of 33 ft in open terrain, as specified in the IBC 2018 and ASCE 7-16 Standard for a Risk Category II building in Honolulu. This wind speed is shown in Figure 3 and corresponds to an ultimate return period of 700 years.

Note that the wind speeds provided in the IBC 2018 and ASCE 7-16 are based on basic wind speed maps consistent with the ultimate event, which corresponds to a load factor of 1.0 when using the Load and Resistance Factor Design (LRFD) approach. The LRFD approach is generally employed for structural loading. For cladding design, an Allowable Stress Design (ASD) approach is more common and permissible following ASCE 7 provisions. Section 2.4 of ASCE 7 specifies a factor of 0.6 on the ultimate wind loads to convert from an LRFD to an ASD approach. ***The design wind loads provided in this report include the 0.6 factor required to convert the ultimate LRFD loads to the nominal ASD level of loading.***

To make some allowance for possible future changes in surroundings, RWDI's recommended cladding design wind pressures do not go below a minimum of ±35 psf, with the exception of +25 psf and -50 psf minimums on top-most open roof areas. These minimum pressure allowances are consistent with Clause 31.4 of ASCE 7, which specifies limits on how much reduction is permissible in the loading when compared to the analytical methods in Chapter 30. Per ASCE 7, the cladding design wind pressures are not to be less than 80% of the Zone 4 (walls) and Zone 1 (roof) values.

3 RESULTS AND DISCUSSION

3.1 External Wind Pressures

The range of predicted local external wind pressures are provided in the histogram below (Image 1). Peak positive and negative wind pressures are presented for both façade and roof surfaces, along with relevant code-based values (Exposure C) for comparison.

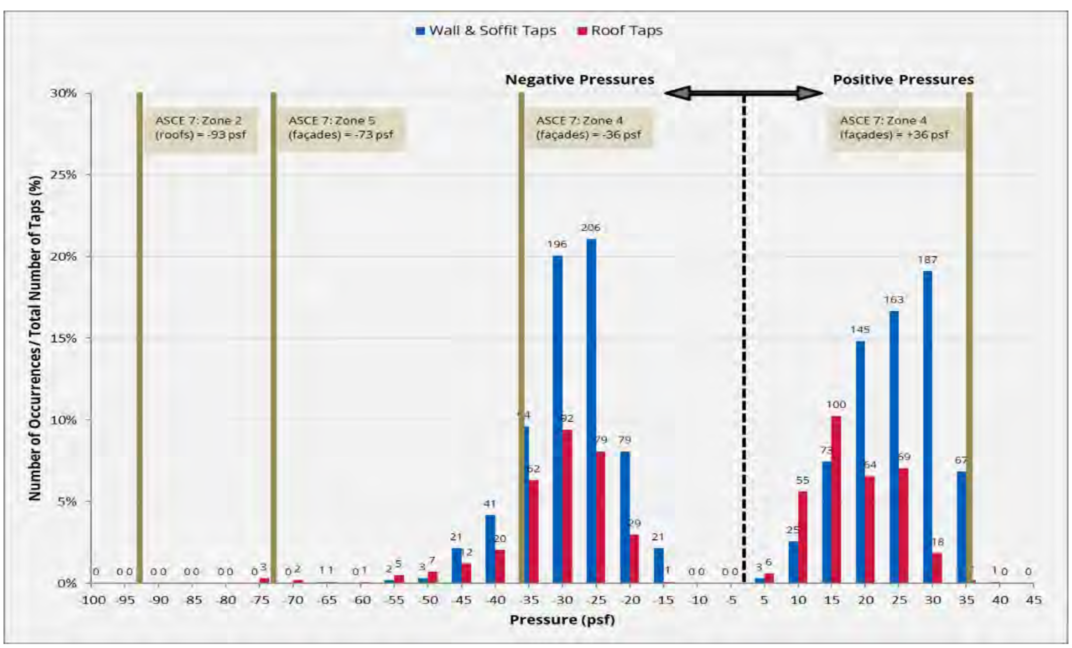


Image 1: Histogram of Local External Wind Pressures

Generally, the negative and positive pressures are lower than code-based values. The distributions of both the positive and negative pressures are in line with expectations based on RWDI's experience of wind tunnel studies conducted on similar buildings in the area.

3.2 Internal Pressures

Taking into consideration the potential for breakage or an opening occurring, the resulting internal pressure allowance values for the Allowable Stress Design are presented in table below. These values are based on the understanding that there are operable windows/sliding doors located over the entire façade.

Table 1: Recommended Internal Pressures

Scenario	Internal Pressures (psf)	
	Positive	Negative
Main Facades	+7	-10
Roofs and Soffits	+7	-7

The internal pressures have been assessed with the understanding that all horizontal roof surfaces are non-glazed. If this is not the case, then RWDI should be contacted.

3.3 Cladding Design Wind Pressures

The negative cladding design wind pressures were determined by combining the negative external pressures with the positive internal pressure, where applicable. Similarly, the positive cladding design wind pressures were determined by combining the positive external pressures with the negative internal pressure.

Pressure contour diagrams (or "block diagrams") of RWDI's recommended negative and positive cladding design wind pressures are presented in Figures 4 to 11 and 12 to 19, respectively. The wind pressures provided in these diagrams are the ***ASCE 7-16 ultimate state wind loads*** ***<u>multiplied by 0.6, as such they are applicable for the Allowable Stress Design approach.</u>*** The contour diagrams presented in these figures have generally been zoned using 5 psf increments so that the pressure indicated is the maximum pressure in that particular zone. For example, a 40 psf zone would have pressures ranging from 36 psf to 40 psf.

The following table provides a summary of the recommended cladding design wind pressures and the location of the largest values.

Table 2: Summary of Cladding Design Wind Pressures

Element	Negative Pressures (psf)			Positive Pressures (psf)		
	Peak Value	Location	Range of Majority	Peak Value	Location	Range of Majority
Main Facades	-65	Figure 6	-35 to -50	+60	Figures 13 & 14	+35 to +45
Roofs	-85	Figure 10	-40 to -60	+40	Figure 18	+25 to +35
Soffits	-35	Figure 11	-35	+35	Figure 19	+35
Solar Panel Array	-55	Figure 10	-40 to -45	+55	Figure 18	+30

For cladding design of all balcony guardrails please refer to Figure 20.

The recommended cladding design wind pressures are derived from model scale tests and appropriate for local elements with a minimum dimension of approximately 0.3 m (1 ft). For smaller elements, the provided cladding design wind pressures may be indicative of the expected loading, however, RWDI should be consulted if there are any queries regarding specific features.

The wind pressures provided in this report are the ***ASCE 7-16 ultimate state wind loads <u>multiplied by 0.6, as such they are applicable for the Allowable Stress Design approach.</u>*** **T**he proved wind pressures are to be applied to the building's cladding system in the same manner as would wind loads calculated by code analytical methods. For Load and Resistance Factor Design applications, the wind loading presented in this report needs to be divided by 0.6. The recommended wind loads are for cladding design for resistance against wind pressure, including an allowance for internal pressures. Design of the cladding to the provided wind loads will not necessarily prevent breakage due to impact by wind-borne debris, which is prevalent in hurricanes, typhoons, and tornadic events.

3.4 Tributary Area Reduction Factors

For the design of cladding and secondary cladding components with tributary areas of 1 m^2 (10 ft^2) or more, the appropriate wind loading may be obtained by multiplying the local cladding design wind pressures presented in this report by the appropriate tributary area reduction factor given in the graph below. The reduction on cladding pressures does not account for added inertial loading that may be caused by the increased flexibility of large cladding elements/systems.

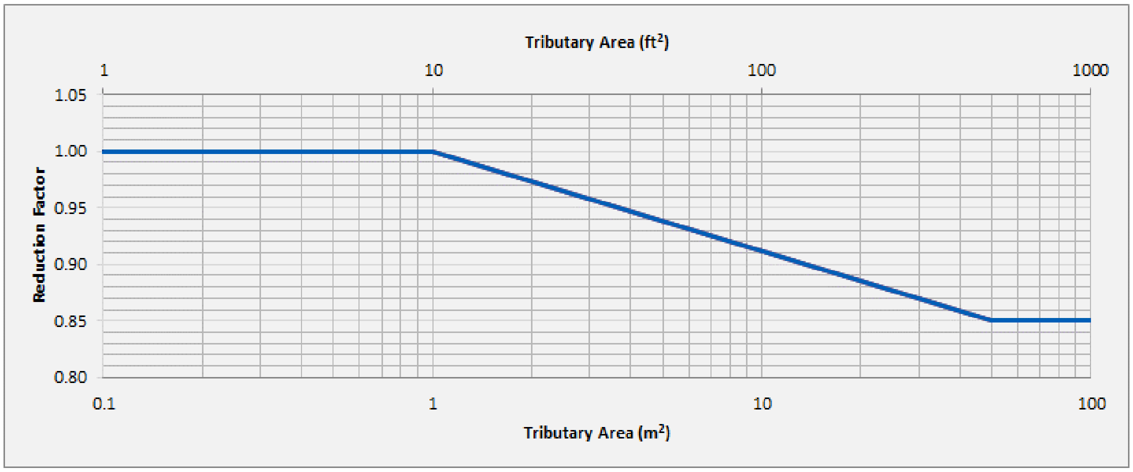


Image 2: Tributary Area Reduction Factors

3.5 Load Combinations at Corners

To design the local framing which supports the curtainwall at corners, one must know the peak loads that occur simultaneously on each face of the corner. Direct measurements of the simultaneous wind pressures were used to develop load combination factors for three significant load cases (refer to Image 4 below): one where the pressures on both faces reach high positive values; one where they both reach high negative values; and a third scenario where one face experiences high positive pressures at the same time that its adjacent face experiences high negative pressures (and vice versa).

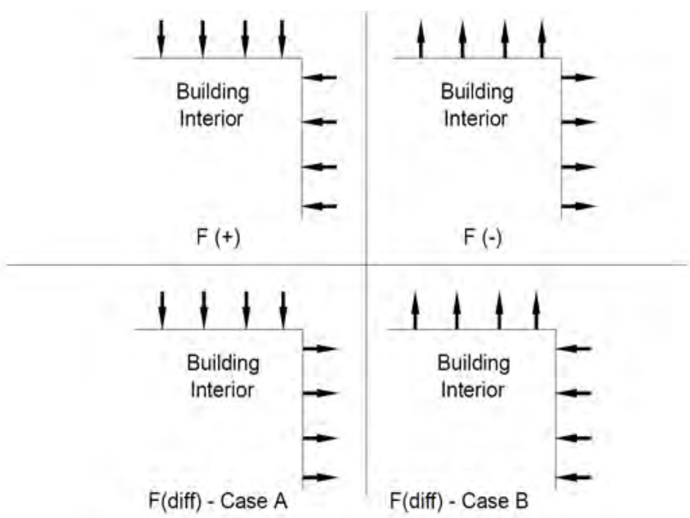


Image 3: Typical Load Cases for Corner Framing Design

Because of lack of correlation of the wind pressures at the corners, the pressures on each face do not all reach their peak pressures at the same instant. To account for this lack of correlation, the following load combination factors can be used to adjust the peak pressures:

Positive Combination Factor, F(+)	= 95%;
Negative Combination Factor, F(-)	= 85%; and,
Difference Combination Factor, F(diff)	= 75%.

The simultaneous wind loads acting on a building's corner can be determined by applying the combination factors directly to the cladding design wind pressures presented in all elevation figures. For example, to determine the simultaneous wind loads for the condition where the pressures on the two faces of the corner are both positive, the loads on the two faces can be taken as 95% of those indicated in the positive pressure block diagrams. To determine simultaneous wind loads for the condition where one face is in a negative pressure zone while the other is in a positive zone, 75% of the positive load is assumed to act on one of the two faces, while 75% of the negative load is taken to act on the other face.

If applicable, the cladding design wind pressures in the figures mentioned above may be first multiplied by the appropriate tributary area reduction factor, as discussed in Section 3.4, prior to the application of combination factors.

3.6 Statement of Limitations

3.6.1 General

This report entitled Cladding Wind Load Study was prepared by RWDI for Kobayashi Group ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided. RWDI assumes no responsibility for any inaccuracy or deficiency in information it has received from others.

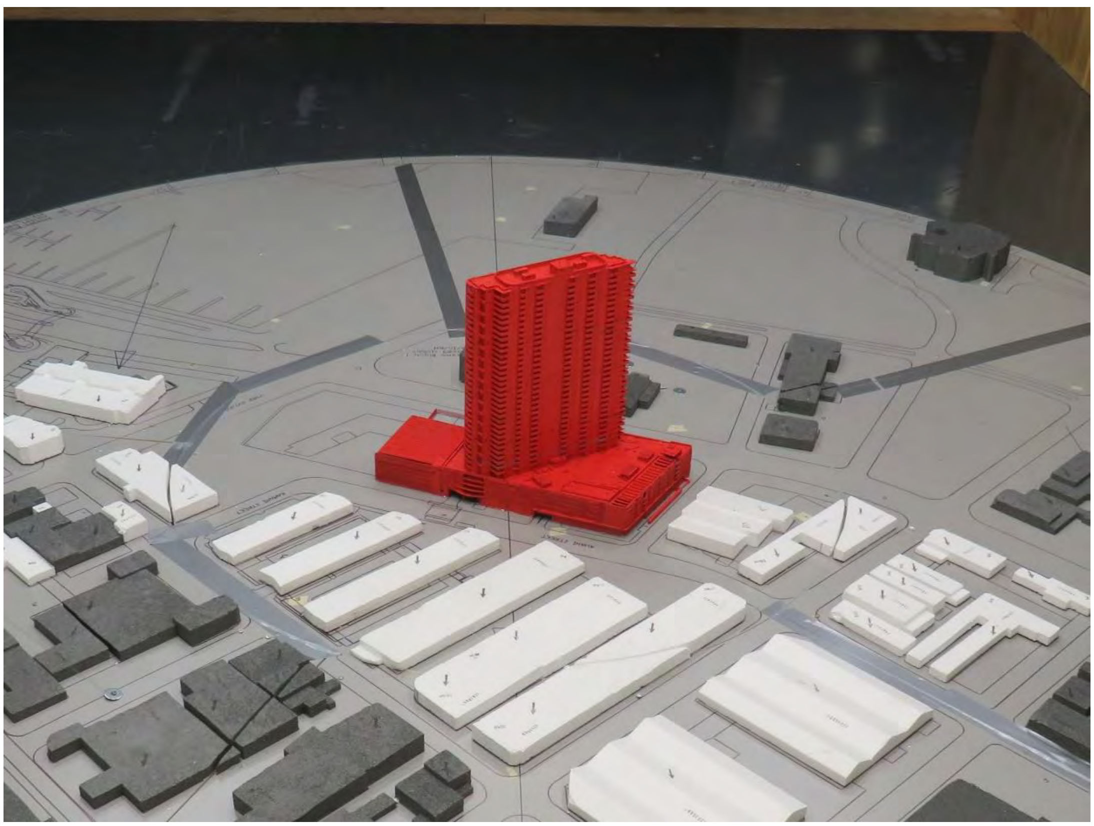
3.6.2 Scope of Assessment

The opinions in this report can only be relied up on to the extent that the Project Data and Project Specific Conditions have not changed. Any change in the Project Data or Project Specific Conditions not reflected in this report can impact and/or alter the recommendations and conclusions in this report. Therefore, it is incumbent upon the Client and/or any other third party reviewing the recommendations and conclusions in this report to contact RWDI in the event of any change in the Project Data and Project Specific Conditions in order to determine whether any such change(s) may impact the assumptions upon which the recommendations and conclusions were made.

3.6.3 Reliance on Historical Data

The recommendations and conclusions in this report are partially based on historical climate data and can be affected by a number of external factors, including but not limited to site conditions, meteorological events, and climate change. As such, the conclusions and recommendations contained in this report reflect reasonable expectations based on the information available at the time of reporting.

FIGURES



Wind Tunnel Study Model

Configuration 1

Alia Block I – Honolulu, HI

Project #2203689

Figure: 1a

Date: May 2, 2022

Wind Tunnel Study Model Configuration 2 Alia Block I – Honolulu, HI Project #2203689	Figure: 1b Date: May 2, 2022	

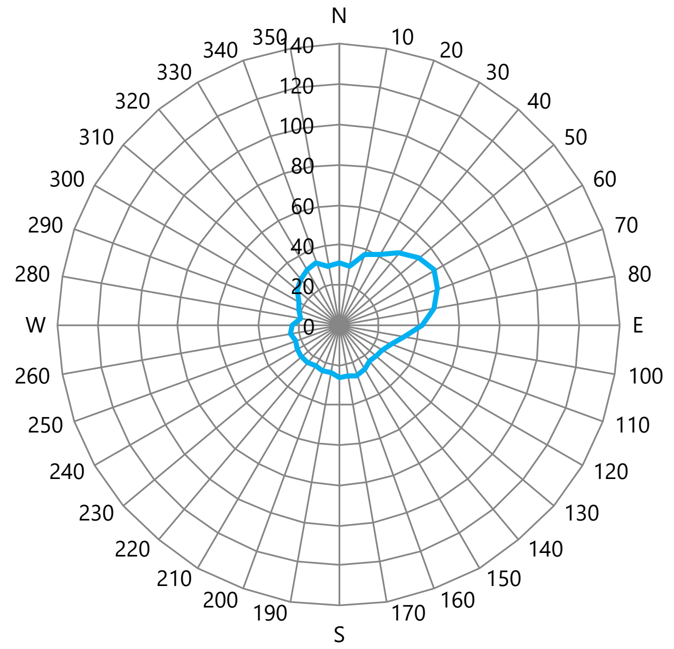
Site Plan

True North

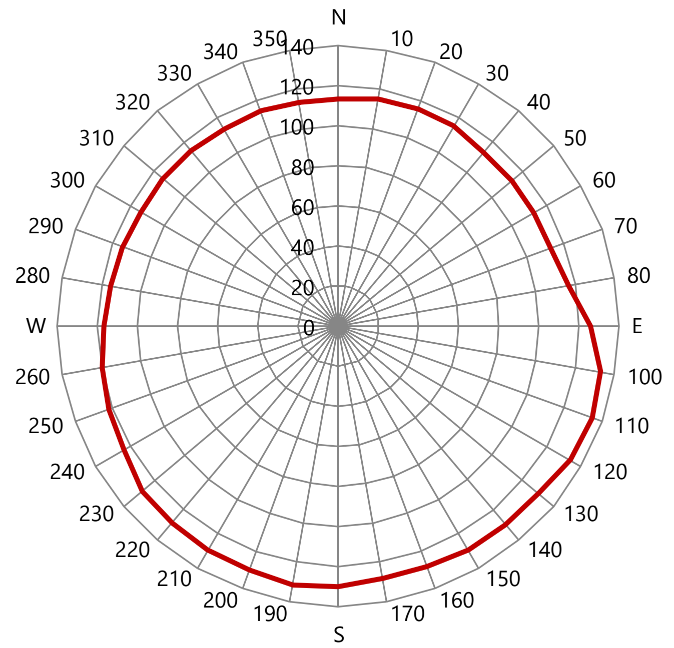
Drawn by: DAR	Figure: 2
Approx. Scale:	1 "=500 '
Date Revised:	Apr. 29, 2022

Alia Block I - Honolulu, HI

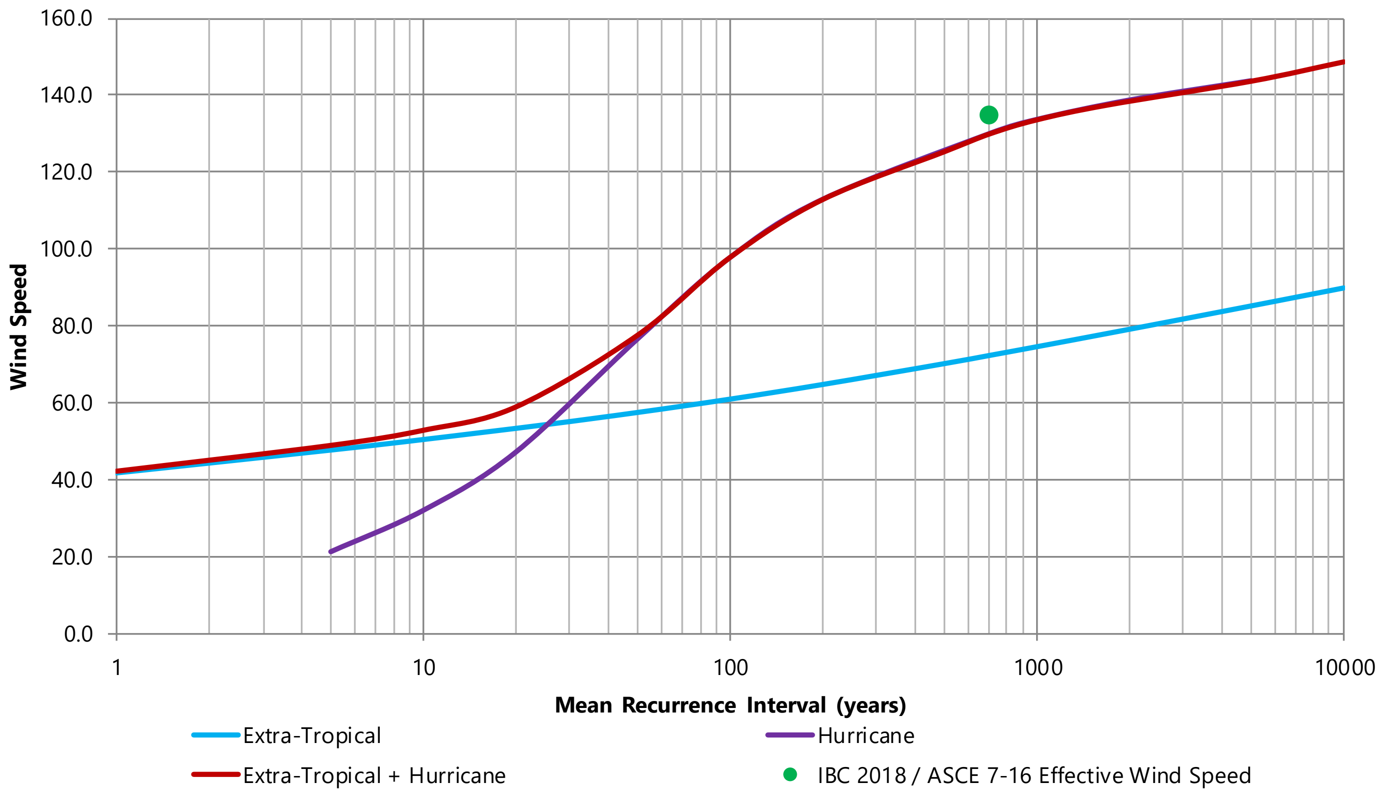
Project #: 2203689



Common Winds

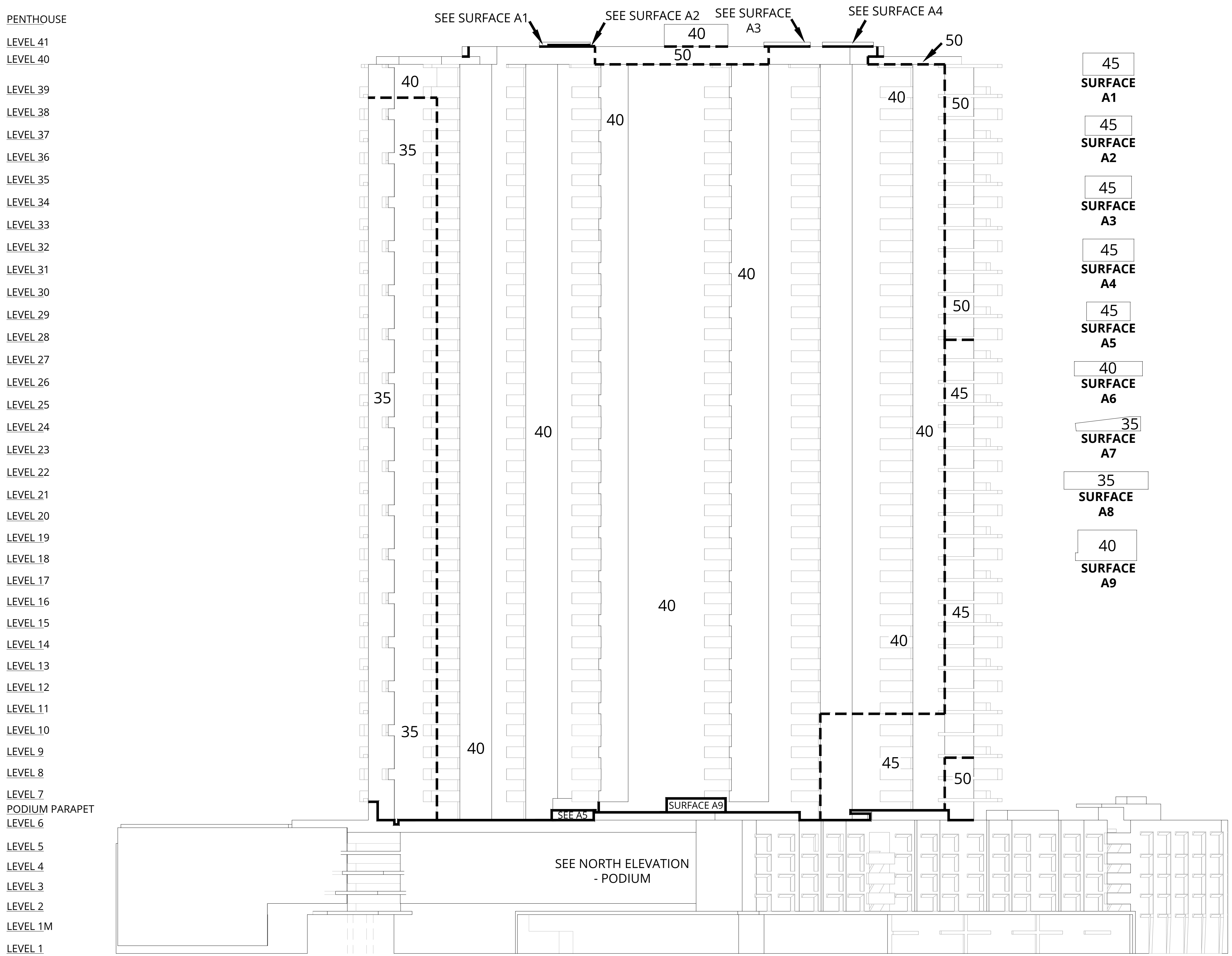


Design Winds

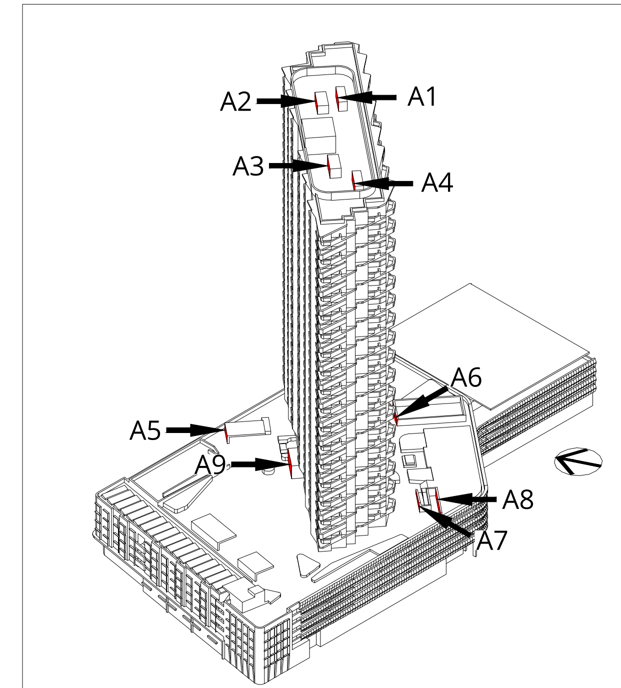


Note: Wind Speeds shown are 3-second Gust Wind Speeds (mph) at 33 ft height in Open Terrain

Directional Distribution of Local Wind Speeds	Figure: 3
Alia Block I – Honolulu, HI — Project #2203689	Date: May 2, 2022



NORTH ELEVATION - TOWER



Isometric View of Wall Surfaces: North (A)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Negative Pressures

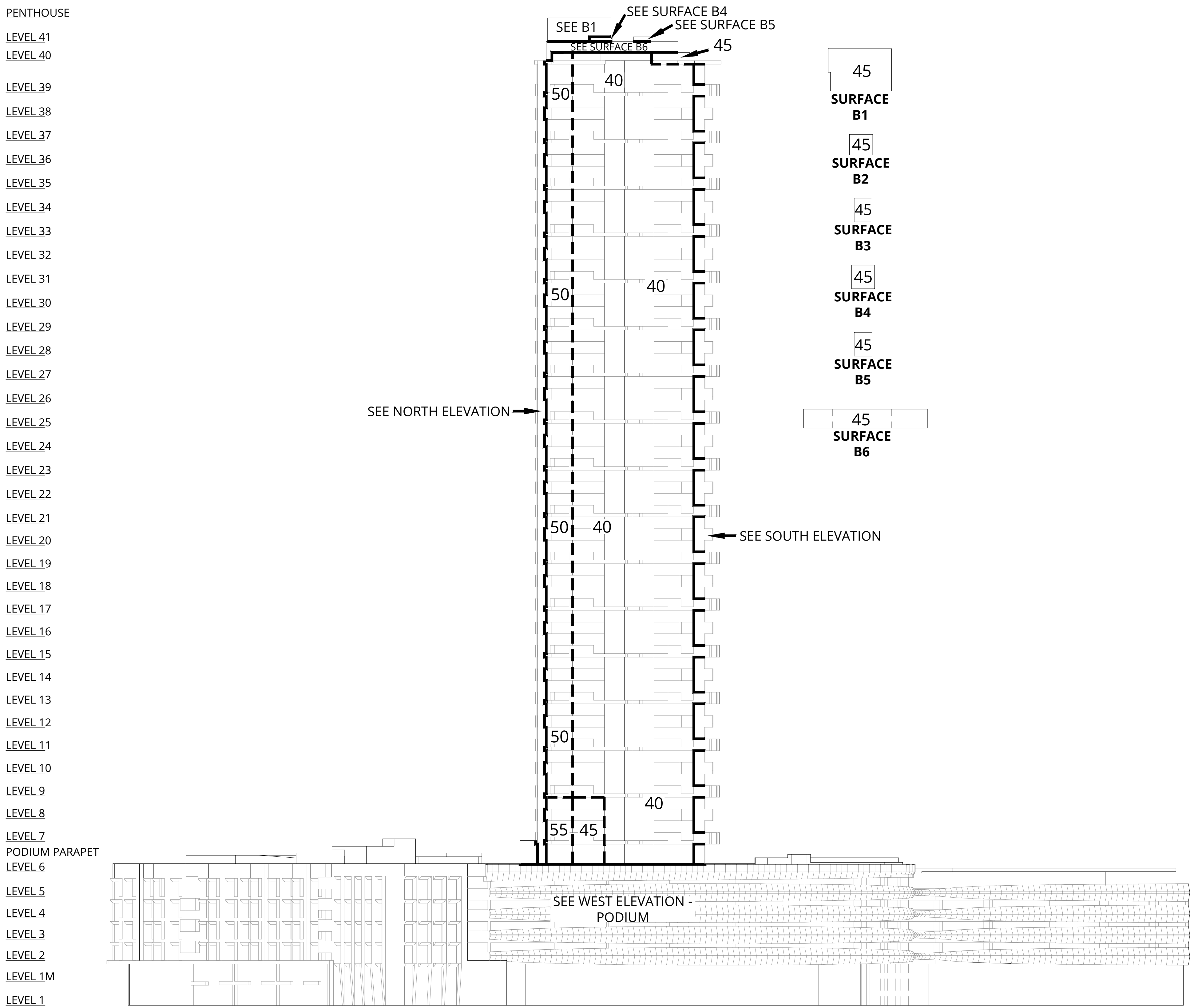
(Negative External Pressure with Positive Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

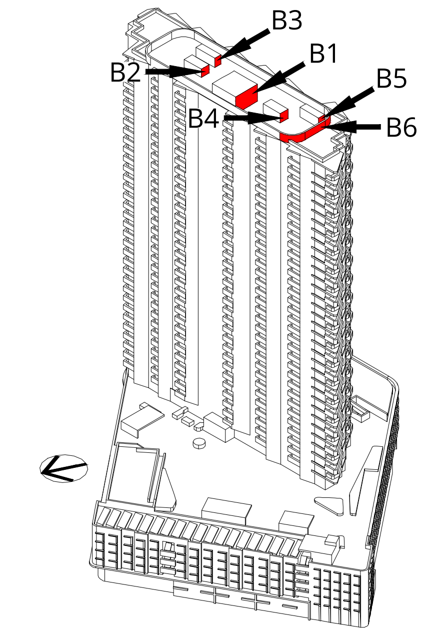
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 4
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



WEST ELEVATION - TOWER



Isometric View of Wall Surfaces: West (B)

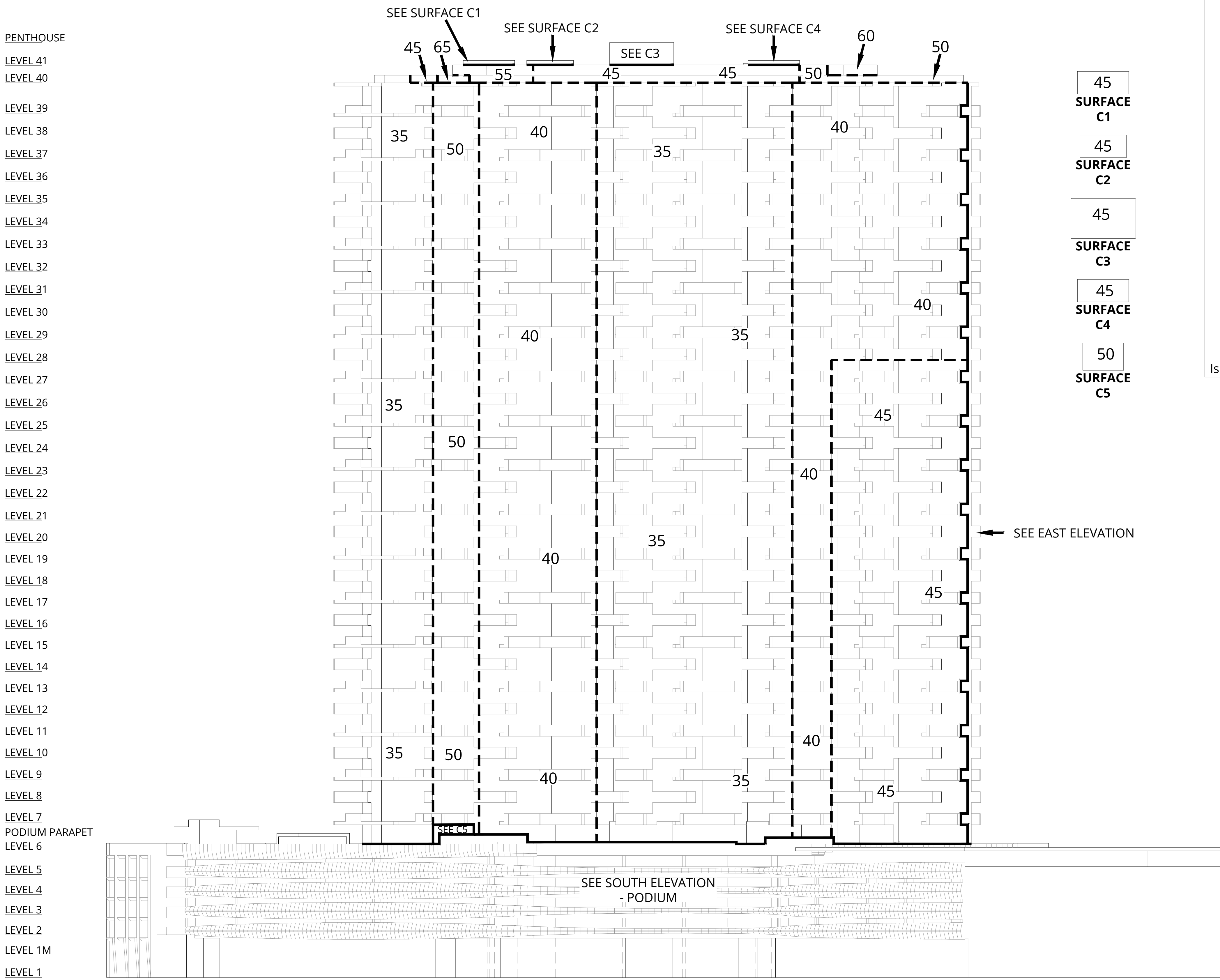
Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

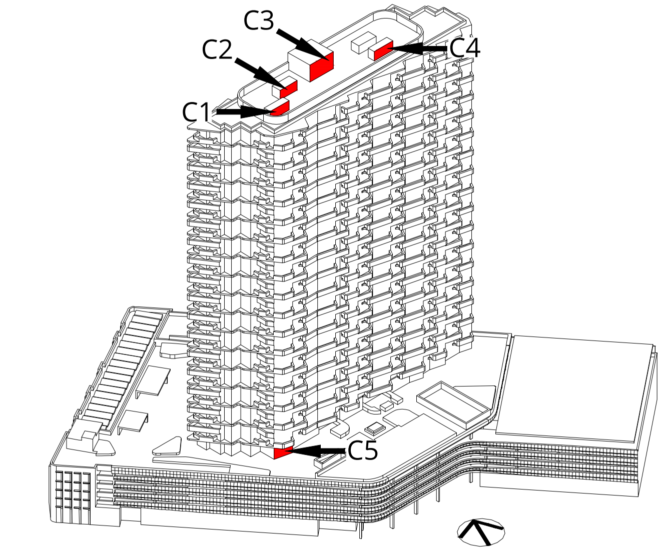
0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Negative Pressures
(Negative External Pressure with Positive Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Project #2203689	Drawn by: DAR	Figure: 5
	Approx. Scale:	1"=50'
	Date Revised:	May. 3, 2022



SOUTH ELEVATION - TOWER



Isometric View of Wall Surfaces: South (C)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Negative Pressures

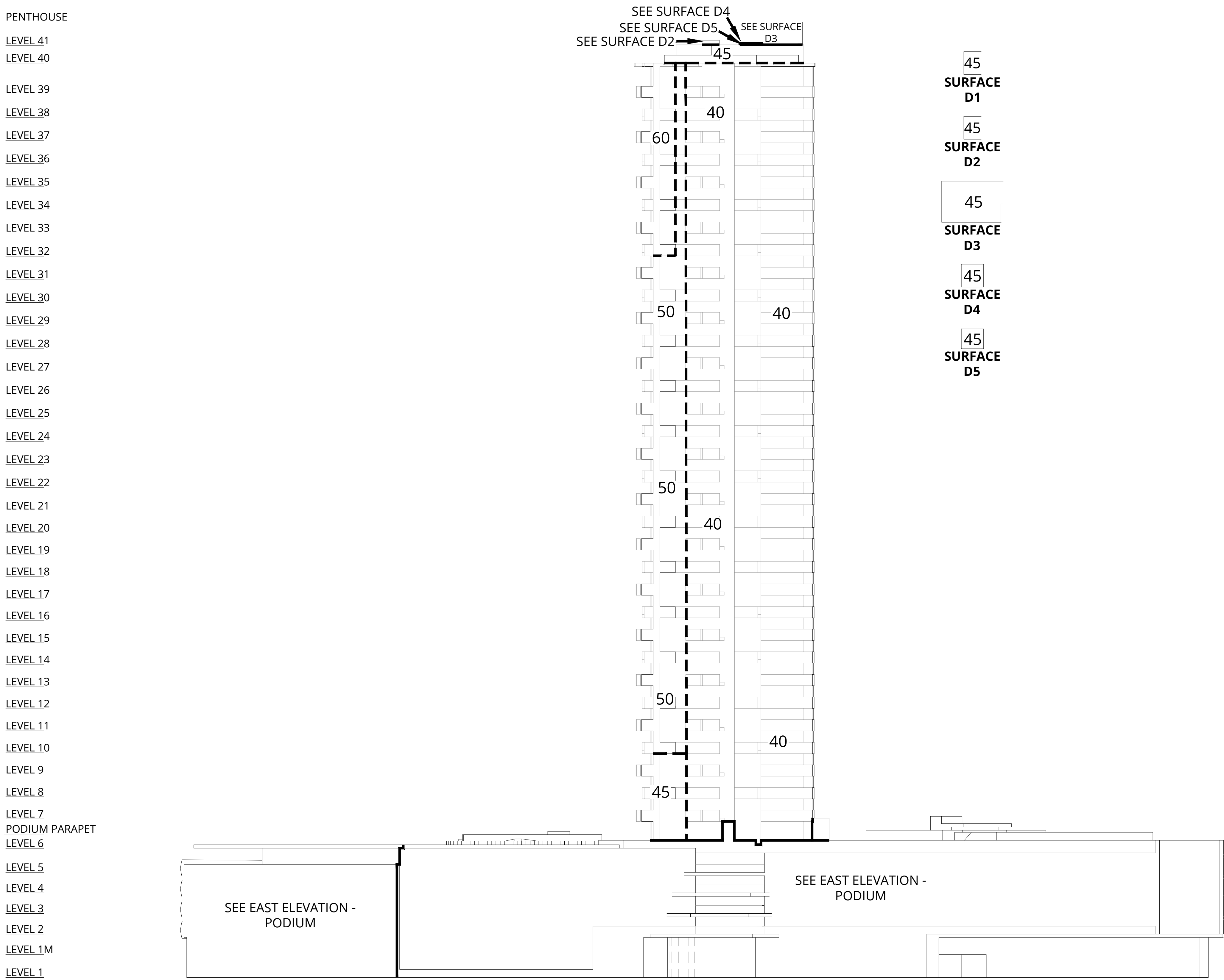
(Negative External Pressure with Positive Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

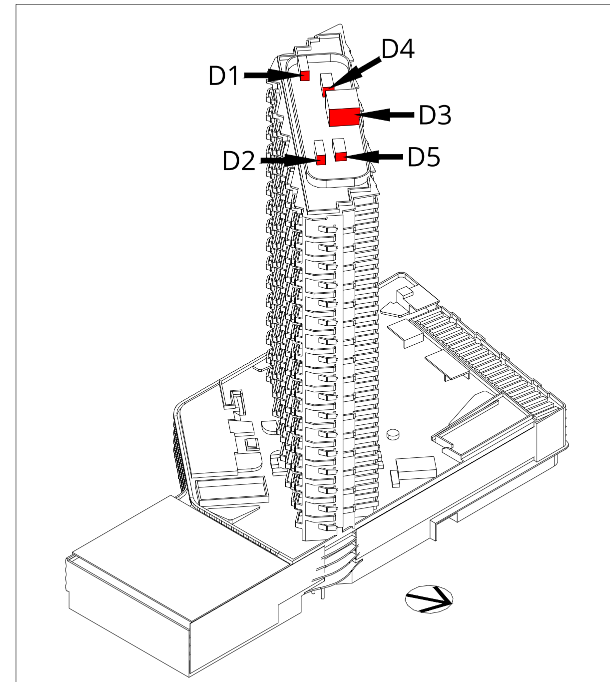
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 6	
Approx. Scale:	1"=50'	
Date Revised:	May. 3, 2022	



EAST ELEVATION - TOWER



Isometric View of Wall Surfaces: East (D)

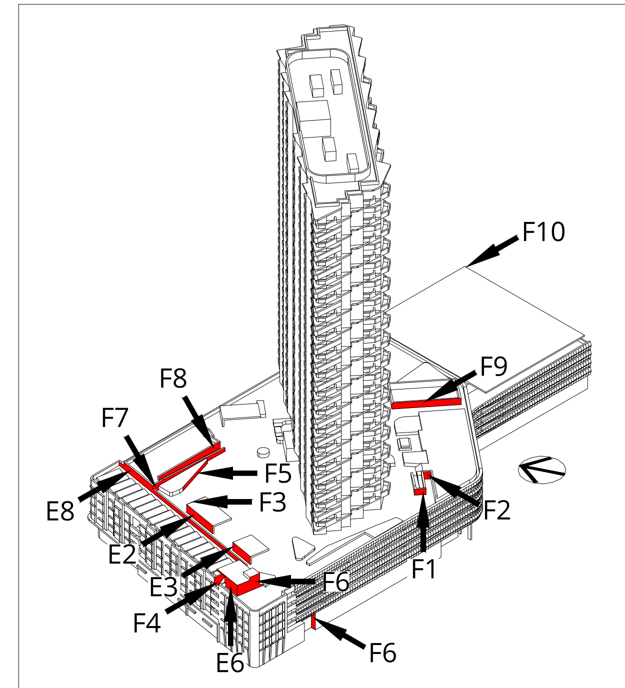
Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

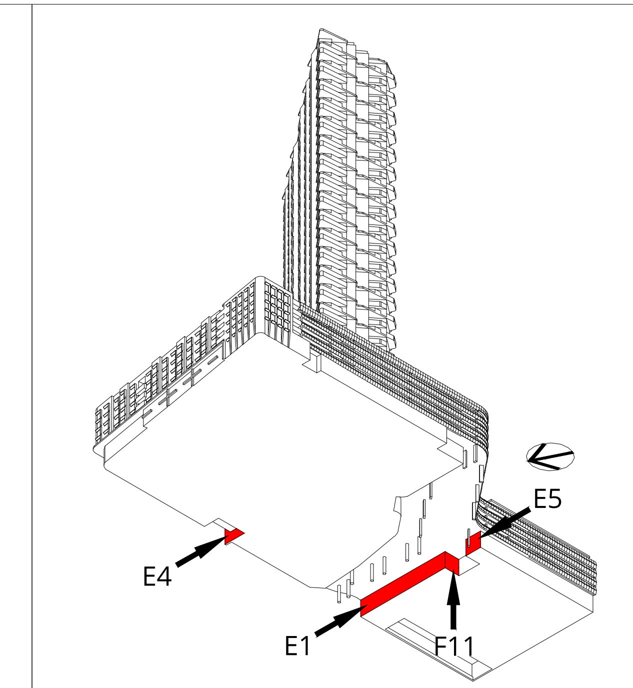
Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Negative Pressures
(Negative External Pressure with Positive Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 7
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



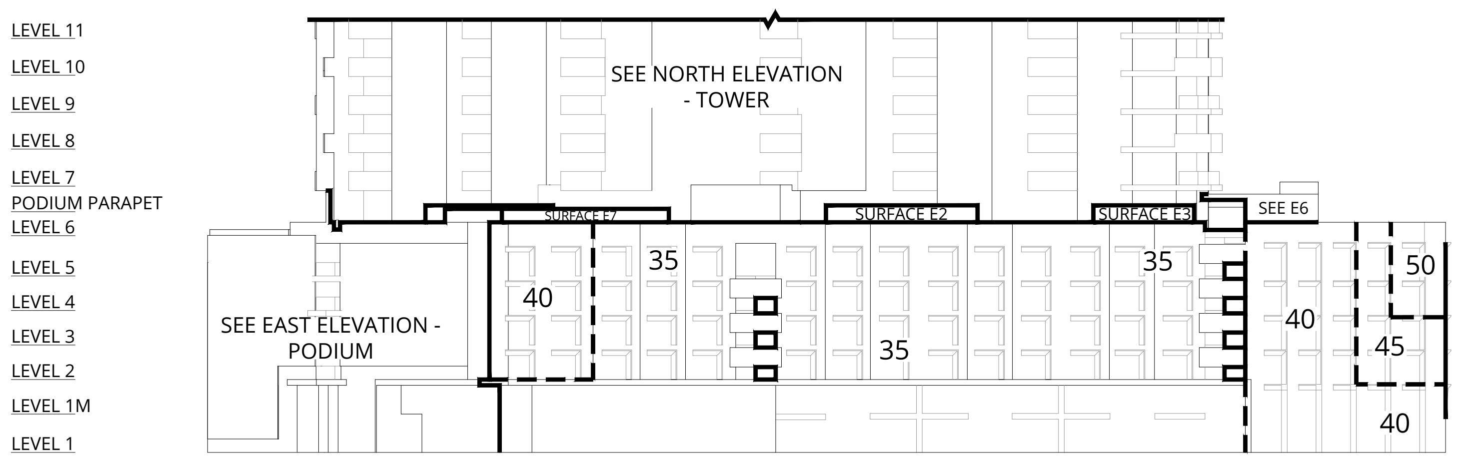
Isometric View of Wall Surfaces: North-Podium (E)



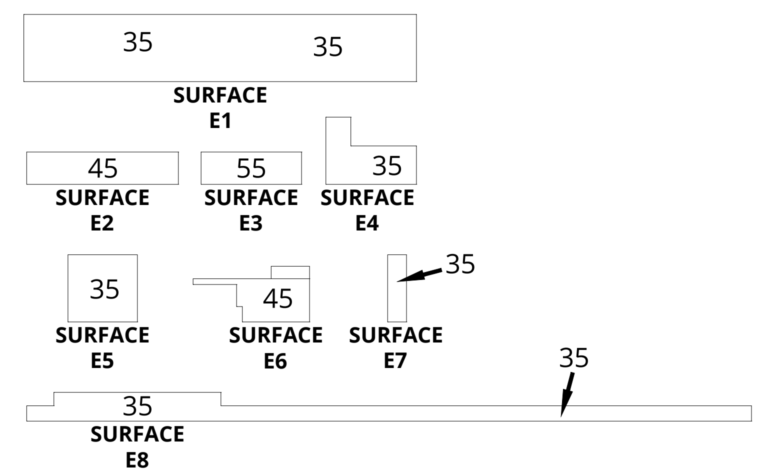
Isometric View of Wall Surfaces: West-Podium (F)

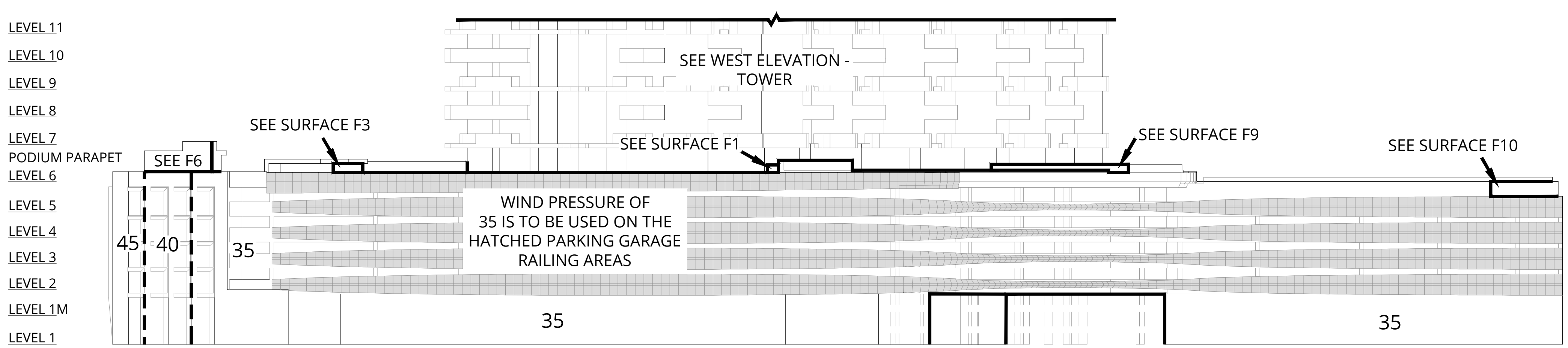
Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

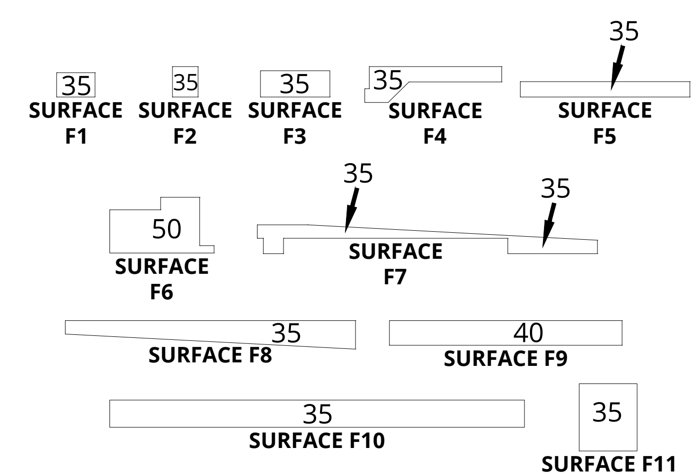


NORTH ELEVATION - PODIUM





WEST ELEVATION - PODIUM



0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Negative Pressures

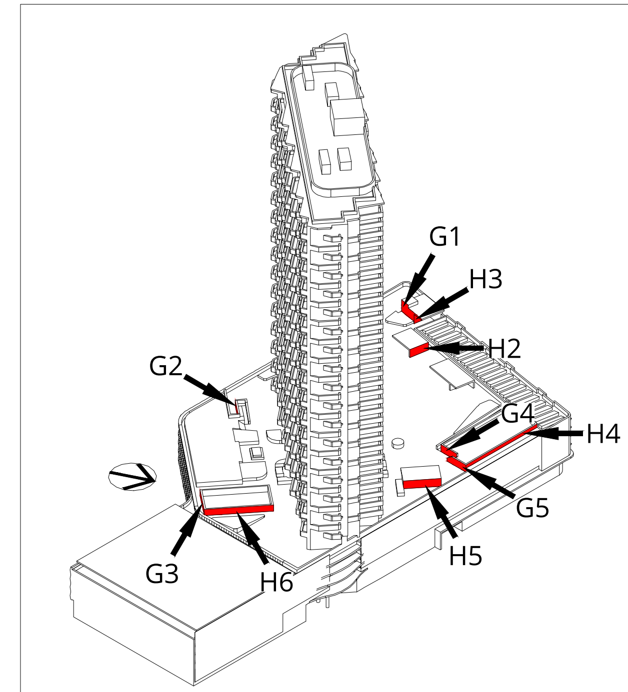
(Negative External Pressure with Positive Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

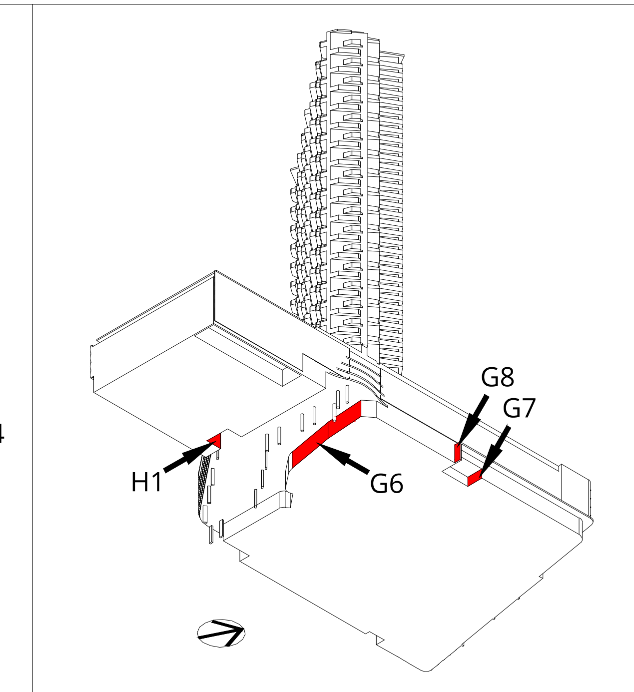
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 8
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



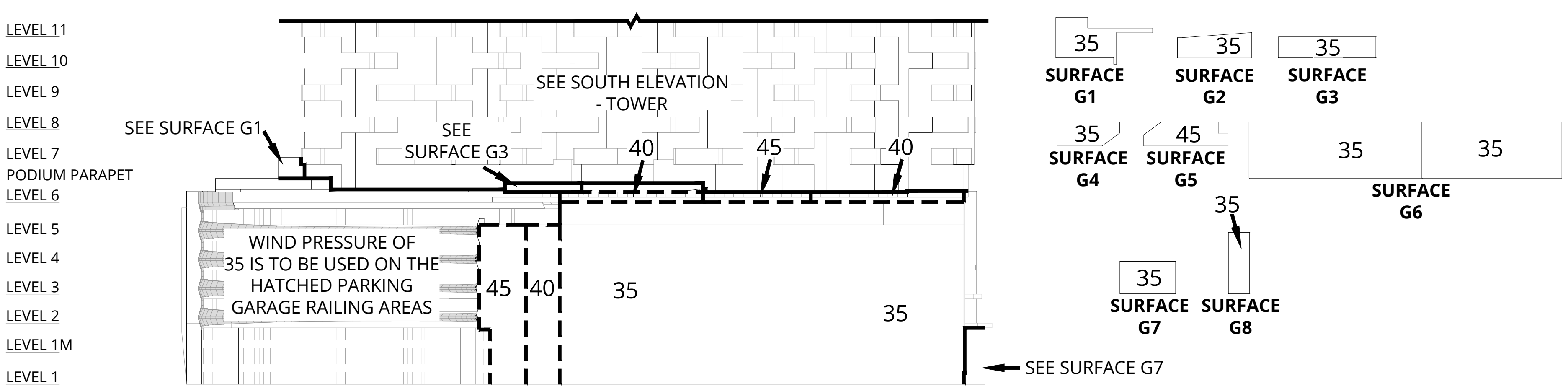
Isometric View of Wall Surfaces: South-Podium (G)



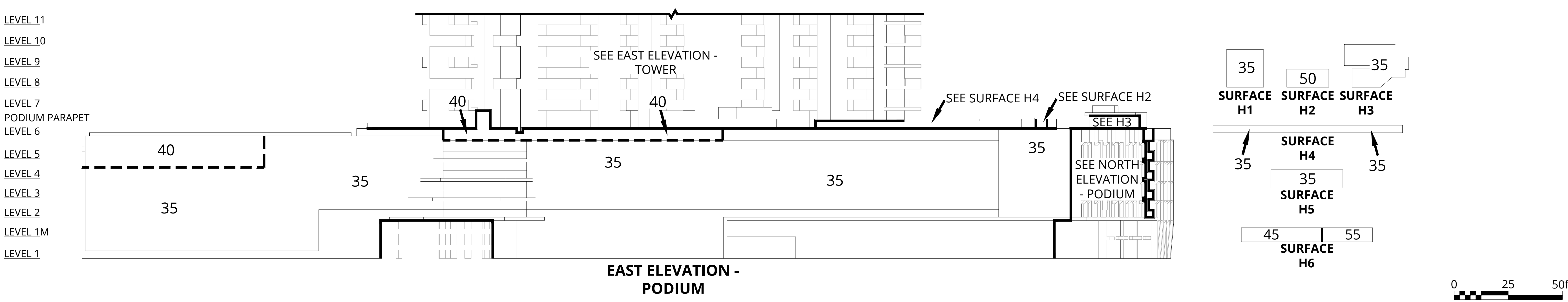
Isometric View of Wall Surfaces: East-Podium (H)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.



SOUTH ELEVATION - PODIUM

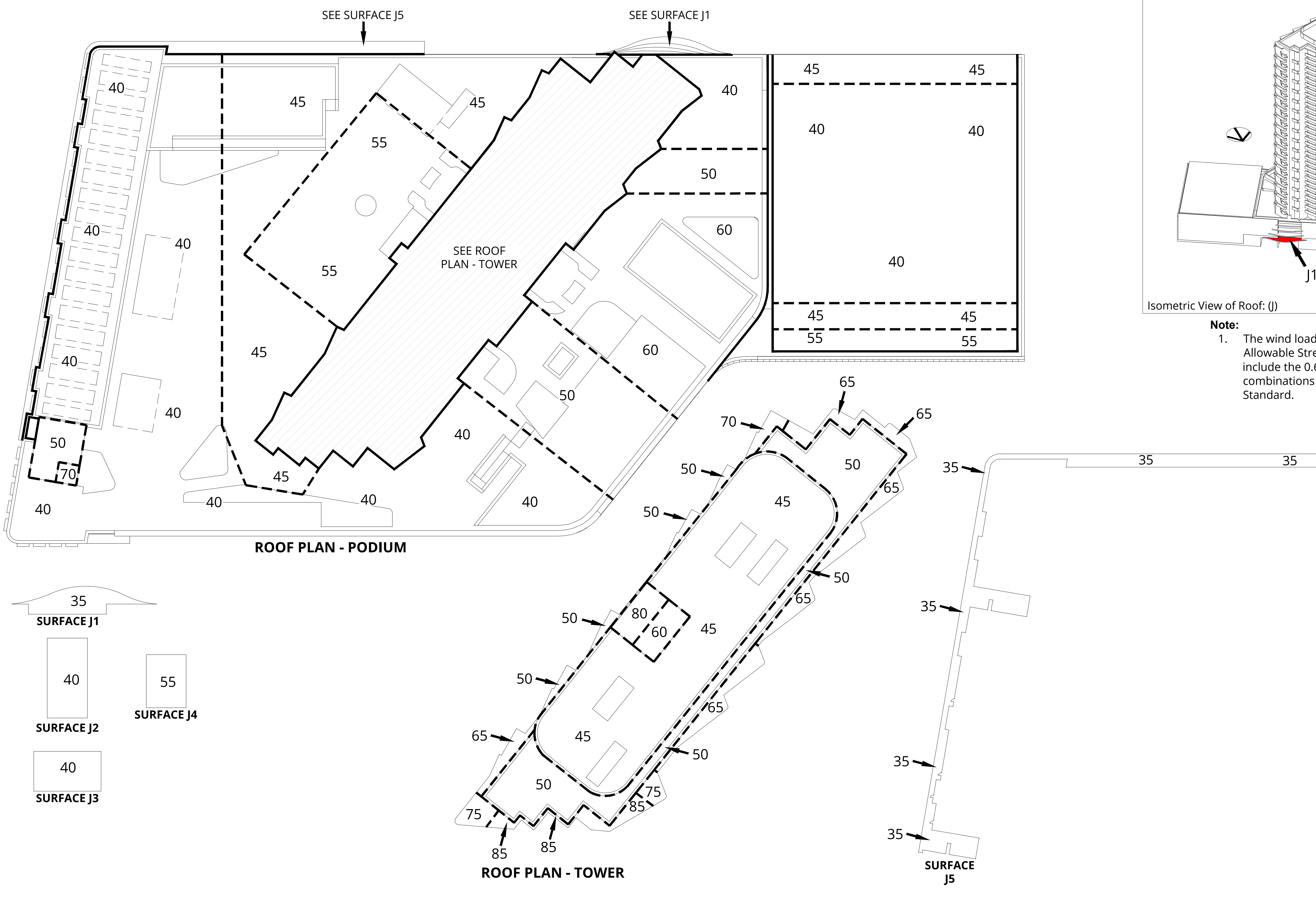


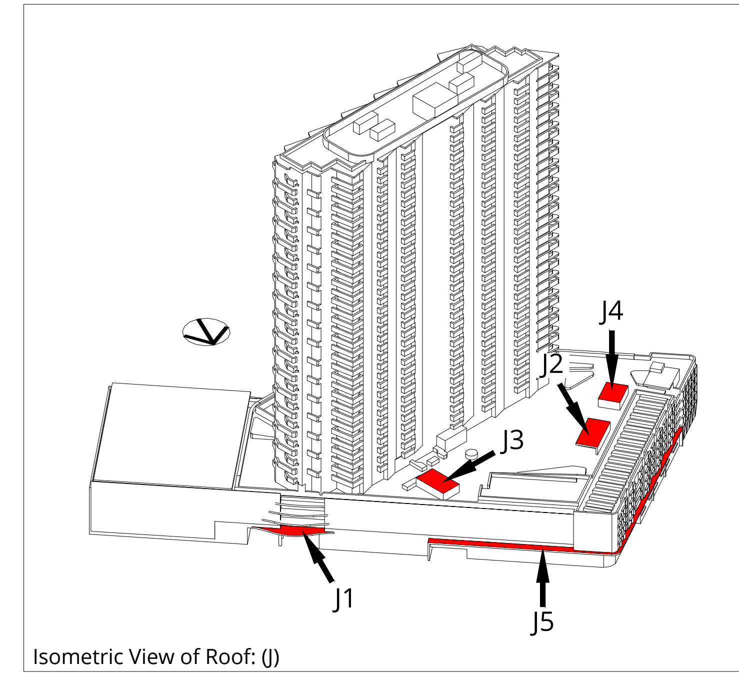
EAST ELEVATION - PODIUM

Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Negative Pressures
(Negative External Pressure with Positive Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 9
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022





Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Negative Pressures

(Negative External Pressure with Positive Internal Pressure Where Applicable)

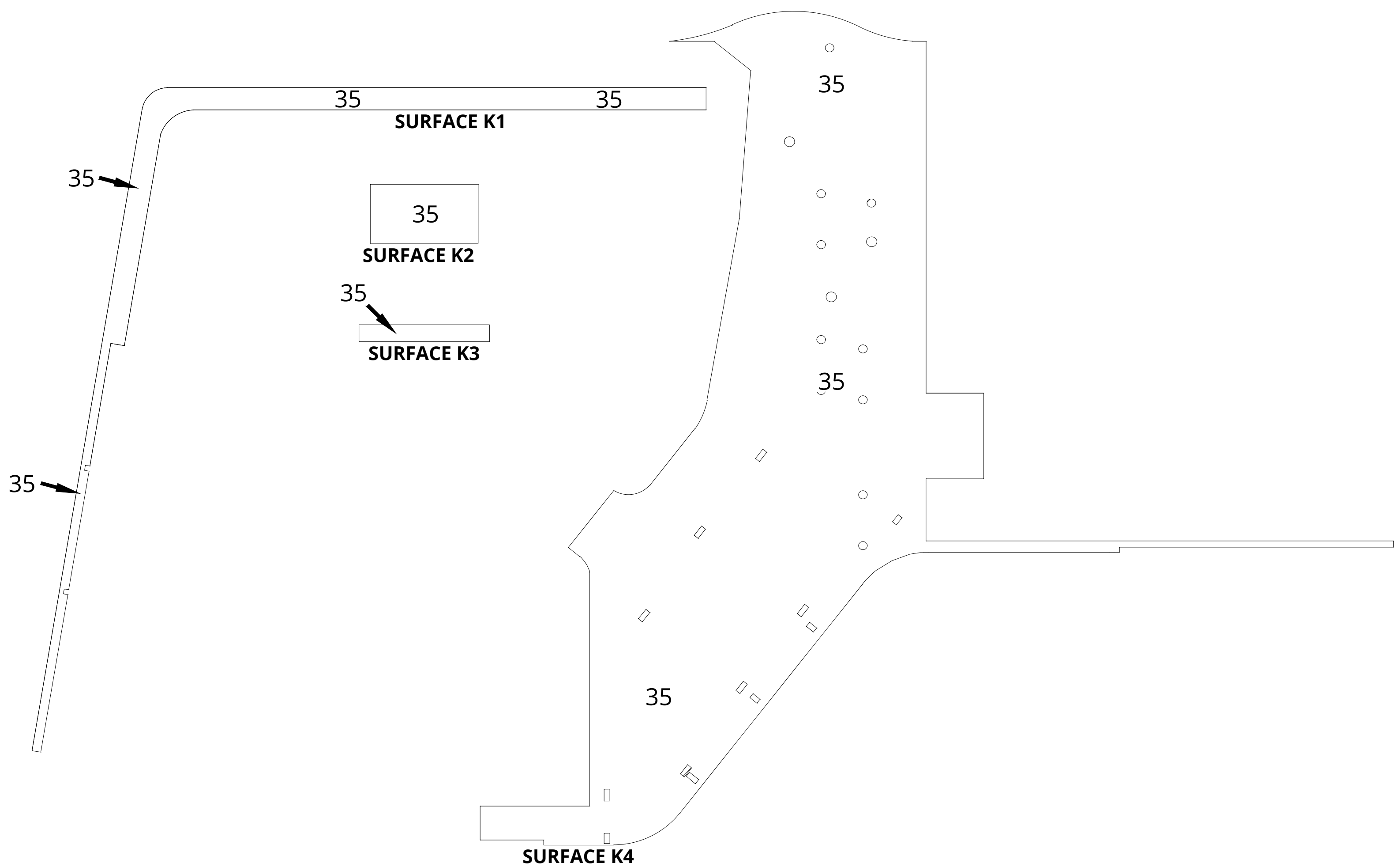
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

Alia Block I - Honolulu, HI

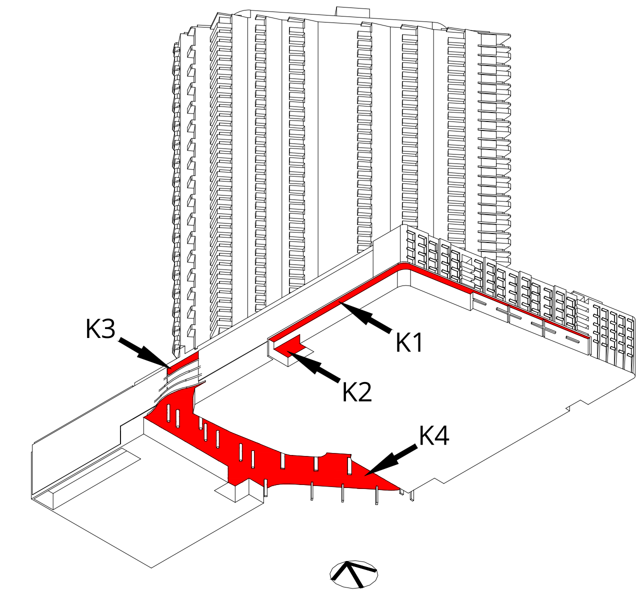
True North

Project #2203689

Drawn by: DAR	Figure: 10
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



SOFFIT SURFACES



Isometric View of Soffit: (K)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.

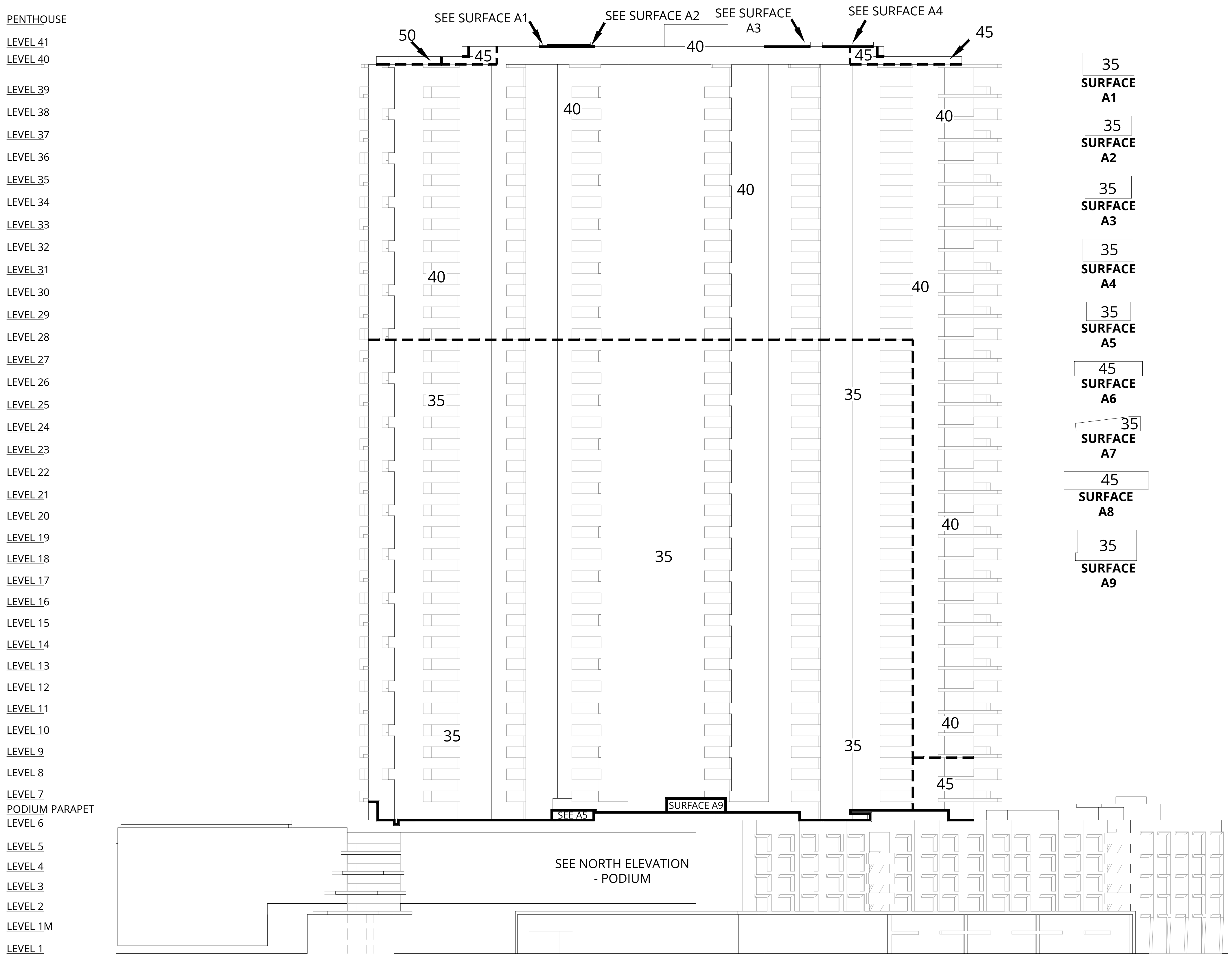
0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Negative Pressures
(Negative External Pressure with Positive Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

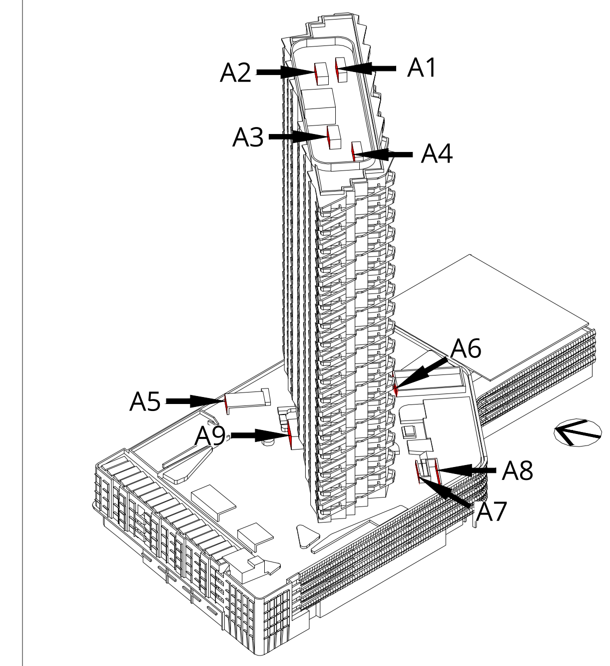
True North

Project #2203689

Drawn by: DAR	Figure: 11
Approx. Scale: 1"=50'	
Date Revised: May. 3, 2022	



NORTH ELEVATION - TOWER



Isometric View of Wall Surfaces: North (A)

Note:

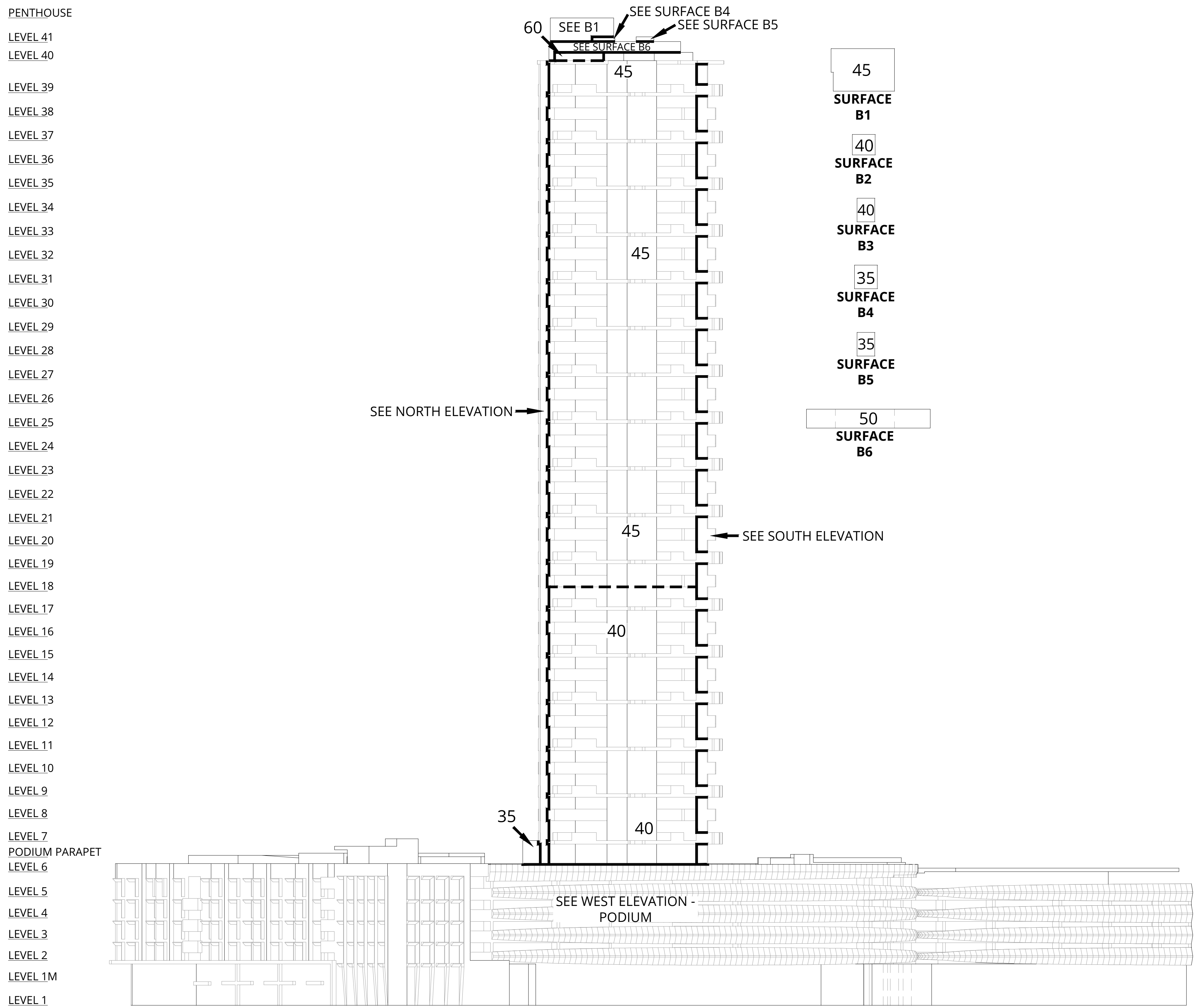
1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

0 25 50ft

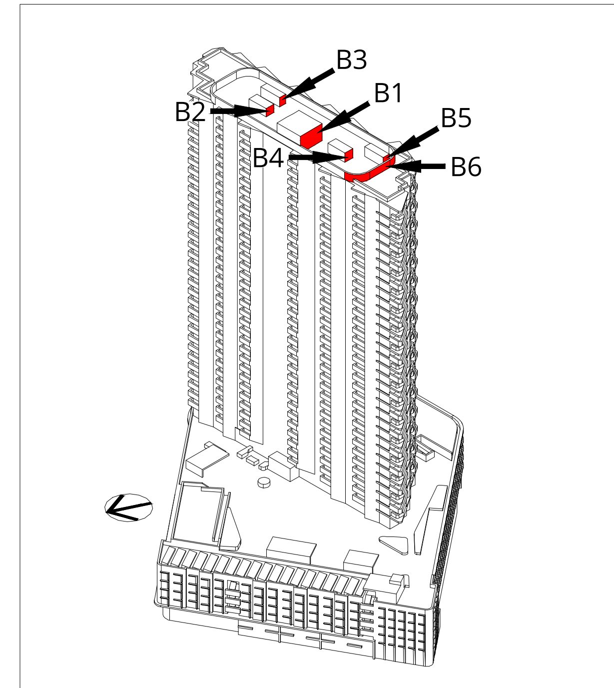
Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Positive Pressures
(Positive External Pressure with Negative Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 12
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



WEST ELEVATION - TOWER



Isometric View of Wall Surfaces: West (B)

Note:

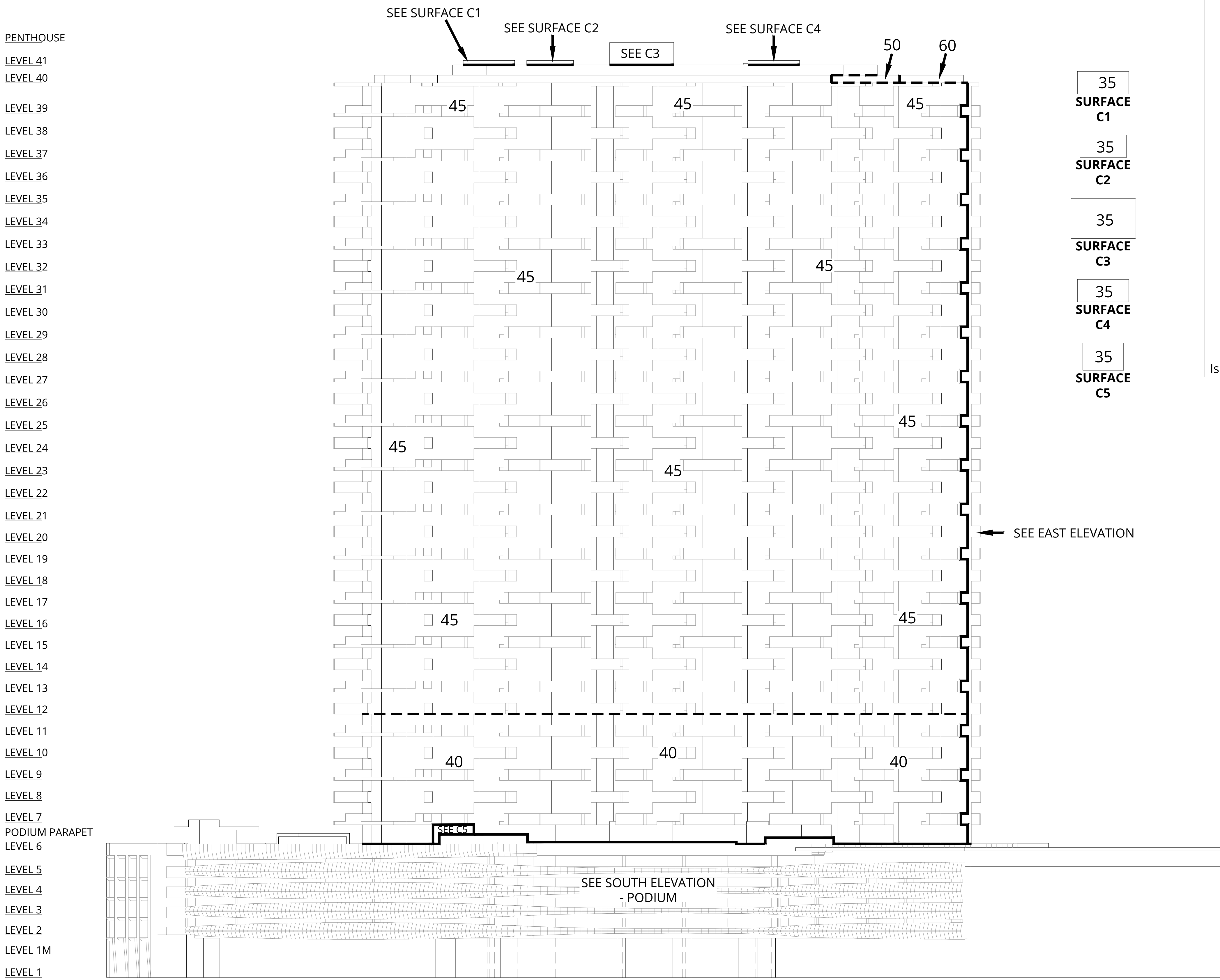
1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

0 25 50ft

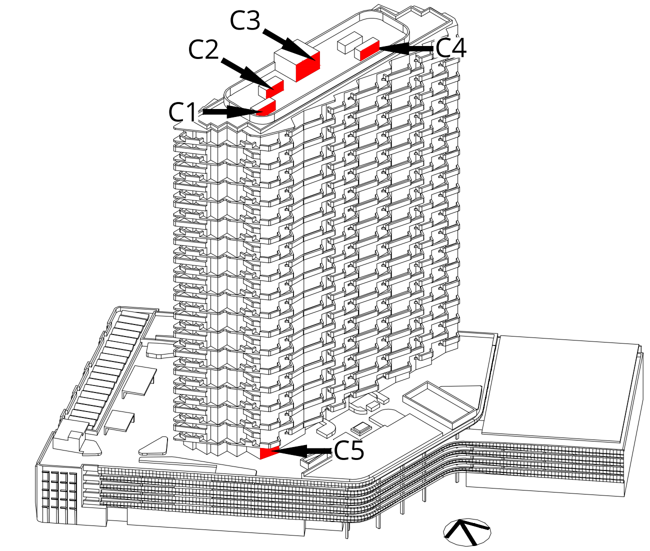
Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Positive Pressures
(Positive External Pressure with Negative Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 13
Approx. Scale: 1"=50'	
Date Revised: May. 3, 2022	



SOUTH ELEVATION - TOWER



Isometric View of Wall Surfaces: South (C)

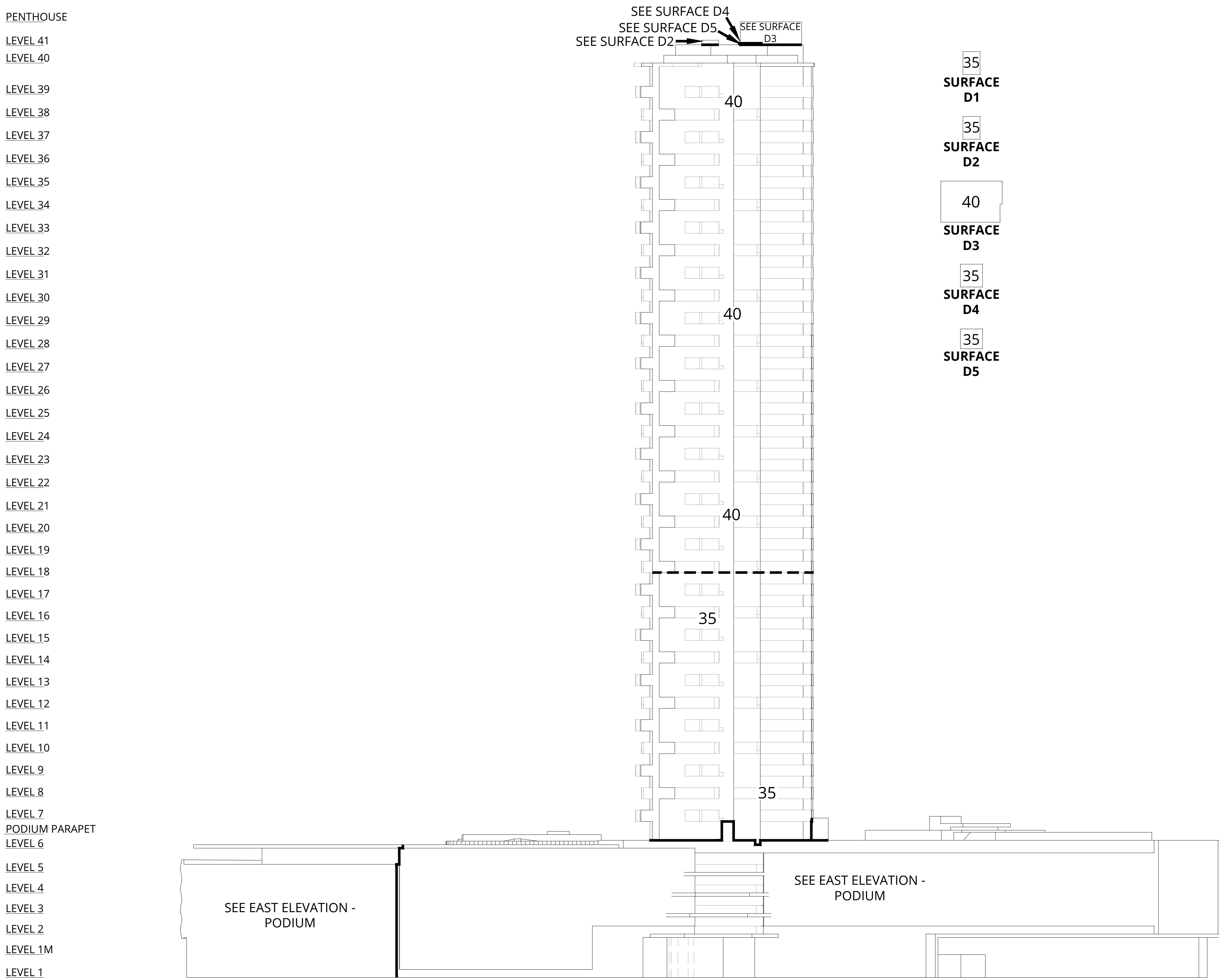
Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

0 25 50ft

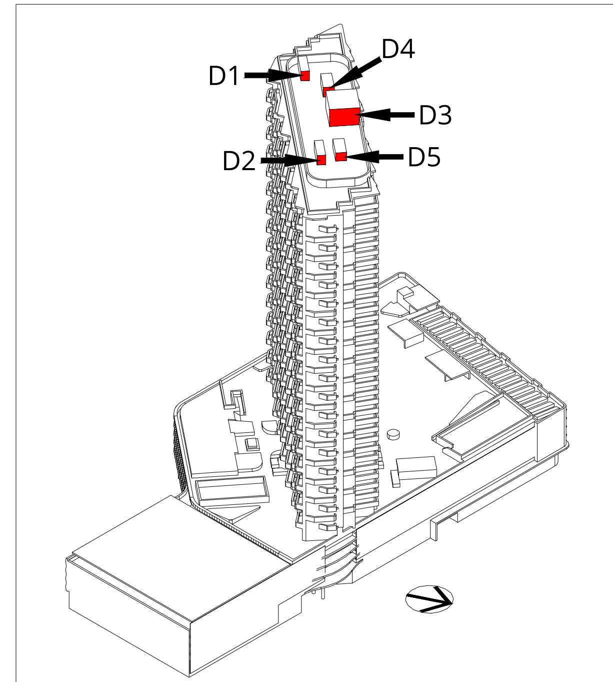
Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Positive Pressures
(Positive External Pressure with Negative Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Drawn by: DAR	Figure: 14
Approx. Scale:	1"=50'
Project #2203689 Date Revised:	May. 3, 2022



EAST ELEVATION - TOWER

0 25 50ft



Isometric View of Wall Surfaces: East (D)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Positive Pressures

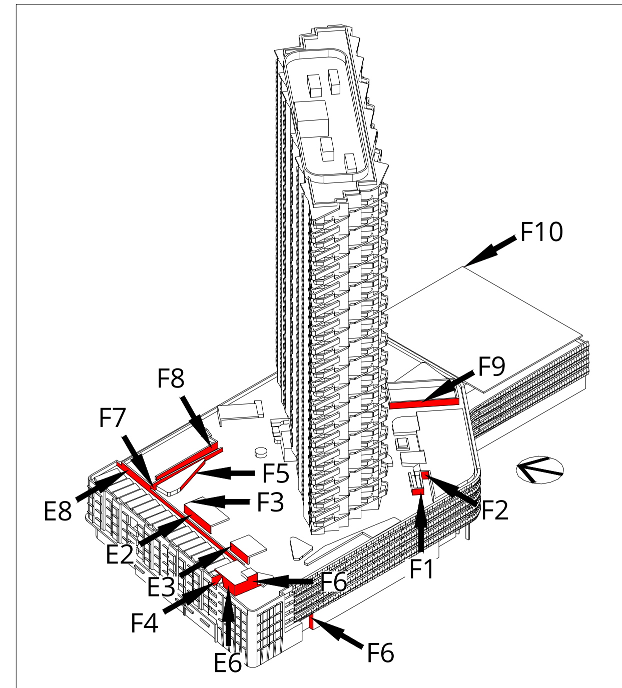
(Positive External Pressure with Negative Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

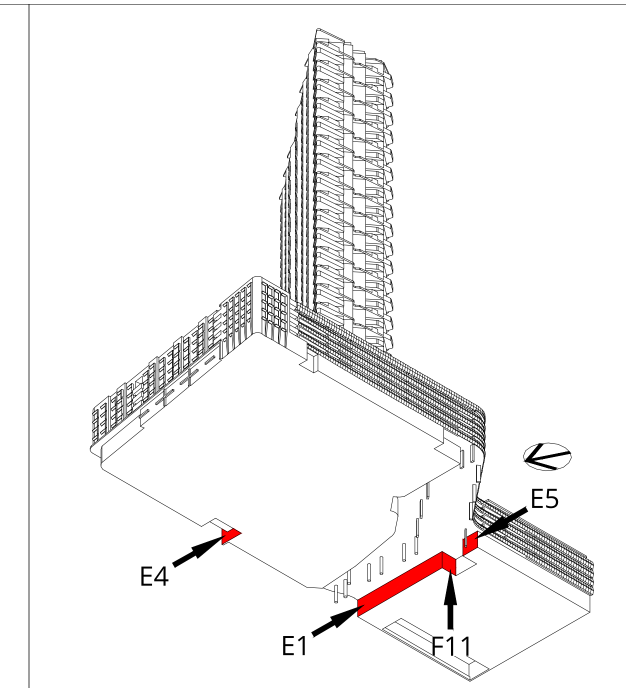
Alia Block I - Honolulu, HI

Project #2203689

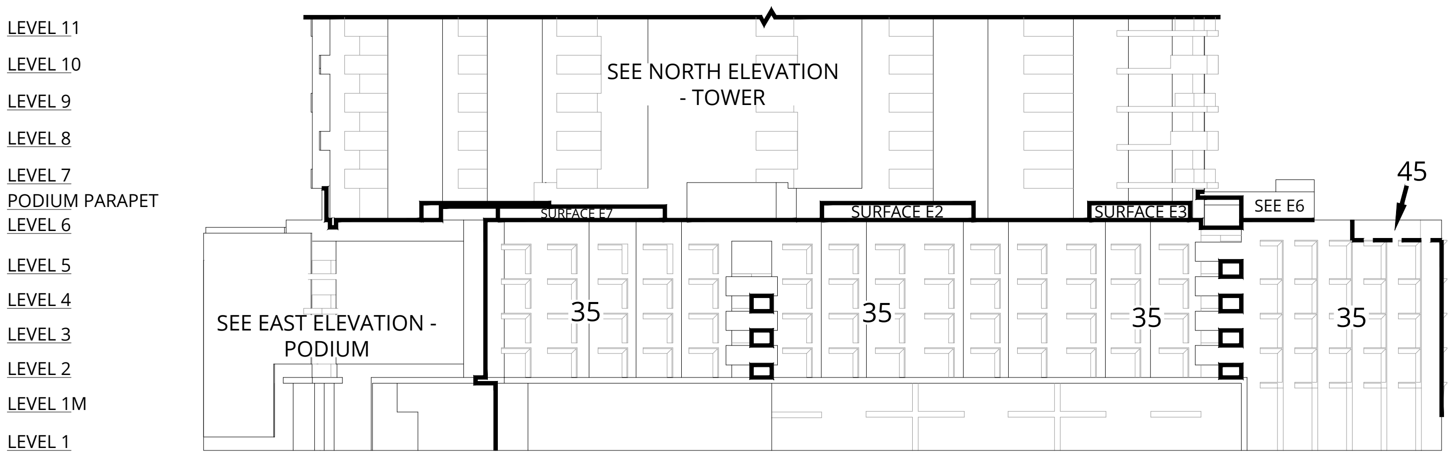
Drawn by: DAR	Figure: 15
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



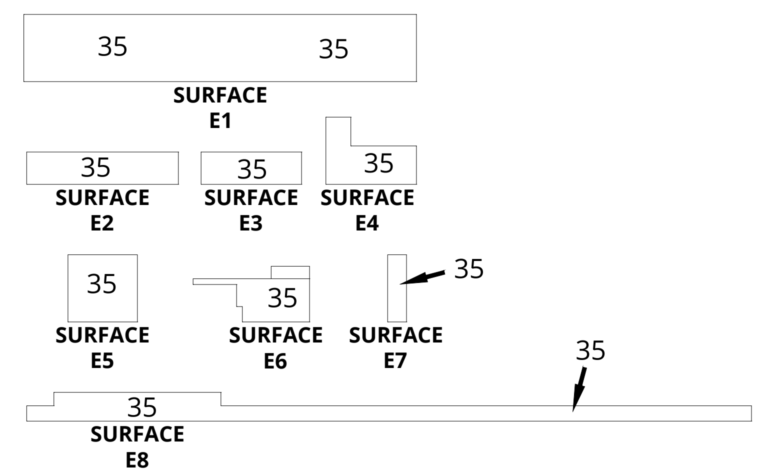
Isometric View of Wall Surfaces: North-Podium (E)



Isometric View of Wall Surfaces: West-Podium (F)

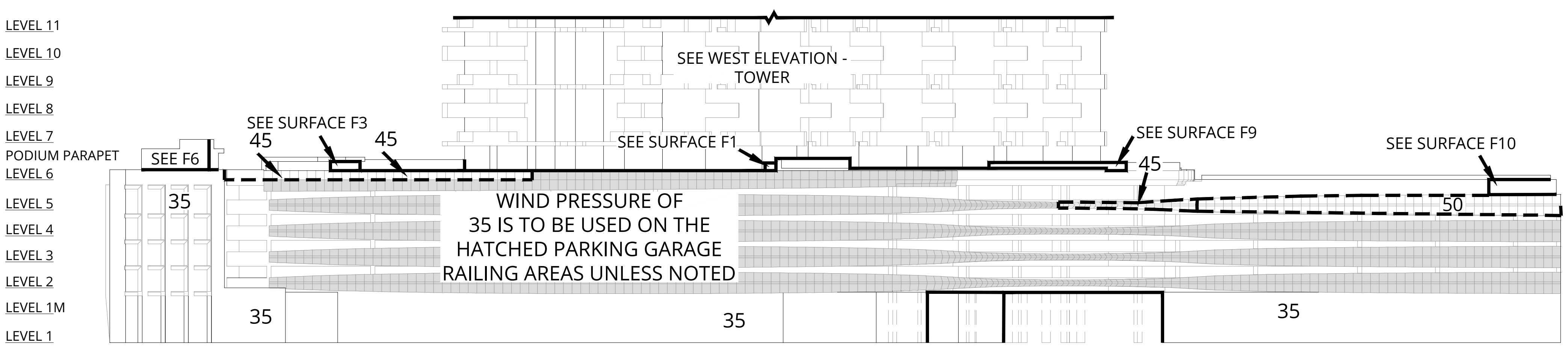


NORTH ELEVATION - PODIUM

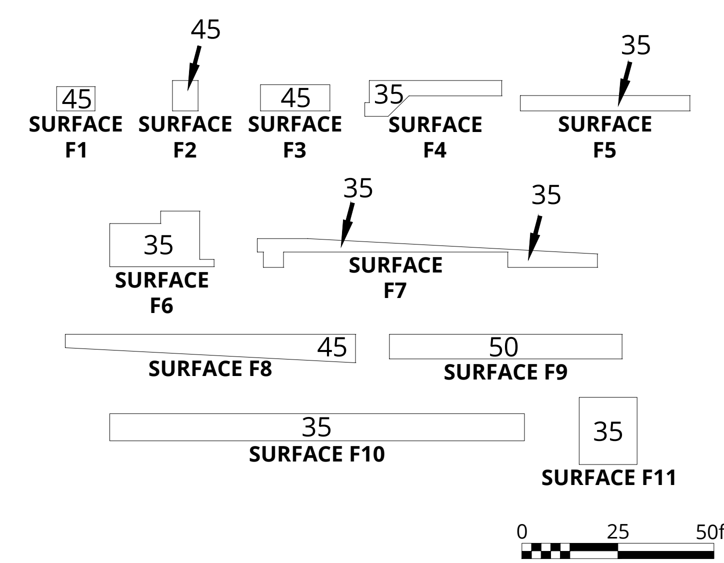


Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.



WEST ELEVATION - PODIUM



Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Positive Pressures

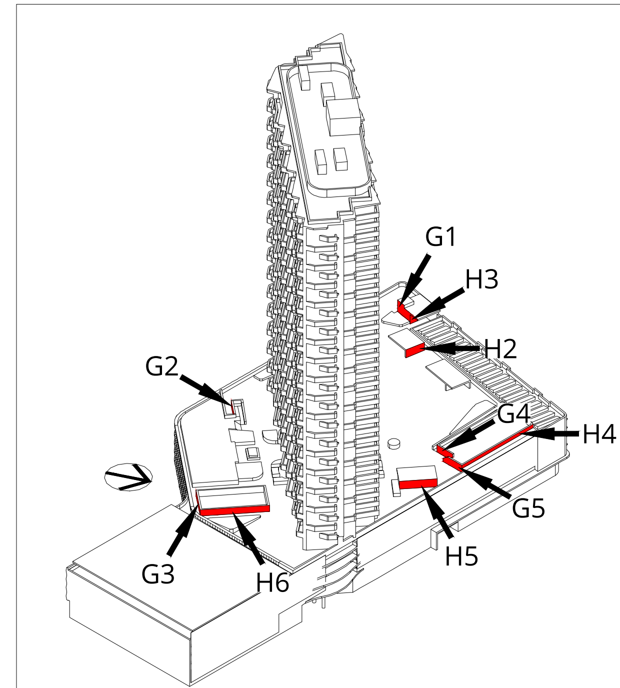
(Positive External Pressure with Negative Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

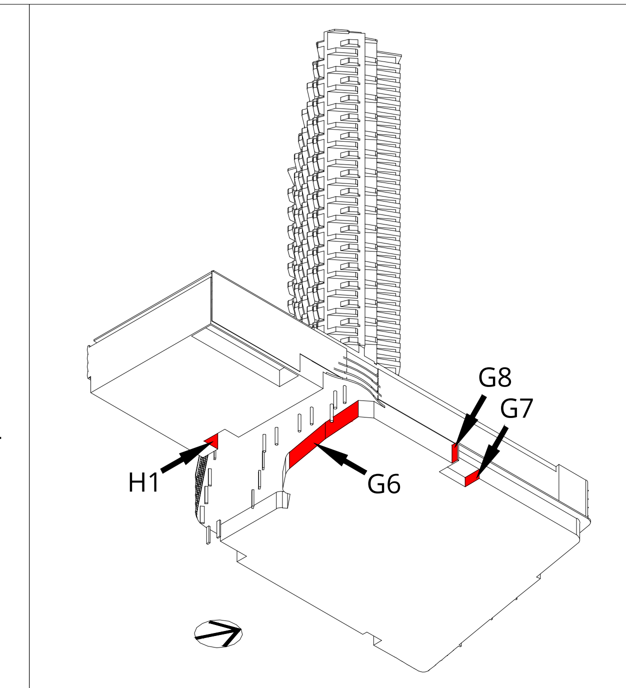
Alia Block I - Honolulu, HI

Project #2203689

Drawn by: DAR	Figure: 16
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022



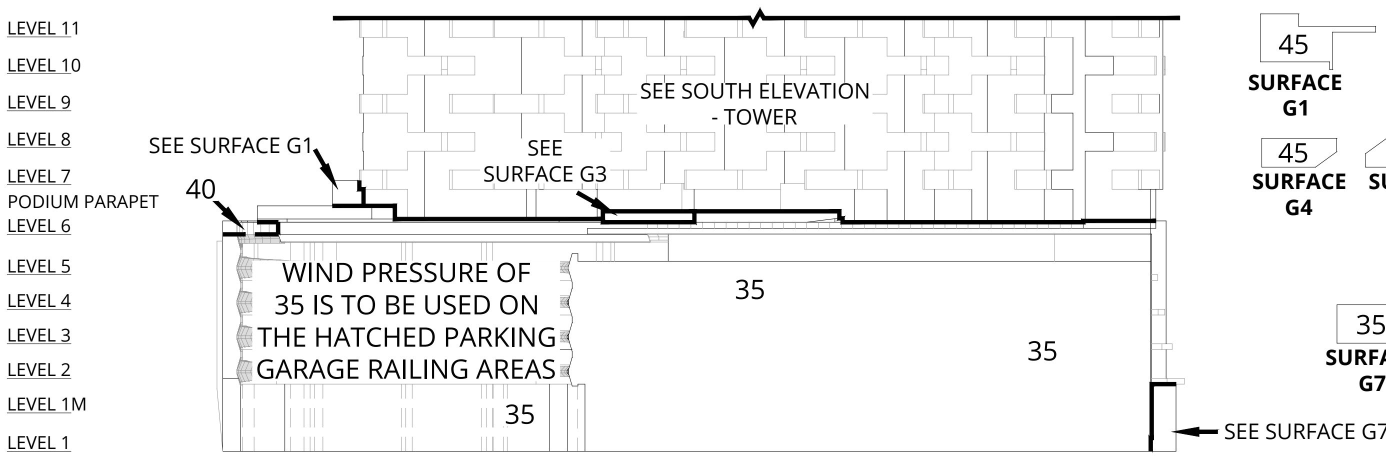
Isometric View of Wall Surfaces: South-Podium (G)



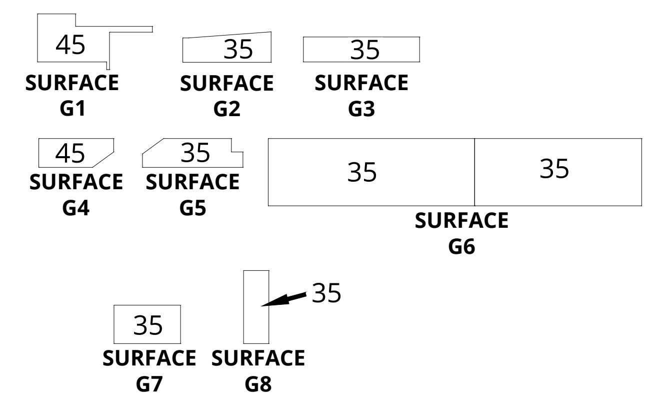
Isometric View of Wall Surfaces: East-Podium (H)

Note:

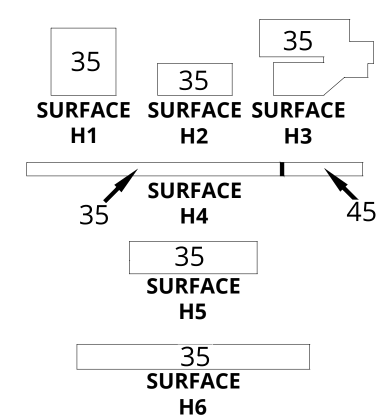
1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.
2. The wind loads provided in this figure apply to cladding elements behind balcony guardrails. For the design of all balcony guardrails refer to Figure 20. For the design of guardrails around open terraces or accessible roof areas, please refer to the recommended wind pressures in this figure.



SOUTH ELEVATION - PODIUM



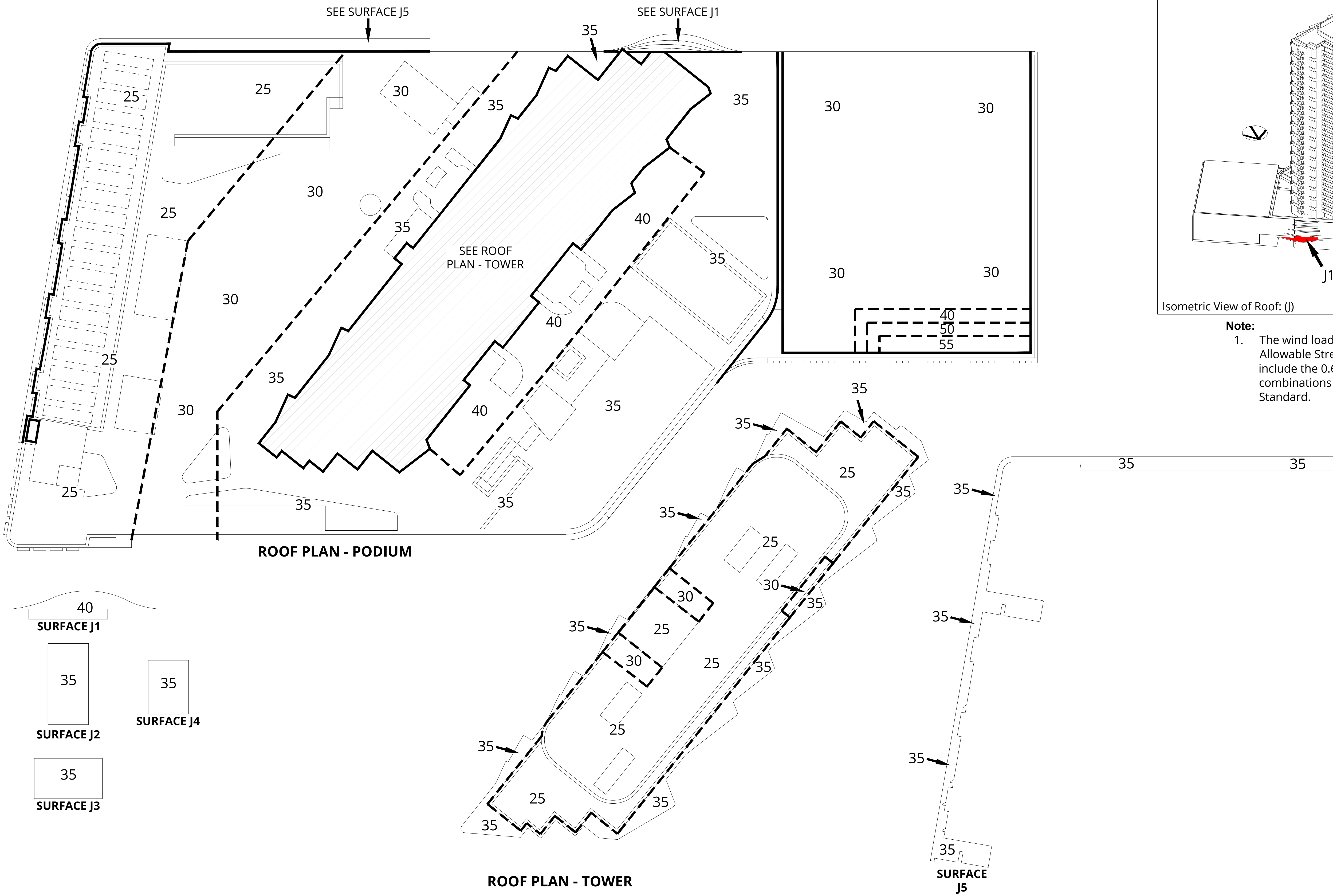
EAST ELEVATION - PODIUM

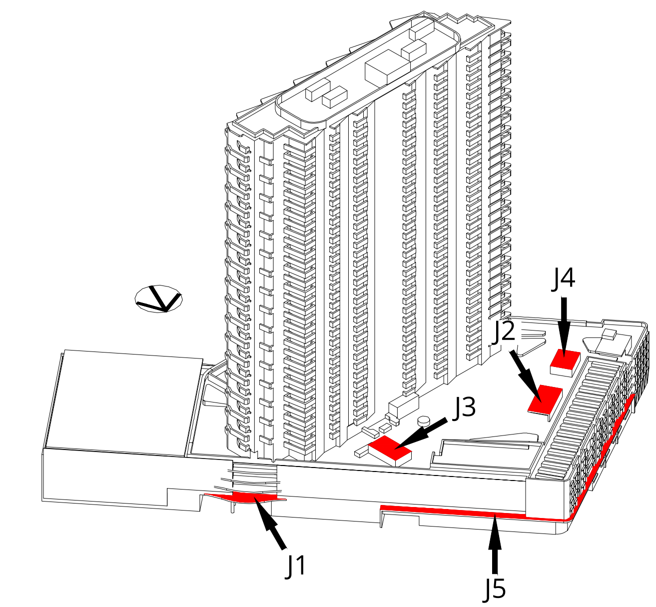


0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)
Peak Differential Positive Pressures
(Positive External Pressure with Negative Internal Pressure Where Applicable)
700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

Drawn by: DAR	Figure: 17
Approx. Scale:	1"=50'
Project #2203689	Date Revised: May. 3, 2022





Isometric View of Roof: (J)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.

0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Positive Pressures

(Positive External Pressure with Negative Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

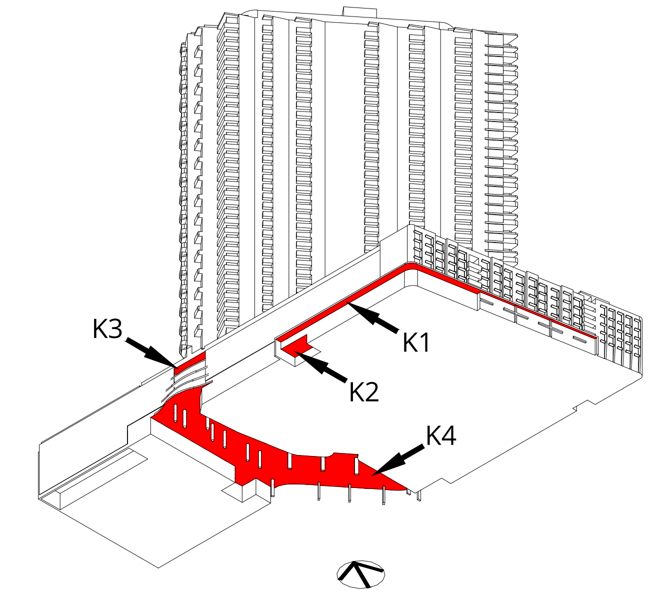
Alia Block I - Honolulu, HI

True North

Project #2203689

Drawn by: DAR	Figure: 18
Approx. Scale:	1"=50'
Date Revised:	May. 3, 2022

SOFFIT SURFACES



Isometric View of Soffit: (K)

Note:

1. The wind loads presented are applicable for the Allowable Stress Design approach. As such, they include the 0.6 factor specified in the ASD load combinations provided in Section 2.4 of ASCE 7 Standard.

0 25 50ft

Recommended Wind Loads for Allowable Stress Cladding Design (psf)

Peak Differential Positive Pressures

(Positive External Pressure with Negative Internal Pressure Where Applicable)

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II

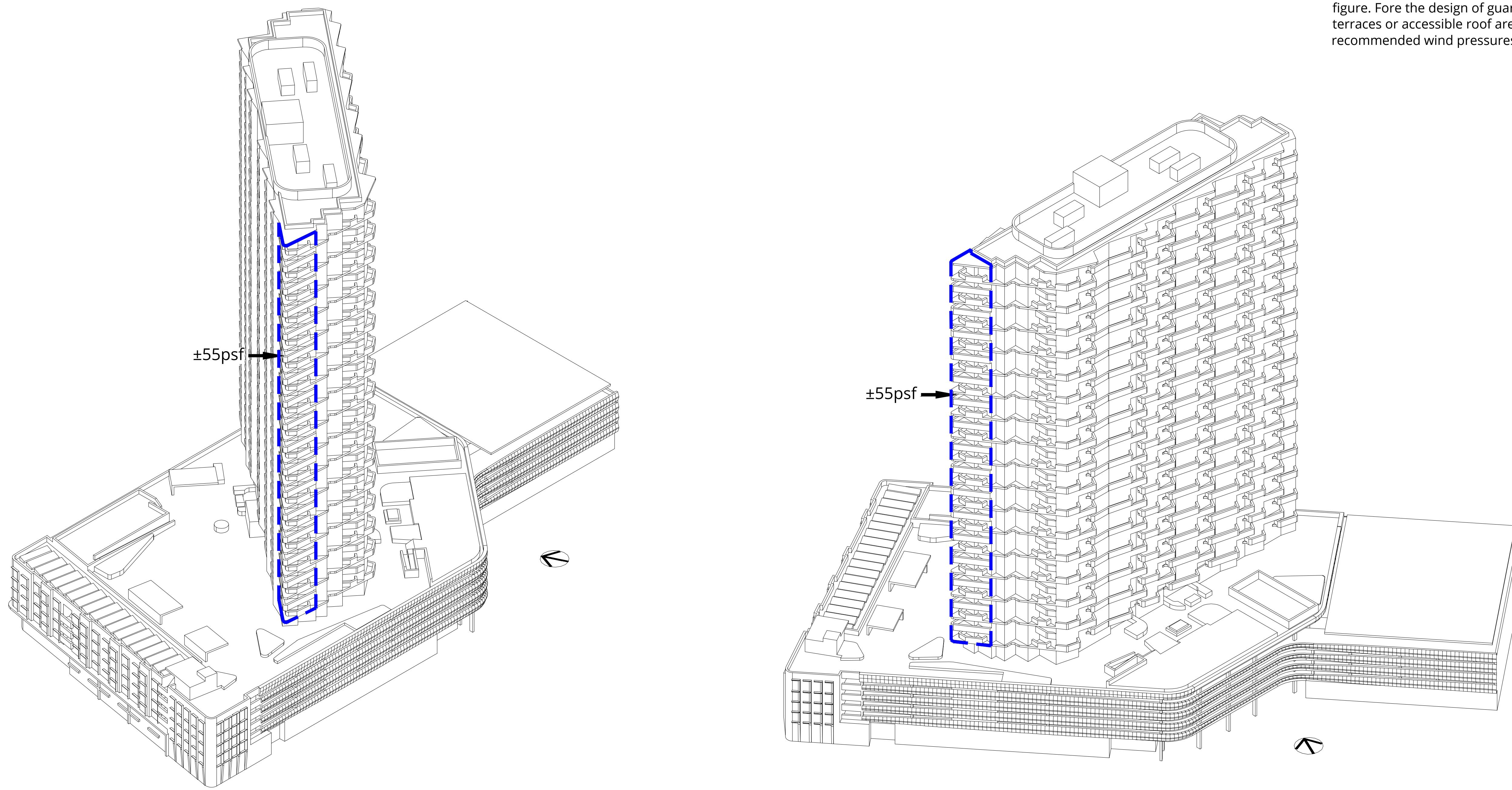
Alia Block I - Honolulu, HI

True North

Project #2203689

Drawn by: DAR	Figure: 19	
Approx. Scale:	1"=50'	
Date Revised:	May. 3, 2022	

Note:
1. The wind loads presented do not contain load or safety factors. The loads are to be applied to the building's cladding system in the same manner as would wind loads calculated by building code analytical methods.
2. For the design of balcony guardrails, it is recommended that a different wind pressure of ±45psf be used, except for those areas shown in this figure. Fore the design of guardrails around open terraces or accessible roof area, please refer to the recommended wind pressures in the elevation figures.



Recommended Wind Loads for Design of Balcony Guardrails (psf)
Peak Differential Pressures

700-Year Effective Wind Speed= 135 mph (3-Second Gust) - Risk Category II
Alia Block I - Honolulu, HI

True North

Project #2203689

Drawn by: DAR	Figure: 20	
Approx. Scale:	NTS	
Date Revised:	May. 3, 2022	

APPENDIX A

WIND TUNNEL PROCEDURES

APPENDIX A: WIND TUNNEL PROCEDURES

OVERVIEW OF WIND TUNNEL PROCEDURES FOR THE PREDICTION OF CLADDING WIND LOADS

A.1 Wind Tunnel Test and Analysis Methods

A.1.1 Wind Tunnel Tests

RWDI's boundary layer wind tunnel facility simulates the mean speed profile and turbulence of the natural wind approaching the modeled area by having a long working section with a roughened floor and specially designed turbulence generators, or spires, at the upwind end. Floor roughness and spires have been selected to simulate four basic terrain conditions, ranging from open terrain, or water, to built-up urban terrain. During the tests, the upwind profile in the wind tunnel is set to represent the most appropriate of these four basic profiles, for directions with similar upwind terrain. Scaling factors are also introduced at the analysis stage to account for remaining minor differences between the expected wind speed and turbulence properties, and the basic upwind flow conditions simulated in the wind tunnel. The full-scale properties are derived using the ESDU methodology[1, 2] for predicting the effect of changes in the earth's surface roughness on the planetary boundary layer. For example, this procedure distinguishes between the flows generated by a uniform open water fetch upwind of the site, versus a short fetch of suburban terrain immediately upwind of the site with open water in the distance.

Wind direction is defined as the direction from which the wind blows in degrees measured clockwise from true north. The test model (study model and surroundings) is mounted on a turntable, allowing any wind direction to be simulated by rotating the model to the appropriate angle in the wind tunnel. The wind tunnel test is typically conducted for 36 wind directions at 10° intervals.

It is prudent to take steps to ensure that the safety of a structure is not entirely dependent on specific surrounding buildings for shelter. Building codes often contain specific provisions to address this. These may include requirements to test with the more significant surrounding buildings removed, and/or lower limits on the reduction that is permitted compared to the code analytical approach.

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1 Wind speed profiles over terrain with roughness changes for flat or hilly sites. Item No. 84011, ESDU International London, 1984 with amendments to 1993.

2 Longitudinal turbulence intensities over terrain with roughness changes for flat or hilly sites. Item No. 84030, ESDU International London, 1984 with amendments to 1993.

A.1.2 Measurement Techniques

This study addresses the local wind pressures that act on the exterior envelope of the building. Predictions of these loads are required in order that the cladding system can be designed to safely resist the wind loads. The technique that is used to make these predictions consists of conducting a wind pressure study. The basis of the approach is to instrument a rigid wind tunnel model of the building with pressure taps that adequately cover the exterior areas exposed to wind. The mean pressure, the root-mean-square of pressure fluctuations and the peak negative and peak positive pressures are measured at each tap using a system capable of responding to pressure fluctuations as short as 0.5 to 1 second at full scale. The measured data are converted into pressure coefficients based on the measured upper level mean dynamic pressure in the wind tunnel. Time series of the simultaneous pressures are also recorded for post-test processing if required. A typical example of an instrumented wind tunnel study model is provided in Figure 1.

A.1.3 Consideration of the Local Wind Climate

Carrying out the procedures described in the previous sections determines the peak local external pressure coefficients expected for a given wind direction. However, in order to account for the varying likelihood of different wind directions and the varying strengths of winds that may be expected from different directions, the measured pressure coefficients are integrated with statistical records of the local wind climate to produce predicted peak pressures as a function of return period. In the case of cladding loads, it is appropriate to consider peak loads associated with return periods comparable to the design life of the structure. The choice of return period will be governed by local code requirements that consider the intended use of the building. For Allowable Stress Design, return periods of 50 or 100 years are often used for cladding design, to which appropriate load or safety factors are applied. For Limit States Design, return periods of 700 or 1700 years, without load or safety factors, are used to represent the ultimate state loading.

Wind records taken from one or more locations near to the study site are generally used to derive the wind climate model. In areas affected by hurricanes or typhoons, Monte Carlo simulations are typically used to generate a better database since full scale measurements, if available for a given location, typically provide an inadequate sample for statistical purposes. The data in either case are analysed to determine the probabilities of exceeding various hourly mean wind speeds from within each of 36 wind sectors at an upper level reference height, typically taken to be 600 m (2000 ft) above open terrain. This coincides with the height used to measure the reference dynamic pressure in the wind tunnel.

In order to predict the cladding wind loads for a given return period, the wind tunnel results are integrated with the wind climate model. There are two methods typically used by RWDI to perform this integration. In one method, the historical (or simulated as is the case with hurricanes or typhoons) wind record is used to determine the full-scale cladding wind pressures for each hour, given the recorded wind speed and direction and the wind tunnel predictions for that direction. By stepping through the wind speed and direction data on an hour-by-hour basis, a time history of the resulting peak pressure is generated. Then, through the use of extreme value fitting techniques, statistically valid peak responses for any desired return period are determined.

The second method is the Upcrossing Method as described by Irwin[3] and Irwin and Sifton[4]. In simple terms, this can be thought of as an analytical representation of the first method, in which a fitted mathematical model of the wind statistics is used in place of the detailed wind records themselves. The Upcrossing Method is currently used by RWDI for cladding wind load studies.

A.1.4 Design Wind Speeds in Hurricane/Typhoon Regions

It may be of interest to compare design wind speeds with the Saffir-Simpson hurricane categories, although this should be done with caution. In particular, while associating the building strength or performance with a given category of hurricane may sound appealing, it ignores the likelihood of that category of storm actually occurring at a given site. It also ignores the distinction between a direct hit from a weak hurricane compared with a glancing blow from a strong one. For this reason, when adopting criteria for both strength and serviceability, building codes and standards relate design wind speeds to return period rather than simply to storm categories or other similar systems.

The commentary to the ASCE 7-10 has a discussion in Section C6.26.5.1 regarding the relationship between the Basic Wind Speeds in the standard and the Saffir-Simpson scale. The Basic Wind speeds given currently in the ASCE 7 are 3-second gust speeds at 33 feet over land. The ASCE commentary also provides guidance on conversion to other wind speed durations *in the same terrain conditions*, which may be considered if the design wind speeds are taken from other sources.

Hurricane wind speeds commonly referred to with the Saffir-Simpson scale are 1-minute averages over water. The conversion between these different averaging times and terrain conditions is complicated by the fact that the effective roughness of the sea surface varies with wind speed. The ASCE commentary (Table C26.5-2) provides the following approximate conversions, reflecting research more current than was reflected in the ASCE 7-05:

Saffir/Simpson Hurricane Category	1-minute average speed, 33 ft (10 m) over water, mph (m/s)	3-second gust speed, 33 ft (10 m) over land, mph (m/s)
1	74-95 (33-43)	81-105 (36.2-46.9)
2	96-110 (44-49)	106-121 (47.4-54.1)
3	111-130 (50-58)	122-143 (54.5-63.9)
4	131-155 (59-69)	144-171 (64.4-76.4)
5	>155 (>69)	>171 (>76.4)

3 Irwin, P.A., "Pressure Model Techniques for Cladding Loads", Journal of Wind Engineering and Industrial Aerodynamics 29 (1988), pg. 69-78.

4 Irwin, P.A. and Sifton, V. L., "Risk Considerations for Internal Pressures", Journal of Wind Engineering and Industrial Aerodynamics, 77 & 78 (1998), pg. 715-723.

It should be kept in mind that the ASCE 7 uses ultimate wind speeds. While this is the case for some other codes and standards, there are others which work with shorter return period wind speeds with a load factor to produce a design load effect. When commenting on the implications of the various storm categories on a specific structure, it is important to consider the code intent, including any load factors if applicable.

A.1.5 Internal Pressure Allowances Considering Localized Breaches in the Building Facade

In strong winds, air leakage effects dominate the internal pressures. Other factors that influence them, but are usually of less significance, are the operation of mechanical ventilation systems and the stack effect. Important sources of air leakage include uniformly distributed small leakage paths over the building's envelope and larger leakage paths. These larger leakage paths include window breakage due to airborne debris in a windstorm and open doors or windows, in cases where they are operable. The internal pressure allowances can be influenced by many factors including the size and location of potential glass breakage, the internal compartmentalization of the building and the internal volumes. During a major storm event, glass breakage can be different sizes and occur at various locations. There are many types of projectiles that typically cause glass breakage, ranging in size from small rocks to tree branches. Larger projectiles impacting the building would be rare events.

To evaluate the internal pressures resulting from dominant openings in the building envelope, simultaneous measurements are taken during the wind tunnel test between pairs of pressure taps located on building walls that share the same internal volume. Of particular interest are measurements taken in areas where large pressure differences can occur such as those that are generated at the corners of the floor plate. A single opening (worst case) scenario is typically considered since multiple leakage sources tend to reduce the magnitude of the internal pressure. Using an in-house approach, these data are analyzed to determine the range of internal pressures that may occur at selected opening locations and for a range of probabilities of these openings occurring. Lower probabilities are used in lower wind speed areas (i.e., – non-hurricane/non-typhoon areas), and higher probabilities are used in higher wind speed areas (i.e., – hurricane/typhoon areas) or for buildings that have a large number of operable windows or doors. Using these dominant opening probabilities, internal pressures are determined for the same level of risk as that assumed for the external pressures.

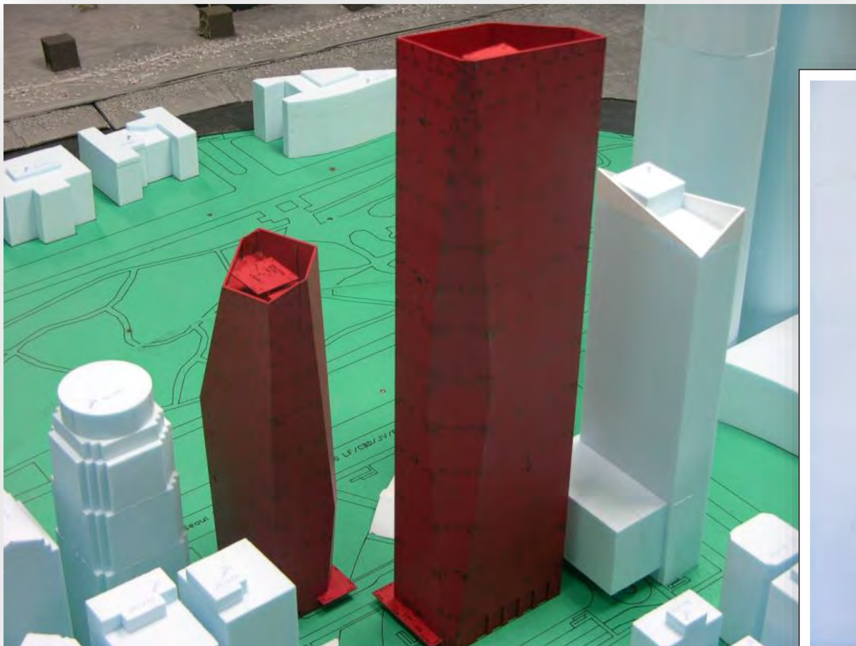
For buildings that use large missile impact resistant glazing everywhere, and do not have operable windows, the potential for breakage due to windborne debris is very low. As a result, the probability of an opening is also very low, and the internal pressures used are at or near the minimum considerations of a nominally sealed building.

The internal pressure allowances are applied to help reduce the possibility of subsequent facade failures due to pressure increases caused by localized breaches in the facade. Design of the cladding to the provided wind loads will not necessarily prevent breakage due to impact by wind borne debris.

A.1.6 Allowable Stress Design: Comments on the Usage of Recommended Cladding Wind Loads for Glass Design in the United States

Glass is a material for which the strength depends on the duration of the applied load, varying approximately in proportion to $(1/T)^{1/16}$, where T = load duration. The glass strength curves in the ASTM E-1300 standard for various types of glass and sizes of panel are provided for a load of specified duration. The specified load duration is 3 seconds. This is consistent with wind loads calculated using the ASCE 7 analytical method, which have a duration in the 1 to 10 second range.

The wind- tunnel derived loads provided in the recommended cladding pressures report are for a duration consistent with that of the ASCE-7 analytical method (i.e., 1 to 10 seconds) and provide the same level of reliability as the analytical method.



(a) Typical Cladding Wind Load Study Model

(b) Data Acquisition

Measurement Techniques for the Prediction of Cladding Wind Loads	Figure: 1
Appendix A - Wind Tunnel Procedures	Date: December 2, 2016

APPENDIX B

DRAWING LIST FOR MODEL CONSTRUCTION

APPENDIX B: DRAWING LIST FOR MODEL CONSTRUCTION

The drawings and information listed below were used to construct the scale model of the proposed Alia Block I development. Should there be any design changes that deviate from this list of drawings, the results may change. Therefore, if changes in the design are made, it is recommended that RWDI be contacted and requested to review their potential effects on cladding pressures presented in this report.

File Name	File Type	Date Received (dd/mm/yyyy)
BLOCKI-CS-AR	Revit	28/02/2022
BLOCKI-CS-AR	Revit	18/03/2022
210318_Block I_Arch_50% SD_Drawing Set	PDF	18/03/2022
Pages from 220315_KG-Presentation_Auahi Street	PDF	21/03/2022