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SEISMIC DESIGN OF DATA CENTERS FOR TIER III AND TIER IV RESILIENCE: BASIS OF DESIGN

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ABSTRACT

This paper proposes a seismic design basis for Tier III and Tier IV class data centers to achieve consistent levels of seismic resilience. Many organizations heavily rely on the operational continuity of data centers for everyday operations. As such, design of data centers is based on a paradigm that has resilience at its focal point. To quantify, standardize and compare the resilience with objective measures, a four-level tiered classification system is being used. However, structural and seismic focus of these tiers are provided in a brief format, and there are some inconsistencies between their prescriptive and performance-based requirements. In overall, a sound design basis with clear details should be established to have consistent levels of resilience. To propose a design basis, first, a brief summary and critique of the structural tiering reference guide provided by the main standard for data center design and tiering, TIA-942-A, is given. Then, structural and seismic design challenges associated with the requirements of this standard and data centers in general are discussed. A design basis that addresses these challenges and satisfy the baseline criteria provided by TIA-942-A is proposed based on an intense multidisciplinary study. The design basis set the intent and include criteria for, but not limited to, the design and performance evaluation of structural and nonstructural elements, acceleration limits, inclusion of vertical ground motion and base isolation. Emphasis is given to base isolation since conventional structural systems are known to have difficulty to achieve the high levels of required performance with reasonable cost. Criteria for base isolation include displacement and axial load capacity of isolators, use of geometric mean and maximum direction spectra for isolator and superstructure design, scaling or spectral matching of historical ground accelerations to a design spectrum including the vertical ground motion. It is considered that proposed design basis establishes a sound ground for seismic design of data centers that is compatible with available tier classification.

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This paper proposes a seismic design basis for Tier III and Tier IV class data centers to achieve consistent levels of seismic resilience. Many organizations heavily rely on the operational continuity of data centers for everyday operations. As such, design of data centers is based on a paradigm that has resilience at its focal point. To quantify, standardize and compare the resilience with objective measures, a four-level tiered classification system is being used. However, structural and seismic focus of these tiers are provided in a brief format, and there are some inconsistencies between their prescriptive and performance-based requirements. In overall, a sound design basis with clear details should be established to have consistent levels of resilience. To propose a design basis, first, a brief summary and critique of the structural tiering reference guide provided by the main standard for data center design and tiering, TIA-942-A, is given. Then, structural and seismic design challenges associated with the requirements of this standard and data centers in general are discussed. A design basis that addresses these challenges and satisfy the baseline criteria provided by TIA-942-A is proposed based on an intense multidisciplinary study. The design basis set the intent and include criteria for, but not limited to, the design and performance evaluation of structural and nonstructural elements, acceleration limits, inclusion of vertical ground motion and base isolation. Emphasis is given to base isolation since conventional structural systems are known to have difficulty to achieve the high levels of required performance with reasonable cost. Criteria for base isolation include displacement and axial load capacity of isolators, use of geometric mean and maximum direction spectra for isolator and superstructure design, scaling or spectral matching of historical ground accelerations to a design spectrum including the vertical ground motion. It is considered that proposed design basis establishes a sound ground for seismic design of data centers that is compatible with available tier classification.

Introduction

Data centers are facilities that house a network of computers and supporting components to store, organize, process and disseminate large amounts of data to address information technology (IT) needs of companies and organizations. Servers, storage computers, networking switches, routers, that are connected with cables and that are placed at racks form a sophisticated IT network that is expected to operate flawlessly. The network should be supported by a well-designed power infrastructure, with a primary power distribution that is designed for everyday operation of the network and supplemental power systems, such as backup power and generators, an electrical switch system that allows uninterrupted power supply to the network. Another component that

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supports the network is an efficient cooling system that includes space for ventilation, cooling equipment such as air handling units, which is also has to be fed by the power system. For a data center to operate with minimal problems, all of the above listed physical components that interact with each other heavily should work flawlessly.

The design of data centers is a challenging task due to several reasons. First, the design process requires an intense multidisciplinary collaboration and coordination since a lot of sophisticated and massively interacting IT, electrical and mechanical components exist. Second, the design should achieve its main goal of providing efficient, fast, reliable IT services to its clients with minimal interruption and should be capable of resuming operation after an interruption. In fact, all these merits of a data center that defines overall operational quality of the center are collectively called "reliability" or "resilience" by IT professionals[1], and there are standards and design guides that help designers to achieve designs with high resilience.

Resilience is also the focal point of classification of data centers as the final product shapes around the design challenges that are defined by resilience. In practice, data centers are classified based on a tiered system that is established by an independent consortium of professionals that have expertise in data center design. This system has four tiers, Tier I, II, III and IV, where the top tier, Tier IV, has the highest level of resilience. General properties of these tiers and further details of quantification and requirements are established by the standard [1]. This standard further references other standard for detailed design practices.

Main focus of the tier standard [1] is architectural, IT, mechanical and electrical disciplines, and structural and seismic design considerations are briefly mentioned. For example, several requirements such as floor loading capacity, structural code to be utilized, seismicity, structural systems, importance factors are stated for the structural system. For non-structural components, another standard [2] is cited. The tier requirements for the architectural/structural discipline are stated vaguely in the form of "data centers should consider all physical events." Structural and seismic design of data centers is significantly different than typical residential or industrial buildings, and conventional design approaches cannot be directly utilized. In overall, there is no clear direction and specification for the design of a data center with high levels of tier classification, such as Tier III and Tier IV, in a highly-seismic region. While a formal standard for seismic design of data centers is needed currently, this requires a broader contribution from the engineering community at large, and it is considered that at least a proposal in the form of a design basis would be useful to practicing engineers.

This paper proposes a seismic design basis for data centers with highest levels of resilience tiers, *i.e.* Tier III and Tier IV that are located in seismic regions. First, current standards that defines tiered classification of data centers and structural requirements of these tiers are reviewed. Design challenges based on the current practice are discussed. After an intense multidisciplinary study of a recent data center project, a design basis that addresses these challenges and satisfy the baseline criteria provided by [1] is proposed. The design basis set the main philosophy of design. Criteria for the design and performance evaluation of structural and nonstructural elements, acceleration limits, inclusion of vertical ground motion, use of capacity design and base isolation are stated. It is discussed that conventional structural systems will not be effective in achieving stringent design

[1] In this paper, the term "resilience" will be used to cover all the operational aspects of data centers.

goals, therefore emphasis is given to base-isolation systems. As part of design basis, criteria for base isolation are also given. In the second part of this paper, data centers that are designed using this design basis are reviewed [3].

Review of Current Standards

Design of data centers are generally based on the tiered classification provided by standard [1]. A summary of the operative performance of these tiers is given in Table 1. Tier specific structural aspects and requirements are summarized in Table 2 and
Table 3.

Table 1. A summary of the tiered classification of data centers.

Tier	Title	General	Availability	Downtime
I	Basic	susceptible to disruptions from both planned and unplanned activity	99.671%	28.8 hr/yr
II	Redundant Components	slightly less susceptible to disruptions from both planned and unplanned activity than a basic data center	99.741%	22.0 hr/yr
III	Concurrently Maintainable	allows for any planned site infrastructure activity without disrupting the computer hardware operation in any way	99.982%	1.6 hr/yr
IV	Fault Tolerant	provides site infrastructure capacity and capability to permit any planned activity without disruption to the critical load	99.995%	0.4 hr/yr

Table 2. A summary of the structural design philosophy of the tiers.

Tier	Structural Requirements
I	No requirements for protection against physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.
II	Tier I requirements and includes minimal protections against some physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.
III	Tier II requirements and has protection against most physical events, intentional or accidental, natural or manmade, which could cause the data center to fail.
IV	Tier III requirements and considers all potential physical events that could cause the data center to fail. Provides specific and in some cases redundant protections against such events. Considers the potential problems with natural disasters such as seismic events, floods, fire, hurricanes, and storms, as well as potential problems with terrorism and disgruntled employees. Has control over all aspects of their facility.

Structural requirements for all tiers are explained by the following statement:

“The building structural system should be either steel or concrete. At a minimum, the building frame should be designed to withstand wind loads in accordance with the applicable building codes for the location under consideration and in accordance with provisions for structures designated as essential facilities (for example, Building Classification III from the International Building Code).”

Two requirements for floor loading capacity are specified. Minimum distributed floor loading capacity should be 7.2 kPa and hanging capacity of 1.2 kPa for suspended equipment, while recommended values are 12 kPa and 2.4 kPa, respectively.

Table 3. Structural requirements of the tiers (taken from [1]).

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Structural				
Facility design to International Building Code (IBC) Seismic Design Category (SDC) requirements	Use SDC requirements for building location	Use SDC requirements for building location	Use SDC requirements for building location	Use appropriate SDC requirements for the site with SDC-C being the minimum
Site Specific Response Spectra - Degree of local Seismic accelerations	no requirement	no requirement	with Operation Status after 10% in 50 year event	with Operation Status after 5% in 100 year event
Importance factor - assists to ensure greater than code design	I=1	I=1.5	I=1.5	I=1.5
Telecommunications equipment racks/cabinets anchored to base or supported at top and base	no requirement	Base only	Fully braced	Fully braced
Deflection limitation on telecommunications equipment within limits acceptable by the electrical attachments	not required	not required	yes	yes
Bracing of electrical conduits runs and cable trays	per code	per code w/ Importance	per code w/ Importance	per code w/ Importance
Bracing of mechanical system major duct runs	per code	per code w/ Importance	per code w/ Importance	per code w/ Importance
Floor loading capacity superimposed live load	7.2 kPa (150 lbf/ft^2).	8.4 kPa (175 lbf/ft^2)	12 kPa (250 lbf/ft^2)	12 kPa (250 lbf/ft^2)
Floor hanging capacity for ancillary loads suspended from below	1.2 kPa (25 lbf/ft^2)	1.2 kPa (25 lbf/ft^2)	2.4 kPa (50 lbf/ft^2)	2.4 kPa (50 lbf/ft^2)
Concrete Slab Thickness at ground	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)
Minimum concrete topping over flutes for equipment anchorage when concrete filled metal deck structure used for elevated floors	102 mm (4 in)	102 mm (4 in)	102 mm (4 in)	102 mm (4 in)
Building LFRS (Shearwall/Braced Frame/Moment Frame) indicates displacement of structure	Steel/Concrete Moment Frame	Concrete Shearwall / Steel Braced Frame	Concrete Shearwall / Steel Braced Frame	Concrete Shearwall / Steel Braced Frame
Building Energy Dissipation - Passive Dampers/Base Isolation (energy absorption)	Not required	Not required	passive dampers for IBC Seismic Design Category D or higher	passive dampers/base isolation for IBC Seismic Design Category D or higher
Elevated floor construction. (Steel structures with concrete filled metal decks are more easily upgraded for intense loads in Battery/UPS rooms. (Also, better for installing floor anchors).	PT concrete	CIP Mild Concrete	Steel Deck & Fill	Steel Deck & Fill

Specification [2] is cited several times in [1] for topics such as floor loading and general seismic requirements. [2] provides generic criteria and testing protocols for earthquake, office and transportation vibration for network equipment and related nonstructural components, and it is not related to seismic design of structure. Further, criteria and testing protocols are based on older U.S. building codes are not compatible with the newer U.S. and other national codes.

As can be seen from the review provided above, there are various unclear points regarding structural and seismic design of data centers, although a crude framework and design philosophy is defined. Some of these points are summarized below:

- Whether the floor loading is live load or superimposed dead load and how it should be included in the load combinations and seismic weight is not clear. This is a major issue since suggested values of the floor loading capacity may result significant variations in seismic weight, which may be major parameter for base isolation design.
- Site-specific spectra for Tiers III and IV correspond to return periods of occurrence of approximately 500 years and 2000 years, respectively, and "Operation Status" is specified along with importance factors of 1.5. However, a seismic hazard of 500 years is considered to be a low level event for Tier III centers. Also, use of importance factors is not compatible with a performance objective. Further, no clear directives are available on the methods of performance verification.
- Passive dampers and base isolation is suggested (or required) for Tier III and IV, however, for locations with low seismicity, this is not reasonable.
- Design of non-structural components (architectural, mechanical and electrical) is not clear and the related code reference is not compatible with newer codes.
- No clear requirement is provided for equipment acceleration.

This approach is probably selected due to the fact that natural events cannot be quantified and measured with a level of accuracy that is typical to IT equipment. Therefore, operative resilience of a network of massively interacting IT, mechanical and electrical equipment is not compatible with seismic resilience of the structure encloses the network. The tier specification simply requires the structure to have enough capacity or performance that allows the network to exhibit its full capacity. *I.e.*, it requires that the structure should not be the weakest or weaker piece of the chain or the bottleneck, yet it does not give specific directions on how this can be achieved.

Review of Current Practice and Structural Codes

Current practice of seismic design of data center structures is based on performance-based approaches using applicable standards such as [4] or similar national codes. While detailed published data is not available, it is considered that performance objectives for the structure is generally selected as “immediate occupancy” and for non-structural components as “operational.” In the recent years, it is also observed that more attention is given to design of nonstructural components, including use of engineered, certified or more efficient connections and anchorages (e.g. more efficient braced systems for raised-floor supported cabinets). Documents such as [5] provides a useful review of these practices. Design of the structure for the operational continuity of the IT network has not been reported.

Proposed Design Basis for Tier III and Tier IV Data Centers

A seismic design basis is developed and used for the design of a Tier III classified commercial data center located in seismic region of Turkey after an intense multidisciplinary study. A similar design basis is used for the design of another data center that belongs to a bank with Tier IV classification located in the same region as the design intentions and requirements for both data centers were similar. For both of the data centers, operational continuity of the IT system during and after a major earthquake was considered the most important concern of the management teams.

Three aspects of the operational continuity of the network are the physical hardware, the data stored in the computers and supporting mechanical and electrical equipment supporting the operation of the network. Safety of the physical hardware, particularly servers and data storage equipment, is emphasized by both of the data center management team. The first data center rents private white spaces to small-to-large scale companies for them to install their servers and associated support services. The data center should provide safe, reliable and resilient spaces and supporting services to the client companies, therefore safety of the equipment is the top requirement in the design process. The second data center has also similar concerns as the hardware holds the whole bank’s data. Safety of the data kept in the data centers, while directly affected by the hardware safety, is equally emphasized in the design process. It is argued that while a major part of the hardware may not be damaged during a seismic affect, storage equipment such as hard drives may be damaged. Therefore, safety considerations of specific components of a computer may be different than the safety of the computer itself. Design of the supporting equipment such as air conditioning units and backup power supplies for operational continuity is a conventional topic, which should be considered along with the structural design. For all these components, economical loss due to possible damage is difficult to estimate. It is discussed that cost of structure is a minor portion of the overall center cost including the hardware costs. Therefore, data center owners are willing to implement the most advanced and efficient methods for seismic protection.

Seismic design of the building structure may or may not have direct impact on the design for operational continuity. Most of the data center buildings are single story structures with large spans, where computer and other supporting equipment experience inertia forces due to acceleration from ground or acceleration from raised floor and they are excited by ground acceleration. For these structures, design considerations for the building structure may be well-separated from the considerations for operational continuity. There are also multistory data centers with computer equipment placed at the upper floors, where inertia forces are occur due to the floor acceleration. In this case, stiffness of the structural system has direct impact on the design for operational continuity. For both single-story and multi-story building types, base isolation immediately appears as a natural choice for advanced seismic protection system if the whole system is placed on the isolated structure since base isolation significantly reduces the support acceleration for both structure and nonstructural components. Therefore, both data centers implemented base isolation. For multistory structures, upper floors may experience amplifications in the accelerations even if base isolation system is employed. Therefore, it is recommended that critical equipment for operational continuity is placed at the first floor.

Considering the seismic design needs of data centers, the following three main components of the design are recommended and design basis is given for these components:

1. Building Structure: Main structure of the building of a data center. For base-isolated structures, this includes sub-structure, superstructure and base isolation system.
2. Sensitive Computer Equipment: Data servers that are known to have costly hardware and to store valuable data.
3. Nonstructural Components: Mechanical and architectural components other than servers.

Seismicity

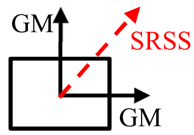
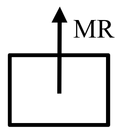
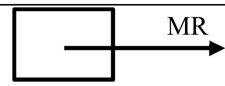
A site-specific seismic hazard study should be performed for the building location, and seismicity as shown in Table 4 should be obtained. This includes design spectra and historical time-histories that are spectrally matched to the design spectra in all three directions. For spectral matching methods such as [6] can be used. Linear scaling is not suggested. Vertical spectra can be derived from literature such as Bozorgnia and Campbell [7]. Design spectra should be obtained using both geometric mean (GM) and maximum rotated (MR) measures. MR spectra can be obtained from GM spectra using literature on historical near-field earthquakes such as Huang, Whittaker [8].

Table 4: Seismicity used in data center design

Name	Return Period	Prob. of Exceed.	Components
Design Basis Earthquake (DBE)	475 Years	10% in 50 years	X, Y, Z
Maximum Considered Earthquake (MCE)	2475 Years	2% in 50 years	X, Y, Z

Directional combination of horizontal and vertical ground motion should based on the following: 100% of Horizontal + 30% of Vertical and 30% of Horizontal + 100% of Vertical. Load cases should be generated for application of GM and MR spectra as shown in Table 5. For static analyses, vertical load should be estimated as $E_v = S_{a,v}^{peak} \times W$ where $S_{a,v}^{peak}$ is the peak spectral acceleration of the vertical spectra and W is the seismic weight of the structure.

Table 5: Application of GM and MR spectra

X-Dir.	Y-Dir	Combination	Graphical Rep.	Use
GM	GM	SRSS		Effective damping Effective period Superstructure base shear Superstructure design Substructure design
MR	–	–		Isolator displacements Superstructure base shear Superstructure design Substructure design
–	MR	–		

Building Structure

Seismic performance objectives for the building structure are given in Table 6. The term Operational Level is used to refer the highest possible performance according to the codes being used. In many cases it should be considered as a complete linear behavior.

Table 6: Target performance levels for building structure.

Target	Seismicity	Target Performance Level
1	Design Basis Earthquake (DBE)	Operational Level (OL)
2	Maximum Considered Earthquake (MCE)	Operational Level (OL)

Further for both MCE and DBE events, the superstructure and substructure should remain linear. No seismic response reduction factor (*R*–factor) should be used. Overstrength factor (Ω) as prescribed by the relevant structural codes should be used where required. Characteristic strengths should be used. Joints should be designed such that capacities of the joints are always higher than the capacity of the connecting beams and braces, where the capacity design results constructible dimensions. Joints should be designed such that joint capacity is at least 1.25 times the factored forces in the connecting elements, otherwise. Transfer and drag-strut elements should be such that their capacity is at least 1.25 times the factored forces in the connecting elements. ϕ-factors should be taken as unity for MCE event. ϕ-factors should be taken as specified in the structural codes for DBE event. As a minimum ordinary ductile systems should be used. Member thicknesses should be seismically compact. Envelope of forces obtained from equivalent lateral force, response spectrum and nonlinear time-history procedures should be used. Design cannot be changed based on forces obtained from solely nonlinear time-history analyses.

Nonstructural Components and Sensitive Computer Equipment

Seismic performance objectives for the sensitive computer equipment and nonstructural components are given in Table 7. Equipment should be classified as acceleration sensitive and displacement sensitive. Acceleration sensitive equipment are considered to achieve Operational

Level of performance if they are designed for the estimated forces. Static seismic forces provided by structural codes can be used for static seismic load, yet they cannot be lower than the static forces obtained from [4]. Nonlinear time-analyses should be used to obtain better estimates of forces, however design cannot be reduced if lower forces obtained in the nonlinear time-history analyses. Anchorages, all connection parts and support platforms such as raised floors should be designed with a reasonable overstrength factor. No seismic response reduction factor (*R*–factor) should be used. No yielding of parts and anchorages should be allowed. Vertical seismic load should be included. Displacement sensitive equipment is considered to achieve Operational Level performance if they are capable of experience relative displacement of 1.25 D_P, where D_P is the estimated relative seismic displacements.

Table 7: Target performance levels for sensitive equipment and nonstructural components.

Target	Seismicity	Target Performance Level
1	Design Basis Earthquake (DBE)	Operational Level (OL)
2	Maximum Considered Earthquake (MCE)	Operational Level (OL)

Peak accelerations of the sensitive computer components should be 0.20g both *X*– and *Y*–directions and 0.30g for resultant. This is a very stringent requirement proposed by the IT professionals. A survey of computer user manuals indicate these values for normal operation and transportation, and it is considered that they will not result damage on the equipment. On the other hand, there are literature indicating that these levels of accelerations may result damage to hard drives due to the contact of the reader head to data disc [9]. It is also argued that new technology hard drives are solid-state-drives, where there is no possibility of damage to due to drive head hitting the disc. Nevertheless, it is difficult to predict when conventional hard drives will retire and these levels of accelerations are requested by the IT professionals. It is considered that this requirement impact many design decisions since they are very conservative. The only way to achieve this requirement seems to use base isolation system. Even so, it is observed that an isolation system with elastomer based isolators will have difficulty to achieve this requirements and additional damping devices may be required. Therefore, acceleration limits on the sensitive computer equipment given above pushes engineer to use base isolation system with friction pendulums.

Structural Loads and Seismic Weight

For floor design and seismic weight, a minimum of the following should be used in the absence of more accurate information:

- Data Racks for Seismic Weight: 5 kPa
- Data Racks for Gravity Design: 12 kPa as live load
- Raised Floor and Partitions: 0.50 kPa

Requirements for Seismic Base Isolation

To facilitate a better understanding of the design basis for seismic base isolation behavior of isolation system is defined as shown in Figure 1. The following response regions are defined:
<u>Region A:</u> The design response spectra with GM measure produces displacements in this region.

This region represents the component (not resultant) of the response. Superstructure design is based on this response, where appropriate directional combination and torsion estimation procedures are applied. Therefore, effective period, effective damping and superstructure base shear have to be estimated based on these displacements.
Region B: This region represents the total and maximum rotated response of the isolator. Total response considers additional displacements for the corner isolators due to the torsional response of structure. Maximum rotated response represents the resultant of the response.
Region C: This region represents the ultimate displacement of the isolator. This region is important to for the design team to understand the reserve capacity of the isolators.

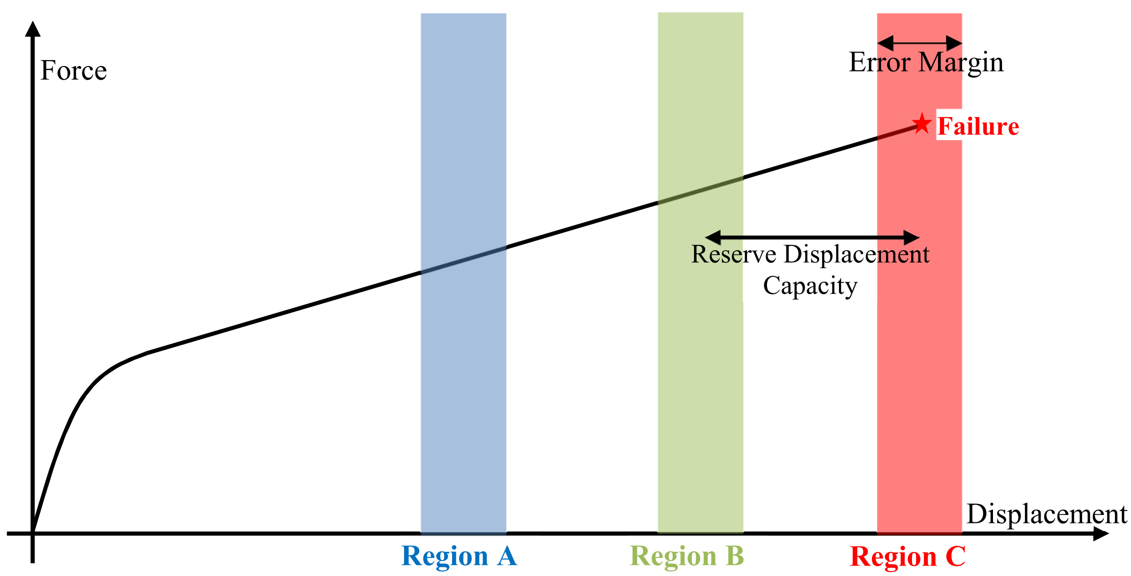


Figure 1. Representative lateral behavior of isolation system.

Base isolation system should be selected and designed such that the following design objectives are met. Displacements and base shears should be the maximum of the values obtained from Equivalent Static Force Procedure and Response Spectrum Analysis procedure. Superstructure base shear under the MCE event for GM and MR spectra should be less than 0.20 g and 0.30 g, respectively. MR displacements are allowed to be estimated from GM displacements for the equivalent static and response spectrum analyses follows: D_{MR}=MR/GM Ratio × D_{GM}. Maximum isolator displacements for any earthquake should be estimated for the equivalent static and response spectrum analyses as: D_{MR-T}=(Acc. Torsion Ratio) × (MR/GM Ratio) × D_{GM}. Selected isolators should satisfy one of the following:

- Isolation system should have fail-safe mechanism for displacements 20% larger than D_{MR-T} at MCE event. Lateral bearing capacity of the fail-safe mechanism should be at least 20% higher than the maximum lateral isolator/isolation shear force at MCE event.
- Isolation system should have a lateral displacement capacity under maximum possible axial loads at least 20% higher than D_{MR-T} at MCE event and a lateral shear capacity at least 20% higher than the maximum lateral isolator/isolation shear force at MCE event.

Maximum axial loads on the isolators should consider the floor loading of 12 kPa as shown in Figure 2, *i.e.* the possibility of on isolator being loaded with 12 kPa should be considered.

Isolators should have a vertical load capacity at least 20% more than the estimated maximum axial load at the maximum total MCE displacement. Isolation layer should be designed for the seismic weight that corresponds to the following: (a) empty building, (b) full use with maximum loading. Isolation system should not be activated under wind loading. For superstructures that are prone to amplify accelerations, design of superstructure should be based on amplified static base shear as recommended by [4], which is based on the research by [10].

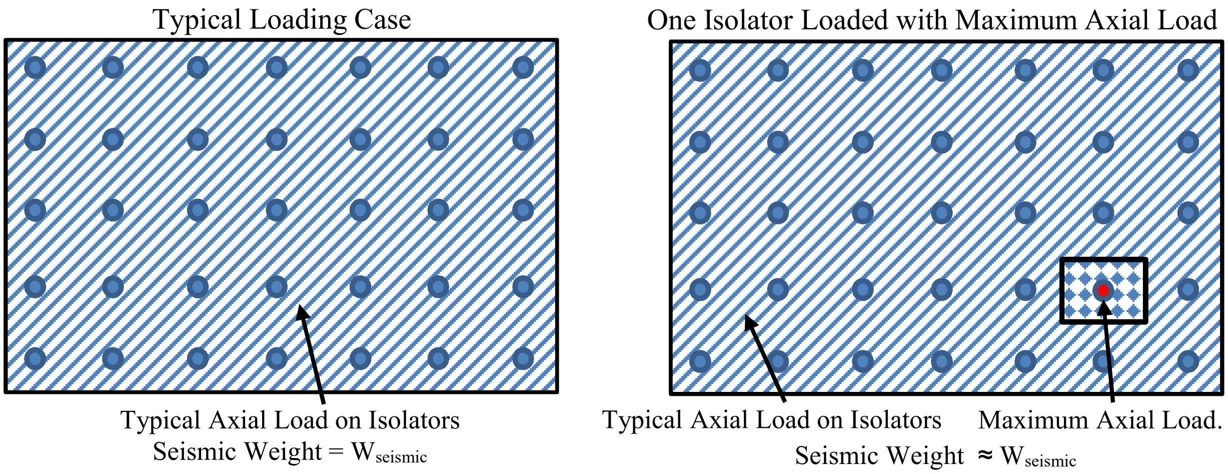


Figure 2. Representative lateral behavior of isolation system.

The most important requirement regarding the base isolation is that all anchorages of isolation (above and below) should be designed for the ultimate lateral load that can be generated by the isolation system, which corresponds to Region C. Further, all connections in the superstructure should also be design for the same load levels. This is a capacity design approach where the structure is designed for the case where the isolation system reaches its full capacity (*i.e.* Region C) during a seismic hazard that produces larger demands than the estimated MCE demands.

Conclusions

In the current IT standards, seismic design of Tier III and Tier IV data centers are not provided in detail. Further, existing information on the seismic design has conflicting or unclear points. It is argued that Tier III and Tier IV resilience of data centers require almost no environmental cause that will interrupt the services. To facilitate the design of Tier III and Tier IV data centers and provide a level of resilience that is compatible with the tier requirements, a design basis is proposed based on two major data center project experience. Various criteria are proposed such as seismicity, performance levels, and acceptance criteria for sensitive computer equipment. Special attention is given to base isolated structures since acceleration criteria required by the IT engineers is almost impossible to achieve by conventional structural systems. In the second part of this paper, two project examples that are designed based on the proposed design basis are given.

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