31 July 2017
(Revised 10 October 2017)

Mr. Angelo Cacciatore
Product Safety & Compliance Engineer
MIDDLE ATLANTIC PRODUCTS
300 Fairfield Road
Fairfield, NJ 07004

Project 167545 – Middle Atlantic Products, BGR Series OPM Submittal

Re: Seismic Evaluation of the BGR Series Enclosures

Dear Mr. Cacciatore:

Simpson Gumpertz & Heger Inc. (SGH) is pleased to present Middle Atlantic Products, Inc. (Middle Atlantic) with the seismic evaluation results for the BGR Series rack enclosures. The purpose of our evaluation was to demonstrate seismic adequacy of these nonstructural components under code prescribed seismic loads and determine a maximum content capacity. The methodology selected (finite element analysis) is one of three methods recommended by the State of California, Office of Statewide Health Planning and Development (OSHPD) for seismic validation of nonstructural components, especially for obtaining a Preapproval of Manufacturer's Certification (OPM) Program approval for the rack enclosure series.

EVALUATION BASIS

To carry out the seismic evaluation Middle Atlantic provided SGH with rack enclosures drawings, material information, and Solidworks models for the governing frame sizes within the series. Additionally Middle Atlantic provided clarifications of numerous assembly details through e-mail. The drawing documents and clarification correspondence is included as an attachment herein.

The BGR series enclosures selected for testing are listed in Table 1. These enclosures are the tallest models in the series, with the largest and smallest footprints, respectively. As the enclosure frame and anchorage details for each footprint within a series are identical, regardless of height, the evaluated enclosures represent a worst case for seismic loading; and seismic results for the tallest enclosures are applicable to all other BGR series enclosures with equal or lesser height and the same footprint. Therefore, the tested enclosures (BGR-4527 and BGR-4538) are considered to bind the results for all enclosures in the series.

Further, the BGR-SA models are also characterized by this analytical evaluation. The side plates, which are included in the BGR-SA models, are a non-structural feature. The framing for a given BGR-SA model is identical to the corresponding size in the BGR Series. Therefore, performance capacity of the BGR-SA models are equal or greater than those determined herein.

The analyses documented herein are in accordance with California Building Code (CBC) 2016 and ASCE 7-10 Chapter 13 for nonstructural components. Specifically, the analysis option of ASCE 7-10 Section 13.2.1 is used to demonstrate seismic qualification of the BGR enclosure series.

EVALUATION METHODOLOGY

We evaluated the seismic performance of each enclosure frame using ABAQUS Version 6.12-1/6.13-1, finite element analysis software. Each model originated from Solidworks STP files provided by Middle Atlantic. Each model was modified into a working finite element structural analysis model by assigning material properties, joint restraints, representative thicknesses, and meshing components to allow for determination of localized stresses. Only major structural members are included in the structural analysis model. For the side-to-side analysis, plates simulating installed equipment have been added to the ABAQUS models. The plates are 0.047 in. thick, which is an estimate of the typical thickness of the faceplates of rack-mounted equipment and is also the thickness of the racks at the equipment connections. Since screws connect the equipment to the rack, the plates are modeled with several discreet connection points to the rack. The element thickness at each connection point are the sum of the added plate thickness and the rack thickness. These plates are considered as structural elements as they act as braces in the side-to-side direction analysis. Justification for this assumption and approach are provided in the calculations within Attachment A.

The weight of contents was included in each model as a uniform mass, distributed such that 50% of total weight was placed in the bottom third of the enclosure rack height, 25% in the middle third, and 25% in the top third. The horizontal mass component of the contents was similarly applied to the nodes along the height of structure.

Each frame was subjected to a lateral pushover analysis in each primary direction (front-to-back and side-to-side), including all seismic mass and both horizontal and vertical seismic force accelerations. Gravity load was applied to the structure before lateral loading and then, lateral seismic loading was applied along with vertical seismic loading. The pushover analysis allows for a progressive visualization of stresses throughout the model while the seismic force is gradually increased. The nonlinear pushover analysis is able to catch the progressive local yielding of structural components. The lateral content capacity is then determined based on the onset of local strain hardening within the structural framing. The ultimate capacity occurs at the local ultimate stress within the framing.

EVALUATION RESULTS

The pushover analysis results for each frame and each loading direction are included in Figures 1 through 4.

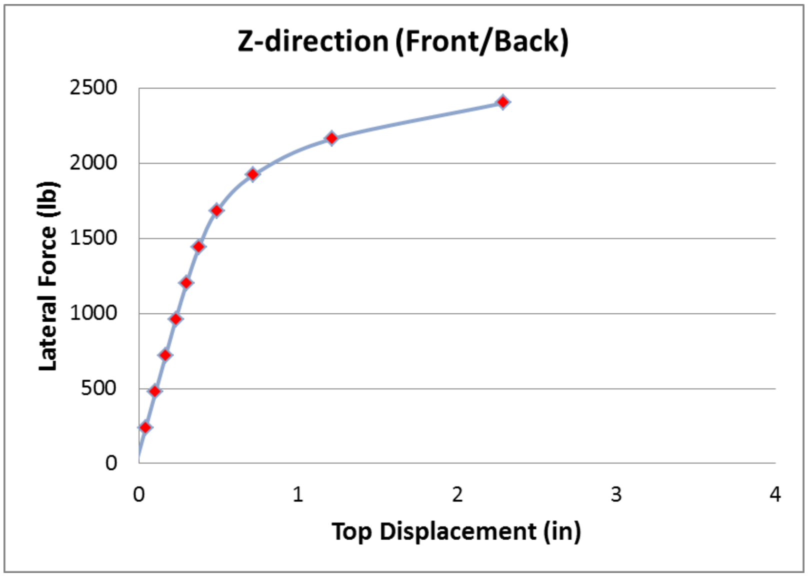


Figure 1: Nonlinear Pushover Analysis Result of BGR-4527 in the Front-to-Back Direction

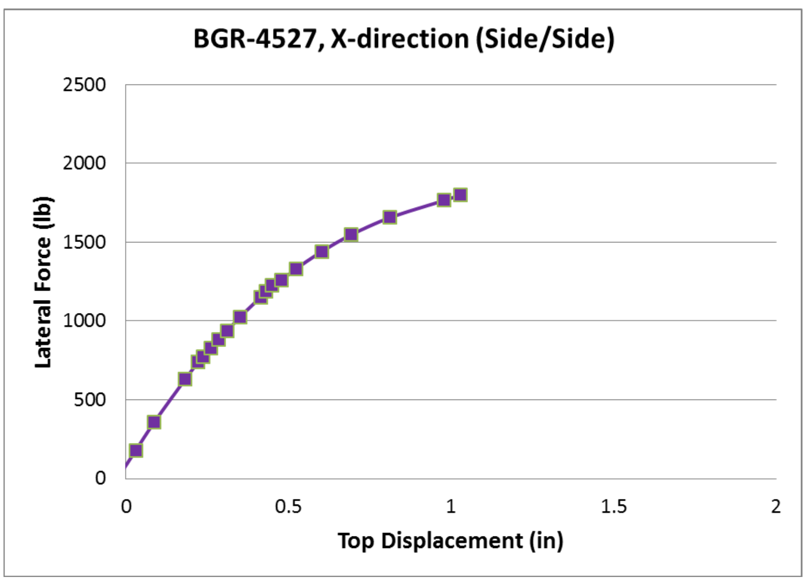


Figure 2: Nonlinear Pushover Analysis Result of BGR-4527 in the Side-to-Side Direction

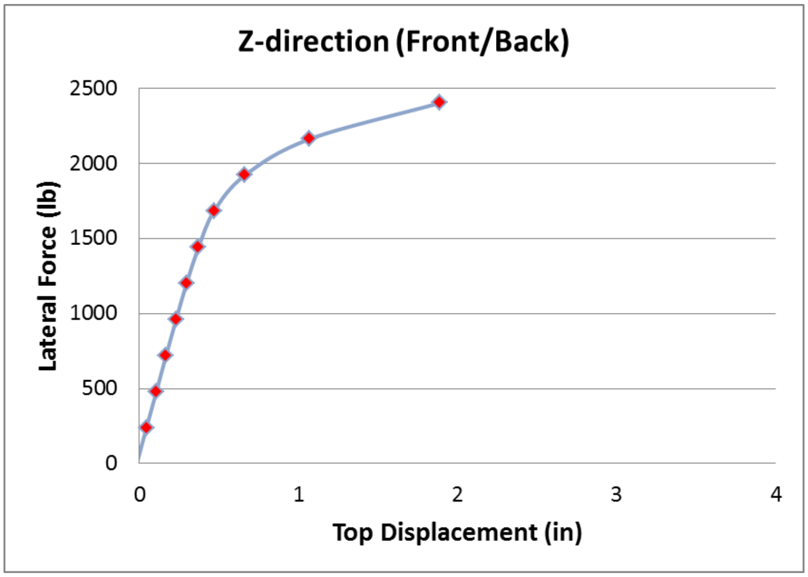


Figure 3: Nonlinear Pushover Analysis Result of BGR-4538 in the Front-to-Back Direction

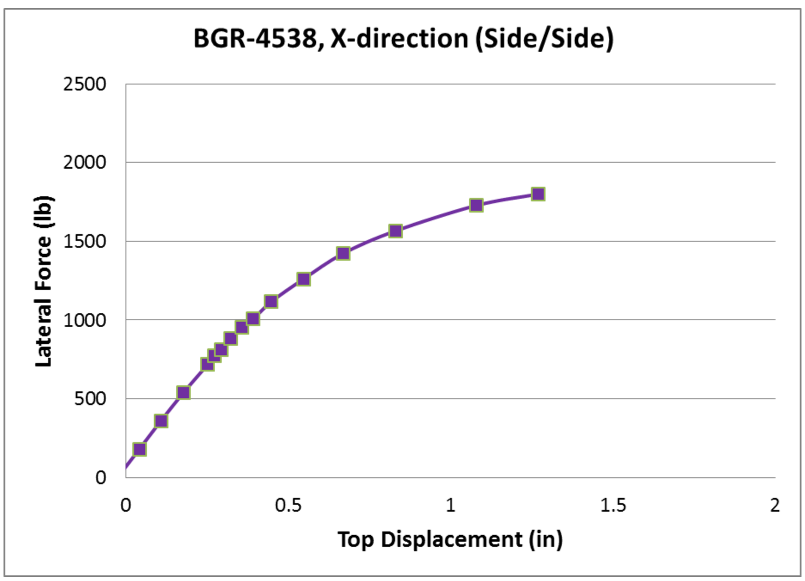


Figure 4: Nonlinear Pushover Analysis Result of BGR-4538 in the Side-to-Side Direction

A summary of lateral force and content capacity is provided in Table 1. The analysis assumes a lateral design force of 1.5g; therefore 'equivalent content capacity' is equal to the lateral force divided by 1.5 minus the self-weight of the structural framing.

Table 1: Evaluation Results and Seismic Capacity (pounds) [1,2,3]

Enclosure	Lateral Force at Plastic Strain		Equivalent Content Capacity	
	Front-Back	Side-Side	Front-Back	Side-Side
BGR-4527	1920	1800	1280	1200
BGR-4538	1920	1800	1280	1200

1 Capacities provided are for the BGR Series enclosures, up to 45 rack spaces tall, using the Middle Atlantic BGR-Z4 seismic anchorage kit. Selection and installation of the enclosure rack anchor bolts are the responsibility of the end user and are not addressed in this evaluation.

2 Capacities provided are applicable when 50% of the enclosure contents are positioned in the bottom third of the rack, 25% in the middle third, and 25% in the top third.

3 Capacities are based on worst case seismicity ($S_{DS} \leq 2.04g$ for ASCE 7-10), top floor or rooftop installation, and High Importance Installations (I_p of 1.5). Additional seismic capacity may be available based on a site-specific evaluation of the installation location.

The capacities in Table 1 are considered a worst case seismicity per current building codes, since the seismic design force is based on the largest mapped accelerations within the Continental US for ASCE 7-10. This approach provides capacities that are the most generic in nature, covering all possible installations. As such, enclosures installed at sites with less seismicity or on lower floors may have content capacities greater than those provided.

The deformed shapes of each frame in the side-to-side loading direction are shown in Figures 5 through 6. The content capacity of both frames is governed by the side-to-side loading. As shown in Figures 5 and 6, the large plastic deformation occurs at the area near the part 720-00152. This large local plastic deformation governs the content capacity of both frames.

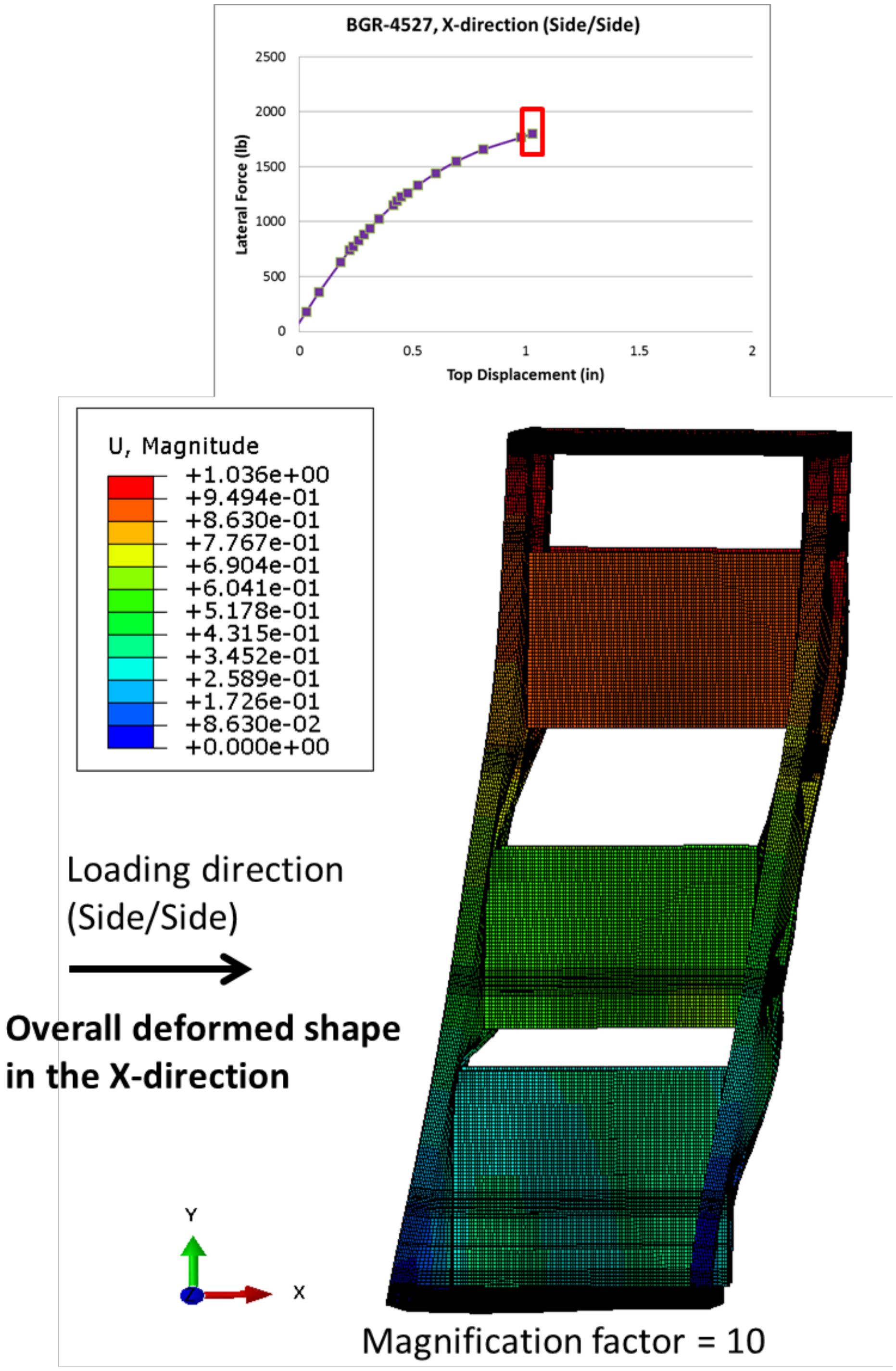
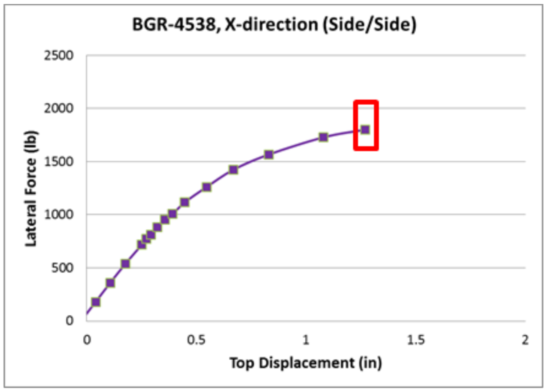


Figure 5: Deformed Shape of BGR-4527 in the Side-to-Side Direction
at a Lateral Loading of 1,800 lbs



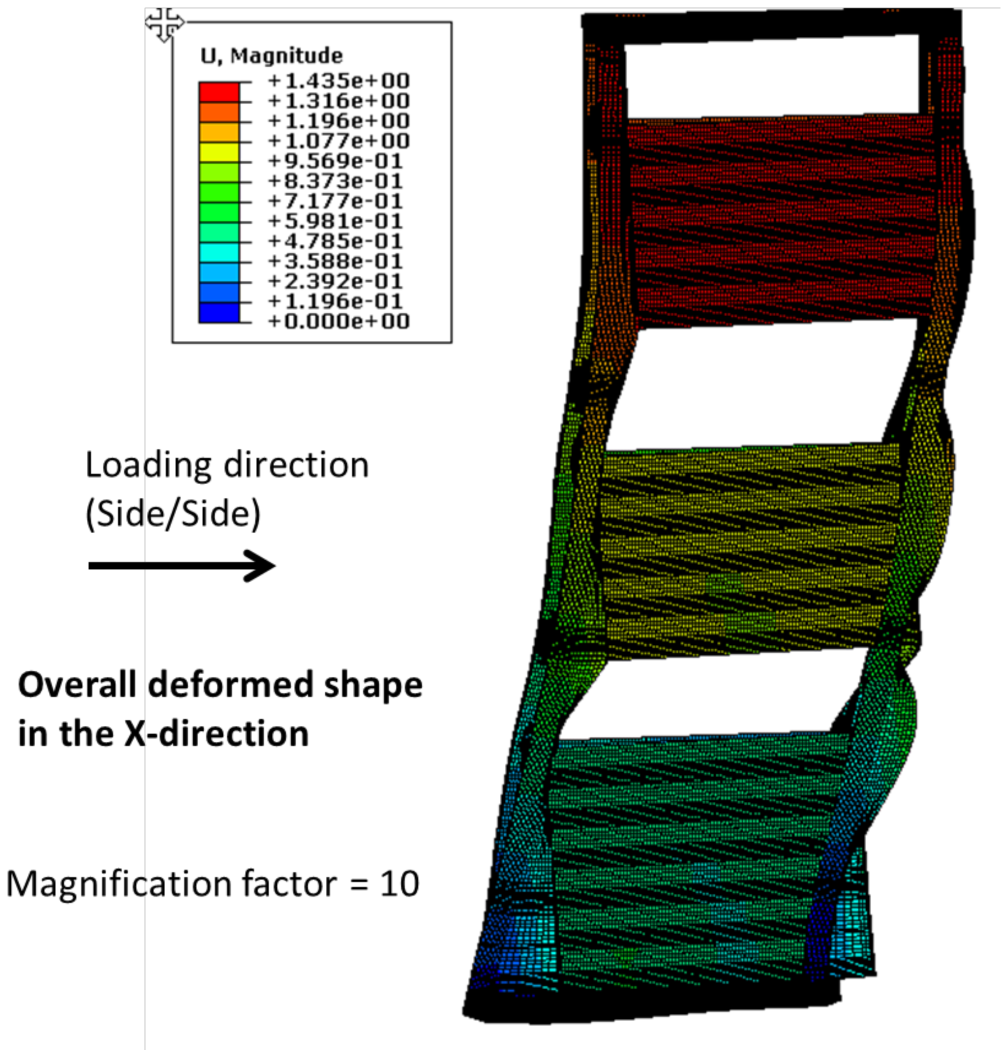


Figure 6: Deformed Shape of BGR-4538 in the Side-to-Side Direction
at a Lateral Load of 1,800 lbs

CONCLUSIONS

Based on this assessment, SGH concludes that the BGR and BGR-SA Series rack enclosures have sufficient seismic load resistance to support a content capacity of 1,200 pounds or more. Additional capacity may be found by conducting a site-specific evaluation considering the site seismicity and installation location. These seismic capacities are appropriate for all models within the series with the same footprint as those tested, and with the same or lower total height and weight.

Please note the conclusions noted herein are applicable only to the BGR and BGR-SA Series enclosures when anchored using the Middle Atlantic BGR-Z4 seismic anchorage kit. Selection and installation of rack-enclosure anchor bolts are the responsibility of the end user and are not addressed in this evaluation. Any changes to the enclosure design, fabrication, materials, and anchorage may invalidate these conclusions.

If there are any questions or comments, please feel free to contact the undersigned directly at 510-457-4449.

Sincerely,

Simpson Gumpertz & Heger Inc.

REGISTERED PROFESSIONAL ENGINEER
WILLIAM M. BRUIN
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CIVIL
STATE OF CALIFORNIA

10 October 2017

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Attachment A – BGR Series Seismic Qualification Calculations
Attachment B – BGR Series OSHPD Drawings