

## New Residential Building to Rest on Vibration Isolation System Designed to Seismic Standards

A new building is being erected under seismic design and engineering standards unprecedented in the history of New York City residential construction. When completed early next year, it will be one of only about 90 buildings in the world – mostly in Japan and California – with seismic engineering measures able to withstand the catastrophic force of a 500-year earthquake. It is also being constructed to meet the latest vibration and acoustical engineering standards. Why all the special engineering for this seemingly ordinary eight-story building?

This construction is the first residential building in New York whose vertical support will come from one of the subway structures of the city's underground rapid transit system. And although the subway structure will be its vertical support, the building is being constructed independently and isolated from the subway structure itself, making this project unique in New York and the U.S.

The main components of this complicated structure are 270 steel-spring vibration isolators custom-designed specifically for the project by The VMC Group, Bloomington, NJ. The building structure sits on these isolators over the subway structure and is restrained by deep pile foundations at east and west locations at the rear of the building. The first floor is like a huge 440-ft-long by 90-ft-wide truss turned sideways. As a result of the isolators, seismic and lateral forces bypass the subway structure and instead are transferred to the pile foundations. The system also isolates the building from structure-borne subway noise.

The New York-based Strategic Construction Corp. is the general contractor for State Renaissance Court – 158 market rate and affordable housing units, 20,000 ft<sup>2</sup> of ground level retail space, and indoor parking. This is all being built directly above the Hoyt/Schermerhorn Street subway station in downtown Brooklyn, NY. The project encompasses a total of 196,000 gross ft<sup>2</sup>. The developers are a joint venture partnership of Strategic Development and Construction Group and IBEC Building Corp., both based in Brooklyn.

Building above New York City's subway system is not new. In the past, all buildings over subway structures were anchored into neighboring ground. But constructing a residential building whose vertical support will be provided by the existing subway structure – without the building's first floor actually being rigidly affixed to the subway structure itself – is unprecedented engineering in New York. The amount of engineering going into this construction is unique to New

York City, according to the project's structural engineers, Wexler & Associates and Gleit Engineering Group, P.C., both New York-based.

Earthquake force was only introduced into New York City's building codes five years ago, and the city has yet to adopt stringent seismic performance standards from the International Building Code (IBC). The engineering of this project rivals high-rise construction in Japan and buildings in San Francisco and other West Coast cities where earthquake activity is frequent. In fact, the architectural design is more akin to the structural design standards of a nuclear power facility, rather than an ordinary building.

The science and engineering had to be developed around parameters mandated by the New York City Transit Authority (TA), the public agency that operates the city's underground rapid transit system. One parameter mandated by the TA was that the developers had to prevent wind forces and other lateral forces (in the event of an earthquake) from impacting the subway structure.

James McCullar & Associates designed the building to fit over the underground subway structure. Their architectural analysis established design requirements that meet the 2000 IBC seismic code and strict criteria of the TA. Acoustical design criteria were then established by Shen Milson Wilke, followed by VMC's design and fabrication of the vibration isolators.

The TA does not want the building to pull the subway structure from side-to-side if earth tremors were to occur. Besides the issue of seismic isolation, with trains rumbling through the subway tunnels on a 24-hour basis, acoustical issues also had to be addressed to ensure quality habitability according to John Frezza, President of Strategic Construction Corp. The developers retained VMC along with New York-based Shen-Milson Wilke, which specializes in acoustical and vibration engineering, for their expertise in this phase of the project.

The subway structure was originally designed in 1936 to accommodate a new building with load points in a grid across the subway roof. Recesses were designed

in the subway roof for future cellar mechanical spaces. After the subway station was built, the site remained an open parking lot on shallow fill above the structure until the design of State Renaissance Court.

“Although the city's forefathers had the vision to pre-engineer this particular subway structure to support a 40-story building, provisions for earthquakes were non-existent when the subway structure was built 70 years ago,” explained VMC Group president John Giuliano. “Since the building will sit directly above a subway structure that will provide its vertical support, we had to meet seismic and gravity load criteria that did not even exist in New York City building codes.”

“Steel spring vibration isolators were used to accommodate the site's vibration exposure of 4-90 Hz, and to maintain performance over time through all types of environmental factors. The isolators also sit on Teflon load-bearing surfaces so the building can effectively slide over the subway structure in the event of shock loading,” said Giuliano, who explained that this was added to the system as a fail-safe measure.

The springs have been designed with a compressibility factor that allows them to maintain their lateral resilience even when the building achieves its maximum dead and live loads. The 270 steel spring isolators sit on top of 26 concrete-encased steel girders, or “load points” (which are part of the original subway structure), and, in turn, the building sits on top of the isolators. The girders were reinforced with concrete ‘pedestals’ to provide a base for the isolators. The first-floor girders of the building sit on the isolators and separate the first floor from the subway structure. The entire first-floor platform is constructed in a way that allows it to actually displace, or move laterally relative to the subway structure to a maximum of 1/2 in.

Part of the external support structure includes two separate monolithic pile caps that are 12.5 ft wide, 9 ft deep, and 50 and 90 ft long, each encasing a deep-battered minipile system containing 140 separately augured minipiles.

At the pile cap, the transfer platform is rigidly connected laterally through the use of seismic restraints that act to transfer the building's lateral loads directly to the pile system but still allow for vertical displacement because of the spring



Architect's rendering of the north elevation of State Renaissance Court being constructed over a subway in Brooklyn, NY.

compression at the application of the final dead and live loads. The seismic restraints are secured to the transfer girders and then welded to an embedded plate within the pile cap, which all allow vertical displacement when the vibration isolators are loaded.

Before approving the project, the TA required the developers to create a computer model to analyze the building's reaction to earthquake forces. A dynamic analysis was required to determine the science and how the science would then translate into meeting seismic, vibration, and sound attenuation requirements.

The building was simulated in three dimensions and the foundation was simulated by inputting each pile geometrically where they occur. The building was de-

signed using static analysis, then checked using dynamic input. The RISA program was used to design and check the building, and STAAD was used for an independent examination. Over 30 load combinations, both static and dynamic, were used. In the three-dimensional building, deflections showing individual mode shapes were very instructive because they identified overall building behavior.

The construction has not been without its architectural issues. It was initially designed as two separate buildings because of an imposing above-ground subway ventilation structure, which sits on this parcel of land. Originally, two separate buildings would have been joined by a one-story connecting building with a common lobby. But the project evolved

into a 'bridge' building that maximizes the allowable floor-to-area ratio and a greater number of much-needed affordable housing units. The building is now being constructed around the vent structure and the 'bridge' allows the building to present itself aesthetically as one building with a uniform façade.

Among other construction and design complexities are the building's elevators. The TA required that the counterweights be equipped with mechanical safety devices that go beyond the requirements of New York City building codes.

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Additional information is available on this project from: Strategic Construction Corp., [www.statestreetliving.com](http://www.statestreetliving.com); The VMC Group, [www.thvmcgroup.com](http://www.thvmcgroup.com).



*External support structure consisting of reinforced concrete pile caps and augered mini-piles*



*Load transfer girder being lowered onto vibration isolators.*



*Close-up of two steel-spring vibration isolators and seismic vibration damping restraints at the end of a load transfer beam.*