

September 1, 2016

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**Structural
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RE: Structural Peer Review, Culture Shed, New York City
Silman Project No 16781

Dear Bob:

At the request of the owner, we have carried out a Structural Peer Review of the Culture Shed (545 West 30th Street, New York City), as per the requirements of Section 1617 of the 2014 New York City Building Code. A Peer Review was called for by the Department of Buildings as per Section 1617.2.7 and carried out in a manner consistent with Section 1617.5. The limitations of this report (and Silman's ultimate responsibility) are clearly indicated within Section 1617 of the New York City Building Code.

Subsequent to our October, 2015 review (which is as per the body of the report below), Silman was asked, in April 2016 to review the design team recommendation for an alternate load path that was used to satisfy the fire protection requirements at the primary structure. Over the course of five days (13 April to 18 April, 2016), Silman reviewed the documents related to the fire protection of the Bogies and our comments have been amended to the end of this report.

Executive Summary:

In general, our review indicates that the structure of the rolling portion of the Culture Shed (and supporting foundations), as designed by Thornton Tomesetti (TT), in collaboration with Diller, Scofidio + Renfro (DSR), meets or exceeds the requirements of the New York City Building Code and good design practice.

Reviewed Documents:

We were provided with the following documents, which were used to complete our review:

- Foundation Documents:
 - CSK-S-091.10 Terra Firma Reinforcement Details.
 - Tower C Foundation Documents
 - Culture Shed Foundation Documents
- Rolling Shed Documents:

- Structural Drawings – 100% Construction Documents 3/18/2015 – Marked up.
- Culture Shed Structural System Narrative – 100% CD
- Bogie Documents:
 - Rail-Bogie Load Summary (TT 6.29.2015)
 - Bogie Shop Drawings (primary structural elements) (Cimolai, 06.07.2015)
 - Double Bogie Drawings (DOB Amendment 7 – Drawing Issue 61, 8/19/2016) on Eastern Bogie Line of the Moveable Shed.
- Analysis Models:
 - Culture Shed Frame Model
 - Culture Shed Frame Model with Plate Modeled Nodes
 - Impacted Substructure Model
 - Mechanical Properties Table of Custom sections
- Supporting Documents:
 - RWDI Wind Tunnel (DRAFT) Report (dated October 18, 2013)
 - Langan Soil Information (Report Figures, 02.24.2012)

Peer Review Comments (detailed):

We note the following on a task by task basis, aligned with the requirements of Section 1617.5.1 of the 2014 New York City Building Code:

1. *Confirm that the design loads conform to this code.*

Silman has reviewed the final Construction Documents and has concluded that the design loads noted within the documents are appropriate to the use of the structure and generally meet the requirements of the New York City Building Code.

2. *Confirm that other structural design criteria and design assumptions conform to this code and are in accordance with generally accepted engineering practice.*

Structural design criteria, including (unique to this project), the kinetic nature of the structure (our review was limited to the loads transfer through the structural elements within the bogies and rolling components); the wind loads applied to the building as developed by RWDI wind tunnel analysis; the transfer of wheel loads through the 'platform' to foundation; and the unique transfer of wind loading from shed façade to isolated support points at the fixed building. In all cases, we have concluded that design criteria and load path(s) are appropriate and consistent with the requirements of the New York City Building Code.

3. *Review geotechnical and other engineering investigations that are related to the foundation and structural design and confirm that the design properly incorporates the results and recommendations of the investigations.*

We have reviewed the foundation elements that support the rolling shed and have concluded that these elements are appropriately designed and meet or exceed the recommendations made in the geotechnical report produced for the project. In reviewing this aspect of the design, we reviewed the three different support conditions that exist beneath the two primary rail lines and the fixed building. In each case, the support conditions are appropriate and reasonable based on the loads imposed from above. We confirmed that, although constructed in three separate portions, the lower level foundations are linked and comprise one continuous diaphragm – providing a consistent lateral base for the rolling shed.

4. *Review the structural frame and the load supporting parts of floors, roofs, walls and foundations. Cladding, cladding framing, stairs, equipment supports, ceiling supports, non-loadbearing partitions, railings and guards, and other secondary structural items shall be excluded.*

We have reviewed, both within the Construction Documents and, more precisely, within the working analysis model(s), the load supporting parts of the roof, walls, Bogies, and foundations and have found the design, sizing, and layout to be appropriate and to meet or exceed the requirements of the New York City Building Code.

5. *Confirm that the structure has a complete load path.*

The shed structure has a complete load path – east-west wind loads are supported by Bogies at base of shed and armature at that transmits upper wind loads into fixed building at roof; north-south wind loads are transmit through diagrid frame into Bogies (no load into roof-top armature); all dead and live loads are supported by diagrid wall structure into Bogies and, under Bogies, into support framing and foundations.

6. *Perform independent calculations for a representative fraction of systems, members, and details to check their adequacy. The number of representative systems, members, and details verified shall be sufficient to form a basis for the reviewer's conclusions.*

Silman carried out an independent review of the components within the primary shed diagrid to confirm that appropriate modeling of the diagrid was carried out and that the representative elements within the model were appropriately incorporated. Specifically, our review included a spot check of random framing members; confirmation that random custom elements within the diagrid at the shed walls were appropriately modeled; support members (beneath rails) at Level 1 were appropriately sized; and support points for rolling shed (at roof of fixed building and at Bogies) were appropriate for loads. Drifts and movement of support beams under imposed loads all appear to be within appropriate recommended limits.

Our calculations indicate that the input of the structural properties of each unique element was consistent with good practice and represented the 'built' elements appropriately. Further, independent calculation of random spanning elements indicated that the design of these elements is appropriate and meets the requirements of the New York City Building Code. Finally, we have carried out independent calculations at the bogie structure and a number of random foundation elements and found them to be appropriately designed for the loads indicated within the documents and the loads generated by the design model(s).
[ONGOING]

7. *Verify that performance specified structural components (such as certain precast concrete elements) have been appropriately specified and coordinated with the primary building structure.*

There are no performance based design elements within the Shed structure, save the kinetic elements. We were provided with the shop drawings related to the structure of the Bogies and were able to review these elements directly for loads imposed (rather than rely on performance language within a specification).

8. *Verify that the design engineer of record complied with the structural integrity provisions of the code.*

TT has complied with the structural integrity provisions of the Code for the Shed structure (BC 1615). Key Element Analysis (BC 1616) is not required – based on the fact that the building does not meet any of the 'threshold requirements' (Section 1616.1.1-5) and the Commissioner, to our knowledge, has not required this analysis).

9. *Review the structural and architectural plans for the building. Confirm that the structural plans are in general conformance with the architectural plans regarding loads and other conditions that may affect the structural design.*

We have concluded that the Structural Documents are in general conformance with the Architectural Plans regarding loads and other conditions that may affect the structural design.

10. *Confirm that major mechanical items are accommodated in the structural plans.*

We have concluded that major mechanical items are accommodated within the structural plans.

11. *Attest to the general completeness of the structural plans and specifications.*

The structural plans and specifications are generally complete and appropriate for a project of this type and size.

Alternate Load Path at Bogies (April, 2016 review):

In reviewing the Design Team approach to fire protection of the bogies, we reviewed the following documents:

- DSR Letter to 7 March 2016 to DOB regarding design team approach to fire protection.
- DOB Letter of 4 April 2016 to Mr. Robert Katcher (DSR) regarding DOB findings on fire protection approach.
- TT Report, dated 13 April 2016 to Mr. Robert Katcher (DSR) noting stresses within shed structure under fail safe condition.

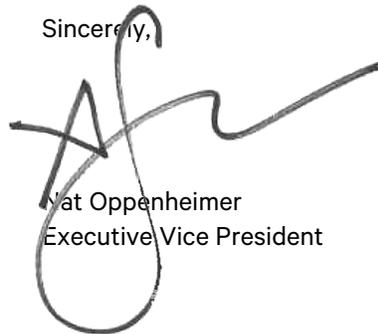
In general, Silman understands the approach to fire protection of the primary structure to consist of two components: fireproofing of all primary structural elements and proof of fail-safe condition at Bogies if wheel fails in fire condition.

We are in support of the approach at the Bogies. We concur with TT (and DSR) and share their opinion that the use of a drop lug and subsequent proof of primary structural adequacy (in 'failed' position – dropped 1") is appropriate. In addition, at our request, TT has demonstrated that a 'dynamic' failure of the wheel and 1" 'drop' of frame can occur without structural failure. Based on the information in hand, we can support the fire protection approach proposed at the Bogies by the design team.

In summary, we have concluded that the structural plans and specifications for the Shed Structure (and foundations) meet or exceed the requirements of the New York City Building Code and good design practice.

If you have any further questions or would like to discuss, please do not hesitate to contact our office.

Sincerely,

A handwritten signature in black ink, appearing to read "Nat Oppenheimer". The signature is stylized and fluid, with a large loop at the bottom.

Nat Oppenheimer
Executive Vice President