RWDI
CONSULTING ENGINEERS & SCIENTISTS

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Platinum member

Memorandum

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Guelph, Ontario, Canada N1G 4P6

Date: February 14, 2017 RWDI Reference #: 1700697P2C3

To: Jay Fang, Hawaii Ocean Plaza LP E-Mail: eb5jay@gmail.com

From: Analene Belanger, RWDI E-Mail: Analene.belanger@rwdi.com

RE: RWDI Consulting Services – Additional Wind Loading Services
Hawaii Ocean Plaza
Honolulu, Hawaii

RWDI is pleased to present this proposal to provide additional analysis for the Hawaii Ocean Plaza project in Honolulu, Hawaii.

BACKGROUND

RWDI is currently in the process of studying the pedestrian wind environment for the Hawaii Ocean Plaza project. The design team has requested additional services to quantify wind loading for the project. As such, we have prepared this proposal for the following services:

- Wind-Induced Structural Responses Study
- Cladding Wind Pressure Study

Due to the intricate louver arrangements around the podium of the project it may be of value to review these designs to look for any risk of wind-induced noise and vibration for the louvers. As this has not specifically been requested, this has been reflected as an optional service.

- Wind-Induced Noise and Vibration Review for Podium Louvers (Optional)

SCOPE OF WORK

Wind Tunnel Proximity Model

The proximity model used for the current Pedestrian Wind Study will be re-used for these assessments.

Wind-Induced Structural Responses Study

Objective: The objective of this study is to provide a detailed and accurate estimate of design wind force and torque distributions acting on the proposed tower that can be used by the structural engineer to achieve the refined design of the tower's primary structural system. This study will provide structural wind loads for the return period of interest accounting for the influence of extreme wind events (hurricanes). An evaluation will also be conducted to identify if the wind-induced motions are likely to be significant enough to cause complaints by the building occupants.

Memorandum

BEST MANAGED COMPANIES
Robbins Hamby

Date: February 04, 2017

To: Jay Fang, Ocean Plaza LP

From: Azalea Dawson, RWDI

RE: **RWDI Consulting Services – Additional Wind Loading Services**
Kiawah Ocean Plaza
Honolulu, Hawaii

RWDI is pleased to present this proposal to provide additional analysis for the Kiawah Ocean Plaza project in Honolulu, Hawaii.

BACKGROUND

RWDI is currently in the process of analyzing the pedestrian wind elevation near the Kiawah Ocean Plaza project. The design team has requested additional services to quantify wind loading for the project. As such, we have developed the proposal for the following services:

- Wind-Induced Structural Response Study
- Cladding Wind Pressure Study

Due to the intricate louver arrangements around the podium of the project, it may be of value to derive these loadings by both the use of wind-induced cladding and vibration for the louvers. As the has not specifically been requested, it has not been offered as an additional service.

- Wind-Induced Noise and Vibration Review for Pedestrian Louvers (Optional)

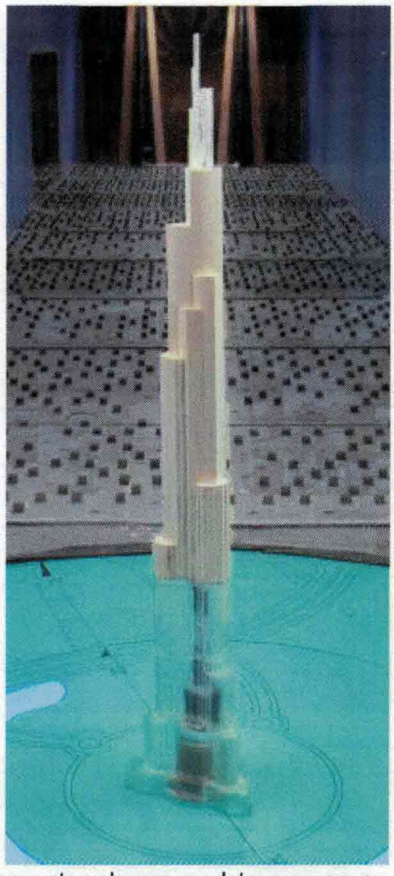
SCOPE OF WORK

Wind Tunnel Property Model

The property model used for the current Pedestrian Wind Study will be re-used for these assessments.

Wind-Induced Structural Response Study

Objective: The objective of this study is to provide a detailed and accurate estimate of design wind force and torque distribution, acting on the proposed tower that can be used by the structural engineer to achieve the desired design of the tower's primary structural system. This study will provide structural wind loads for a wind tunnel pedestal to interact across for the response of extreme wind events (monthly). An evaluation will also be conducted in the case if the wind-induced motions are likely to be significant enough to cause discomfort by the building occupants.



Study Model Construction: A rigid 1:400 (or similar) scale model of the proposed tower will be constructed and mounted on one of RWDI's high-frequency response strain gauge force-balances. These balances are capable of accurately measuring the instantaneous base bending moments, base shears and base torsional moments for the frequency range of interest (corresponding to about 0 Hz to 80 Hz at model scale).

Testing: The model of the proposed tower will be tested in position with the proximity model, in our boundary layer wind tunnel for 36 wind directions at 10 degree intervals in a fully simulated turbulent wind. The mean, RMS and peak values of the base moments, shears and torque will be measured for the building's principal axes. Spectra of moment and torque will also be recorded. All results will be corrected for the effects of flexibility of the nominally rigid model.

Test Configuration: One (1) configuration of the study site and surroundings will be tested for our base studies consisting of the proposed project, in the presence of the existing surrounding structures.

If the project team is aware of any future buildings that are located in close proximity to the development which could impact wind flows, a second test configuration (Future) may be warranted. This has been reflected as an optional service.

Data Analysis: The test data will be combined with structural information (i.e., natural modes of vibration, the building mass distribution and the structural damping) to determine the dynamic response of the structure. The results will be in the form of base moments, shears and torque as a function of wind speed and direction. These results will then be combined with the mathematical model of the wind statistics for the area to predict the wind-induced loads as a function of return period.

Structural Loads for Design: From the data analysis results, wind force and torque distributions as a function of height will be provided for the proposed tower in the form of floor-by-floor loads for the 50-year return period (or other return period of interest). We will also recommend appropriate combinations of design loads in the two principal directions and in torsion.

Building Motion Effects: The acceleration on the top occupied floor of the tower will be predicted as a function of return period by combining the wind tunnel data with the wind statistics for the area. The results will be provided in graphical form and will be compared to motion criteria for human comfort.

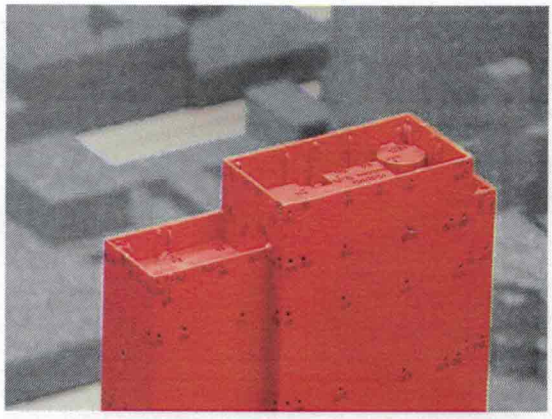
After the initial testing and analysis has been completed, RWDI has the ability to produce results for revised structural designs based on the initial wind tunnel test data (assuming the main building geometry is unchanged). This has been reflected as an optional service.

Report & Deliverables: Preliminary design loads and essential information will be submitted as soon as they are available in the form of an interim report. The final report will include a full description of test methodology, analysis, results and recommendations.

Cladding Wind Pressure Study

Objective: The objective of this study is to provide a detailed and accurate estimate of peak cladding loads for the proposed development for the design of the exterior wall cladding systems and roof systems. This study will provide loads for the selected return period of interest accounting for the influence of extreme wind events (hurricanes).

Study Model Construction: To conduct the pressure tests, a resin model of the proposed building will be constructed to include all surface details measuring greater than 1 ft. at full scale. To begin this process, RWDI will produce three-dimensional solid models from surface geometry (i.e., elevations, sections, and roof plans) provided by the project team. Pressure taps, which measure wind pressure on the surface of the model, will be installed at numerous locations on the outside surfaces of the development. The distribution of pressure taps on the model will take into consideration possible regions of high wind loads on the roof and facades of the development.

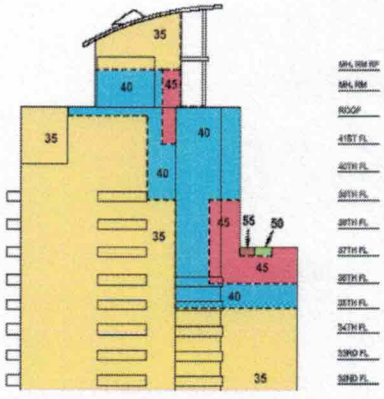


Wind Tunnel Testing: The pressure model of the proposed building will be tested in our boundary layer wind tunnel where the natural wind and turbulence levels will be simulated. During the tests, the instantaneous wind pressures at each pressure tap will be measured for 36 wind azimuths in 10° increments. The mean, root-mean-square (RMS) and the peak maximum and minimum pressure coefficients, based on the gradient wind pressure, will then be derived from the wind tunnel data. For canopies and walls open to the air on both sides, the differential pressures will be measured by simultaneously measuring the instantaneous pressures on the opposite faces of these surfaces.

Test Configurations: One (1) configuration of the study site and surroundings will be tested for our base studies consisting of the proposed project, in the presence of the existing surrounding structures.

If the project team is aware of any future buildings that are located in close proximity to the development which could impact wind flows, a second test configuration (Future) may be warranted. This has been reflected as an optional service.

Cladding Design Loads: The test data will be combined with the statistical model of the local wind climate, which includes the strength and directionality of severe winds. The results of this analysis are the predicted peak exterior pressures for the 50-year return period (or another return period of interest). To determine the peak cladding loads, the interior pressure will be estimated and added to the exterior pressure where applicable. The estimated design loads for the selected return period will be presented in the form of block diagrams superimposed on the building's elevations and roof plan. The block diagram presentation will allow the building designers to better estimate the design loads for the wall and roof systems of the proposed development.



Report & Deliverables: Interim information on the initial cladding loads can be sent as soon as available. A final report will be prepared upon completion of the study, which will contain a complete discussion of the test procedure, results and the recommended design loads.

Wind-Induced Noise (Aeroacoustic) and Vibration Design Review (Optional)

Objective: The objective of the Wind-Induced Noise (Aeroacoustic) Design Review is to determine whether the geometry of the proposed podium louvers, when combined with varying wind conditions, will have a potential for wind induced noise that is often heard as a 'whistling' or 'humming' type of sound. We will also assess whether the geometries of the proposed façade elements will vibrate or rattle in the wind ('flapping' of the fins). Wind-induced vibration can be generated by vortex shedding from objects with flows perpendicular to the edges of an object.

Noise: We will review the detailed design of the building podium louver designs to identify the potential for the typical mechanisms of flow-induced noise. These phenomena may include: Helmholtz Resonance which is similar to blowing across the top of an empty bottle; perforation noise; edge tones generated by flows parallel to gaps between objects; and, vortex shedding from objects with flows perpendicular to sharp edges. In the case of vortex shedding and/or edge tones, a potential mechanism for this building would be the air 'downwash' at the building facade facing the wind. Wind induced noise can sometimes be exacerbated by a combination of these mechanisms working together to significantly amplify the noise.

Vibration: We will review the design of the podium louvers to identify the potential for vibration caused by typical mechanisms such as vortex shedding. The design review will reference basic calculations for details that are identified as having potential for producing wind-induced vibration, combined with statistics of the local wind climate. Based on expected wind speeds we will provide estimates of the probability of wind-induced vibration problems, including the anticipated occurrence frequency. General recommendations will be provided where needed to reduce the potential.

The expected noise levels will not be estimated. The vibration mechanism will be assessed in terms of low, medium and high risk.

Should significant issues be predicted, the project team may benefit from additional scale model testing to quantify surface wind speeds and flow directions along the façade of the building to understand where high risk noise zones are, and potentially full scale aeroacoustic wind tunnel testing to develop mitigation strategies. A separate proposal would be issued for this work if required.

Deliverables: Results would be reported via a brief summary report, identifying design features that have potential for wind-induced noise and vibration, and level of risk associated (low, medium or high). If high risks are predicted, mitigation concepts will be suggested.

BUDGET & SCHEDULE

Our fees (which include all professional fees and office expenses) and timelines are shown in the table below. We are prepared to commence work within about one week of receiving all required information and your signed authorization to proceed. Our schedule will be discussed with you upon approval as it may have changed from the time our proposal was issued. Terms and Conditions are per the current work on the project.

Tasks	Pricing (USD)	Schedule
Additional Services		
Wind Tunnel Proximity Model	Completed	
Wind-Induced Structural Responses Study	$15,000	4 – 5 weeks
Cladding Wind Pressure Study	~~$18,000~~ 15,000	4 – 5 weeks
Optional Services		
Wind-Induced Noise (Aeroacoustic) and Vibration Design Review	$5,000	3 – 4 weeks
Future Test Configuration for Structural Study	$3,500	
Future Test Configuration for Cladding Study	$2,500	
Wind-Induced Structural Loading Re-Analysis	$3,000 *per* set of structural properties	~ 1 - 2 weeks

Notes:

1. The proximity model will be re-used from the current Pedestrian Wind Study.
2. Fee assumes that the project will test simultaneously with the Hawaii City Plaza project.
3. The cost for the additional test configurations assumes they occur during the same set of tests for the Base Studies.

If you wish us to proceed with these services, we have included a letter of authorization in **Appendix A.**

BUDGET & SCHEDULE

Wind Tunnel Geometry Model	Completed	
Aero-Acoustic Wind Tunnel Research Study	$[illegible],000	4 – 5 weeks
Cladding Aero-Acoustic Research Study	$[illegible],000	[illegible] weeks
Optional Deliverables		
Wind-Induced Noise (Aeroacoustic) and Vibration Design Review	$5,000	1 – 4 weeks
Future Wall Configuration for Cladding Study	$3,500	
Future Roof Configuration for Cladding Study	$2,500	
Wind-induced Structural Loading Re-Analysis	$5,000 per wall or structural properties	1 – 2 weeks

Notes:

1. The geometry model will be re-used from the current Pedestrian Wind Study.
2. Fee assumes that the project will include only the Henry Duty Plaza and the roof for the conditional test configurations as they occur during the same test as the Site Specific Studies.

If you wish us to proceed with these services, we have included a letter of authorization in Appendix A.

APPENDIX A: LETTER OF AGREEMENT

We hereby authorize Rowan Williams Davies & Irwin Inc. (RWDI) to provide the services outlined in this proposal, reference #1700697P2C3 dated February 14, 2017 for the Hawaii Ocean Plaza project in Honolulu, Hawaii. This letter of agreement together with the proposal constitutes the entire agreement. No other agreement shall take precedence unless agreed to by both parties in writing.

RWDI is authorized to proceed with the services identified with a check mark:

Tasks	Pricing (USD)	Approved (Please Check)
Additional Services		
Wind Tunnel Proximity Model	Completed	
Wind-Induced Structural Responses Study	$15,000	[✓]
Cladding Wind Pressure Study	~~$18,000~~ 15,000	[✓]
Optional Services		
Wind-Induced Noise (Aeroacoustic) and Vibration Design Review	$5,000	[ ]
Future Test Configuration for Structural Study	$4,500	[ ]
Future Test Configuration for Cladding Study	$3,500	[ ]
Wind-Induced Structural Loading Re-Analysis	$3,000 *per* set of structural properties	

This quotation covers all professional fees and expenses (as per the scope of work defined in the proposal) but excludes any other tax that might be applicable. Progress invoices will be submitted as follows: 30% upon authorization; thereafter, monthly according to work complete. Invoices will be sent by email and mail. Payment is due within 30 days of receipt of invoice.

Client

Zhe Fang
Name (Please print)

Hawaii Ocean Plaza LP
Company

Manager
Title

2/15/2017
Date

Signature (I am authorized to bind this corporation)

RWDI and the Client agree that this Proposal may be communicated and/or accepted by email or facsimile transmission and that the said communication and/or acceptance shall be legal and binding upon RWDI and the Client. RWDI and the Client further agree that reproductions of signatures by telecommunications will be treated as original signatures.