bridges dominated the investment package.
No more than $25 million can be awarded for a single project and no more than $150 million can be awarded to a single state. There is a $5 million minimum award for projects located in urban areas, and a $1 million minimum for rural projects.
FY 2018 was the tenth annual round of grants under this program, which came into existence in the fiscal 2009 ARRA stimulus act. A total of almost $7 billion in funding has been distributed to date.
The Federal government has recently placed emphasis on projects that are in rural areas, have applied in previous rounds (repeat applicants), have local and state matching funds and other innovations and partnership. They will also ensure that there is geographic diversity among recipients. BUILD Grants can be awarded to projects that include the following criteria in their applications:

- Safety
- State of Good Repair
- Economic Competitiveness
- Environmental Protection
- Quality of Life
- Innovation
- Partnership
- Non-Federal funding sources
- Demonstrated Project Readiness
- Project Costs and Benefits

- **INFRA Grants:** Infrastructure for Rebuilding America (INFRA) is a discretionary grant program from the USDOT. INFRA was established in the Fixing America's Surface Transportation (FAST) Act of 2015 and is funded by the Highway Trust Fund. The FAST Act created a $500 million cap on multimodal projects for the program's five-year duration, and approximately $200 million remains available through FY 2020. The INFRA grant program preserves the statutory requirement in the FAST Act to award at least 25 percent of funding for rural projects. INFRA grants fund both large and small projects. A large project INFRA grant must be at least $25 million, and a small project must be at least $5 million. For each fiscal year of INFRA funds, 10 percent of the funds provided are reserved for small projects.
  The Administration is specifically focused on projects in which the local sponsor is significantly invested and is positioned to proceed rapidly to construction. Eligible INFRA project costs may include: reconstruction, rehabilitation, acquisition of property (including land related to the project and improvements to the land), environmental mitigation, construction contingencies, equipment acquisition, and operational improvements directly related to system performance.
  In the FY 2019 INFRA program there was approximately $855-900 million in funding available. The application period was very tight opening on January 7, 2019 with applications due March 4, 2019.
- **FEMA Port Security Grant Program:**
  FEMA administers these grants in coordination with the Department of Homeland Security. In 2018 there was $100 million available for FEMA security grants to fund projects that include but are not limited to perimeter security, information technology, GIS, and certain disaster relief monitoring. The funding opportunity window is usually in

the summer and successful grantees say that advance groundwork is needed. In most Ports the Captain of the Port (the Coast Guard) must "vet" all potential projects submitting applications under this program. If it does not have the support of the Captain of the Port or the local equivalent authority, FEMA will not award. These grants also usually have a small timeframe for spending the grant money which makes it important to have your project ready to go.

STRATEGY, PLANNING AND APPROACH

Evaluation of your project and how it would fit the criteria for the grants is crucial. It is important to review the criteria of each grant and match your project's scope to the criteria. For example, if the criteria states that your project must show reduction in greenhouse gas emissions (GHG), you should not be applying for a project that adversely impacts GHG emissions. Here are 6 key strategies that will help a port plan for and then develop grant applications:

- Do your homework – Go to the agency website and find out what the goals, hot topics, and current issues are with the agency staff who will be reviewing the grant application. In the grant information section, key goals for the funding opportunity are typically well defined. Successful applications address these key goals that grant evaluators want to see.
- Find the right "ask" - Most applications do not receive the amount they ask for. Because there is a lot of competition and the Federal Government is trying to spread their dollars to as many states as possible with a limited amount given to each State, most applications do not receive approval for the full amount that they request. There is an art to finding the right amount to ask for. If you request too much and your Federal government portion of the project is too high, you may not get any award (they want to see a variety of other sources supporting the project – both public and private). On the other hand, if you request too little, you could be leaving money on the table. It is important to have a plan "B" to cover the gap between the requested federal grant amount and the actual award received.
- Lay out the schedule for submission – Most grants have regular cycles during the year for submission. You cannot just submit whenever you are ready. There is a notice of funding opportunity that specifies a submission date. These windows are usually very small and so advance planning is critical. You will need to clearly define your project, performed a cost/benefit analysis and developed a complete funding plan. In order to do these things the project scope must be well defined. Sometimes, the scope of a project may need to be adjusted to improve the cost/benefit ratio, meet a funding partner's request, or grant criteria.
- Get commitments for "other" funding in advance– this may be in the form of a grant or a letter of commitment from another entity that is providing funding to your project. It may also be approval from your governing authority such as board of directors to provide matching funds.
- Get letters of support – All project stakeholders should show support by writing letters to be included with the application or sent separately. Spend time educating the community about the benefits of the project and then ask for their support. Chambers of commerce, customers, tenants, contractors, and elected officials can all help.
- Ensure that the application submitted matches all the grant criteria and conforms to the grant instructions. Projects have been disqualified for missing a check in an important box. Read the fine print carefully.

CASE STUDIES

Three people who have a lot of experience with applications for federal funding were interviewed for this paper.

1) The first person interviewed was Matt Davis, Director Government affairs, Port of Oakland, CA. Mr. Davis was and still is involved in many grant applications for the Port of Oakland, the third largest container Port on the West Coast. Below is his story.

In early 2009 when the Recovery act was still in its early stages and the TIGER program was still being developed by the federal government, The Port of Oakland hosted the then-Secretary of DOT, Ray LaHood. He encouraged the Port to apply for an about to be released marine highway grant along with the Ports of Sacramento and Stockton. Oakland had identified quite a bit of infrastructure needs but a marine highway was not one of them. However, the Port needed grant funding to pay for a new State regulation requiring ocean going vessels to plug into the grid while they were at berth. The Port needed to provide the electrical infrastructure to 30 berths. The Port developed a bifurcated approach of a Green Trade Corridor which would provide funding for the shore power for Oakland, and funding for barges and container handling equipment at Sacramento and Stockton. Ultimately, the $56m request was approved for only $30m and there was a lengthy negotiation process not only with MARAD but also with the fellow recipients. The scope needed to be reduced and there needed to be metrics developed for grant performance.

The Port tried again in round 3 of TIGER to get funding for development of a former Army Base adjacent to the Port and was unsuccessful because they asked for too much money and had a large and complex project. There is an art to making a request that is flexible enough to withstand gaps in funding but not so flexible so that it appears you don't need the funding at all. The lesson Oakland learned was that the feds want to be the last dollar in to put the project over the top and into construction. In round 4 of TIGER they asked for only $20m for a discrete portion of the project and received $15m. This federal grant elevated the project to into one of national significance and Oakland was able to lock down state corridor funding of over $240 million. The successful application included heavy lobbying by the Port. They had cross sectional group of agricultural growers, labor interests, business interests, community members, and politicians writing letters and making calls in support of the project. They had their members of congress personally call the DOT secretary.

The most difficult part of a successful grant applications is reconciling the project readiness with funding availability and timelines. In particular, the Federal environmental process (NEPA) was delegated to individual federal agencies (in this case, MARAD) and it took several months to get a "categorical exemption" ruling from that agency where they had made many close friends with staff. The Port could not just go "do NEPA" in advance of federal funding being allocated. While Oakland had been successful with two rounds of TIGER applications, and several rounds of Port security grants, it has had no success yet with BUILD (or former INFRA) grants. Part of that is because there is increased competition and part of that is that CA is not getting a lot of Federal funds under the current administration. But the failures do not deter the Port and they will continue to be persistent.

2) The second person interviewed was Kristin Decas, Executive Director, Port of Hueneme, CA. Ms. Decas has been very successful with federal grants for her small cargo and fishing Port in Ventura County, CA. Below is her story.

Applying for federal grants is not luck; it is all strategy. Assuming your project has all the merits and the application conforms to the requirements, success is achieved through careful and deliberate outreach to garner support for the project. For Hueneme's successful TIGER grant, there were 38 letters of support. These came from years of fostering relationships across all Port constituents including the Board of Supervisors, Ventura County Transportation Council, Southern California Area Governments (SCAG), businesses, chambers of commerce, Metropolitan Planning Organization (MPO), local, county and state officials, labor, trades, and customers. Her project ended up as one of four projects on the Governor's list. Nobody ever got turned down for a grant from having too many letters. They also had members of Congress call the Secretary of DOT. The Port realized that their efforts to educate the community about the economic importance of the Port and bringing them in to see and participate in the business of the Port was instrumental when they needed their support for letters.

The Port has not always been successful (they applied 3 times for TIGER and 3 times for DERA), but it has been persistent and creative with finding other sources of funds and private capital. Through networking, participation in associations and industry organizations such as the National Freight Advisory Committee the Port learned about other non-traditional funding opportunities such as an economic development grant for $1.7m that paid for paving work in the Port area because the Oxnard Harbor District was carved out as economically needy. The Port was able to get TIGER money for berthside dredging. Normally dredging would be considered maintenance and not eligible; but they were very strategic and called it a project to remove sediment and dirt excavation. The Port has also pursued funding from New Market Tax Credit deals where lenders get tax credit for investing in green jobs, etc. The Port credits this success with persistence and creativity. They look under every rock for money and are not intimidated by the process. Ports can also succeed with grants that are traditionally given to transit projects such as Congestion Mitigation Air Quality (CMAQ) grants. Hueneme got CMAQ funds for their shoreside power project.

Another strategy has been partnering with neighboring Ports such as Los Angeles which made it a "regional" request for funding and not just a small town. Hueneme and Los Angeles got grant funding to participate in Zero Emission technology test (ZETT) for Port equipment.

3) The third person interviewed was Keith Lesnick, retired Director of MARAD and former grant reviewer. Below is his story.

Successful grants require work on the political side. Know who is reviewing the grant application, study the goals of that department (easily found on websites) and speak to those goals in your application. Reviewers are looking to see if the project meets their goals and the current administration's initiatives . When the notice comes out there is usually a pre- application seminar for any questions people have about the grant process. These can be very valuable sessions especially to entities new to the process but also to experienced grant writers who will need to listen for the key goals and what matters.

Once the application is sent to the Secretary's desk, the political process kicks in. It is important to have as many elected officials and particularly members of Congress to call - not just write – the Secretary's office. Rumor has it that the Virginia Governor called Secretary Fox every week to lobby for a State highway project and it was one of the highest funded out of the first round of INFRA grants. The process of applying for these grants is like a poker game where you need to figure out what card to play and when.

CONCLUSION

Key Factors for Success

- **Plan ahead and determine timing of application** - Each grant has a typical annual cycle (BUILD is in January, Security in Summer, etc.). know what cycle you will aim for based on your project readiness.
- **Obtain letters of support for the project and conduct outreach** – Grant applications were never turned down due to too many letters of support. The more people and entities at all levels who know and support your project is important.
- **Be persistent** – You may need to apply for the grant multiple times before success is achieved. It is not luck, it is strategy and persistence.
- **Don't make mistakes on your application** – Read and execute the grant instructions carefully. One box unchecked can disqualify you. Hire professionals who know how to submit these applications and who have done it before and can dedicate resources to meeting all the criteria. The window for grant applications is usually very small but the work to put them together is large.
- **Secure a variety of funding sources** – Local and state funding is critical to leverage the federal grants but other fund sources are also important. A project without significant matching funds will not be successful. The current administration has put emphasis on diversifying infrastructure financing and applications do not always receive the amount that is requested. Have a plan B for the gap in funding.
- **Get creative with partners** – Look for funding in non-traditional funding opportunities such as community economic development grants. Partner with other public entities to leverage local and regional visibility similar to the Port of Oakland's use of marine highway partnership.

REFERENCES

Davis, Matthew, Director Government Affairs, Port of Oakland, CA Interviewed and email exchange conducted in December 2018;

Decas, Kristin, Executive Director, Port of Hueneme, Ventura, CA Interview via telephone January 2019;

Lesnick, Keith, Retired, former Director, Maritime Administration (MARAD) Napa, CA Interviewed via telephone, January 2019.

3-Dimensional Nonlinear Static Analysis for Waterfront Structures with Torsional Response under Seismic Loading

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ABSTRACT

This paper presents a methodology to analyze waterfront structures using a 3-dimensional nonlinear static (pushover) analysis to capture the torsional response caused by the eccentricity between the center of mass, and, the centers of stiffness and strength. Waterfront structures often exhibit torsional responses under seismic loading due to the mass and stiffness eccentricity caused by the sloping ground between the nearshore and offshore ends of the structure. The torsional response is further intensified when the structure exhibits an irregular geometric configuration. Typical practice is to analyze these structures using an elastic modal response spectrum analysis, which relies on the equal displacement assumption, that states the inelastic displacement demands can be approximated using an elastic analysis. This assumption may or may not be accurate depending on the extent of nonlinearity in the structure, and the method used for equivalent linearization. The proposed 3-dimensional nonlinear static pushover analysis methodology accounts for the varying eccentricity with displacement demand as yielding of the structure and soil occurs and provides a more direct analysis based on the well accepted nonlinear static methodology. The methodology will be presented as a case study based on marine loading platform analysis and design for the Puget Sound Energy (PSE) Liquified Natural Gas (LNG) Bunkering Facility located in Commencement Bay on the Blair-Hylebos peninsula in Tacoma, Washington.

INTRODUCTION

The Puget Sound Energy (PSE) Liquified Natural Gas (LNG) Bunkering Facility is located in Commencement Bay on the Blair-Hylebos peninsula in Tacoma, Washington. The facility receives natural gas from PSE's existing pipeline system, chills it to a liquified state and stores it for delivery to existing public-and private-sector natural gas customers through an underground cryogenic pipeline and new loading platform. In addition to providing natural gas to customers during periods of high demand, the facility provides LNG as a cleaner fuel option to domestic maritime shippers that must comply with current and future clean air standards. The marine facilities include a loading platform, breasting dolphin, catwalks and catwalk foundations.

This paper focuses uses the seismic analysis for the loading platform as a case study to present a methodology to analyze waterfront structures using a 3-dimensional nonlinear static (pushover) analysis to capture the torsional response caused by the eccentricity between the center of mass, and, the centers of stiffness and strength. The proposed methodology accounts for the varying eccentricity with displacement demand as yielding of the structure and soil occurs and provides a more direct analysis based on the well accepted nonlinear static methodology.

Figure 1: Loading Platform (Looking North)

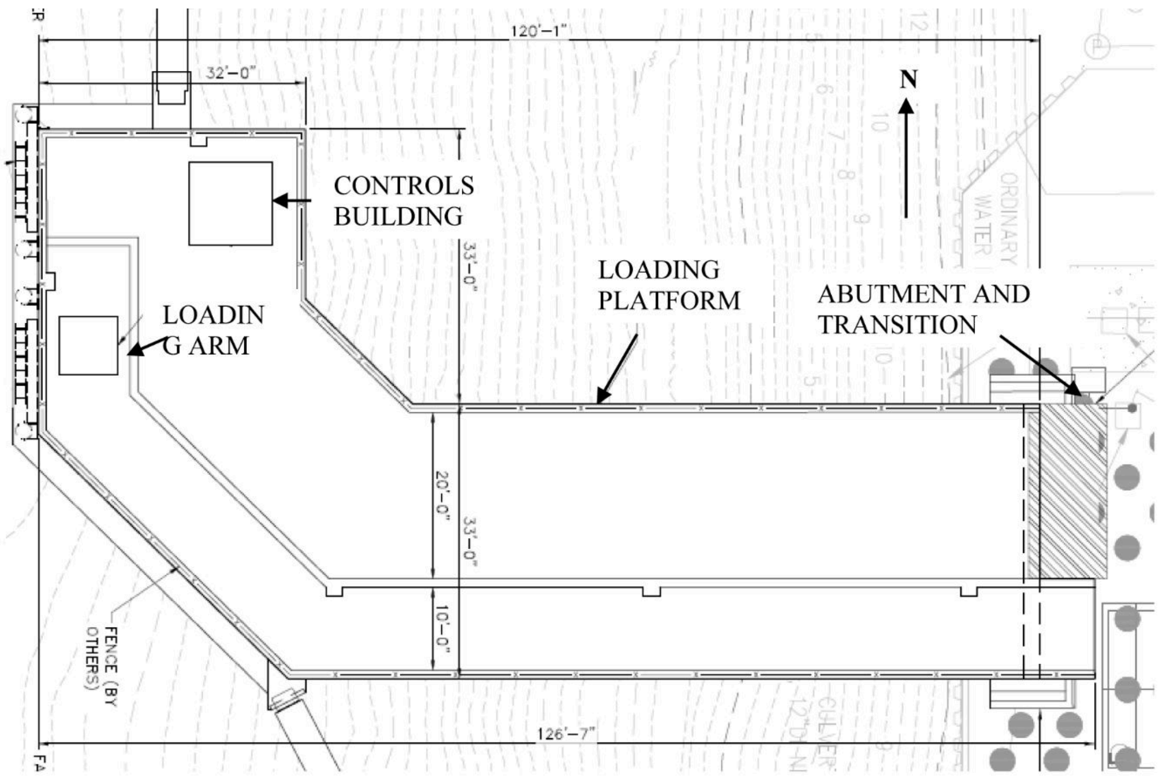

Figure 2: Loading Platform – Layout

LOADING PLATFORM CONFIGURATION

Figure 2 and 3 illustrate the layout and longitudinal cross-section (perpendicular to the shoreline) for the PSE LNG Bunkering facility loading platform. The layout of the loading platform was governed by the need to avoid conflicts with the mooring line arrangement at the existing TOTE Terminal.

The loading platform is a steel pipe pile-supported structure with a cast-in-place concrete superstructure. Along the shoreline, the platform is supported on an abutment via elastomeric bearing. The elastomeric bearings are free to slide on the abutment during a large seismic event. The bearings are detailed so that they are only rigidly connected to the loading platform and free to slide on the abutment seat once the static friction between the elastomer and the concrete is overcome. The loading platform design complies with the two design earthquake levels specified in the National Fire Prevention Association (NFPA) 59A standard: An Operation Basis Earthquake (OBE) and a Safe Shutdown Earthquake (SSE).

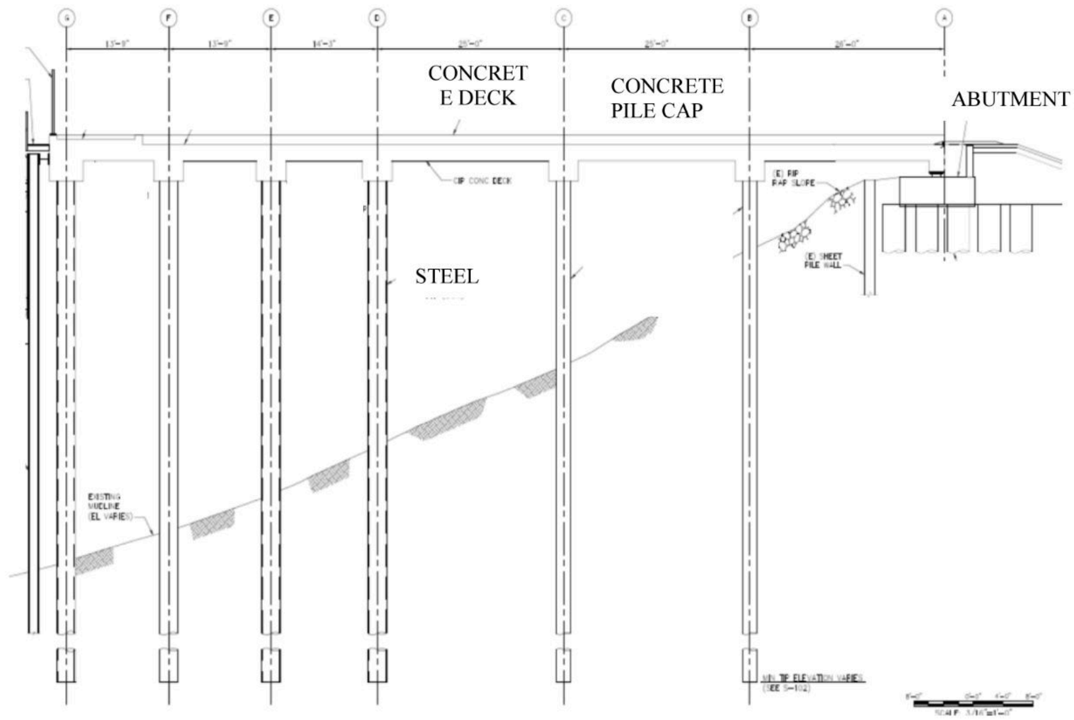

Figure 3: Loading Platform – Typical Cross-Section

SEISMIC DESIGN CRITERIA

There is little to no guidance available on design of LNG marine terminals in the NFPA 59A. The NFPA 59A provides a three-level performance-based design approach for minimum seismic design criteria LNG containers, system components required to isolate the containers and maintain them in safe shutdown condition, and any structures or systems whose failure can affect the integrity of the LNG containers. These three level and associated performances were evaluated for applicability to LNG marine terminals.

Based on the interpretation of the NFPA 59A requirements, the third level (aftershock level earthquake) does not apply to marine facilities because the marine facilities are not part of the secondary containment system. Table 1 presents the seismic design criteria for the project based on the interpretation of the NFPA 59A.

The loading platform was assessed for horizontal irregularities in accordance with IBC-2012 and ASCE 7-10. The horizontal irregularities 1a, 1b and 2 required further detailed evaluation. Detailed evaluation revealed that Type 1a irregularity exists and it required modal response spectrum analysis (RSA) based on ASCE 7-10 and IBC 2012.

Table 1: Earthquake Levels and Performance Requirements

Earthquake Level	Probability of Exceedance	Performance Requirements
Operating Basis Earthquake (OBE)	10% PE in 50 years	Facility expected to remain operational during and after the event. The loading platform will be designed to remain essentially elastic, with minimal damage. All damage, if any, shall be located where visually observable and accessible for repairs. Minimal damage performance limits from ASCE 61-14 will be used.
Safe Shutdown Earthquake (SSE)	2% PE in 50 years	Facility is not required to be operational or repairable. The loading platform will be designed for collapse prevention/life safety protection. The spillway will be designed to ensure LNG containment. Life Safety Protection performance limits from ASCE 61-14 are used with modification to the steel pipe pile strain limits based on recent experimental research results.

Table 2: Horizontal Structural Irregularities

Type	Description	Discussion
1a	Torsional Irregularity	Requires detailed evaluation due to possible eccentricity between the center of mass and center of stiffness. If $\Delta_{max}/\Delta_{avg} > 1.2$ this irregularity exists.

Waterfront structures often exhibit torsional responses under seismic loading due to the mass and stiffness eccentricity caused by the sloping ground between the nearshore and offshore ends of the structure. The torsional response is further intensified when the structure exhibits an irregular geometric configuration. Typical practice is to analyze these structures using an elastic modal response spectrum analysis, which relies on the equal displacement assumption, that states the inelastic displacement demands can be approximated using an elastic analysis. This assumption may or may not be accurate depending on the extent of nonlinearity in the structure, and the method used for equivalent linearization. The 3-dimensional nonlinear static substitute structure method (SSM) used for the loading platform accounts for the varying eccentricity with displacement demand as yielding of the structure and soil occurs and provides a more direct analysis based on the well accepted 2D SSM procedure.

3D SUBSTITUTE STRUCTURE ANALYSIS METHODOLOGY

The substitute structure method (SSM) outlined in ASCE 61 Section 6.8.3 and 2010 MOTEMS 3104F.2.3.2.5 uses the nonlinear static (pushover) response of a structure to determine the displacement demands based on the secant stiffness and equivalent hysteretic damping of the structure. Typically, the pushover analysis is performed on a 2-dimensional typical bent. However, for the loading platform and similar structures, that are irregular in plan, or with no typical bents, the 2D pushover analysis will not adequately capture the response of the structure. In these cases, the global response is better captured with a 3D SSM analysis. This 3-dimensional extension of the SSM analysis is allowed under the commentary of ASCE 61 Section C6.8.3.

This methodology assumes that the structures seismic response is dominated by a single mode of vibration in each orthogonal direction and that higher mode effects are not significant. Therefore, this method applies to structures such as loading platforms and short piers that have rigid diaphragm (deck) responses, and minor to moderate torsional response. It is assumed that torsional response of the structure is not extreme, as structures with this type of behavior should not be used in high seismic regions. This method is also not suitable for long piers that exhibit higher mode responses.

To perform the 3D SSM analysis, the structure is pushed in each orthogonal direction by loading the structure at the center-of-mass. This can be accomplished in the analytical model by applying a uniform acceleration in each direction, or by applying a point load at the center-of-mass of the structure. Due to nonlinear soil and structural response, the locations of the center-of-stiffness and the center-of-strength change depending on the center-of-mass displacement demand. Because any eccentricity between the centers of stiffness and strength and the center-of-mass are explicitly accounted for at each step of the pushover analysis the torsional response of the structure can be estimated.

The following outlines the general analysis procedure for the 3D SSM analyses:

1. Develop a 3-dimensional global analytical model of the loading platform including soil-structure interaction (typically with a p-y/q-z spring approach, along with plastic hinges for structural nonlinear effects.
2. Locate the center-of-mass of the structure based on the joint masses that contribute to the seismic weight.
3. Perform pushover analyses in each of the four plan orthogonal directions (upslope, downslope, and the two transverse directions). The pushover force (base shear) is the horizontal load applied at the center-of-mass. The displacement is recorded at the center-of-mass node and at the top of each pile
4. The resulting pushover curves are used to determine the displacement demand at the center-of-mass using the SSM provisions of ASCE 61 Section 6.8.3 and MOTEMS 3104F.2.3.2.5. The seismic weight used to determine the base shear remains constant for each loading direction and load combination.
5. At the center-of-mass displacement demand, the individual top of pile displacement demands is recorded. If there is no significant torsional response in the direction of loading, the center-of-mass displacement will equal the top of pile displacement demands. If there is a torsional response, the center-of-mass displacement will not equal the top of pile displacements.
6. The top of pile displacement demands is combined using the orthogonal combination rules in MOTEMS Section 3104F.4.2 to determine the resultant displacement demand for each pile.
7. The displacement capacity for each pile is determined by recording the top of pile displacement (during the global pushover analysis) when the first strain limit is reached in each pile. Individual pile pushovers with the appropriate axial load may also be used to determine the displacement capacity for each unique pile.
8. The design displacement demands are then compared to the displacement capacity for each pile to determine the displacement demand-to-capacity ratio.