Asian Concrete Federation E-Newsletter

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The theme of this edition of ACF E-Newsletter is Performance Based Design (PBD) of Concrete Structures.

In order to obtain the philosophy on this topic from a specialist of this field, ACF E-Newsletter invited President Tamon Ueda, a current President of International Committee on Concrete Model Code (ICCMC), which is responsible for developing Asian Concrete Model Code (ACMC).

He is also a professor in the Dept of Civil Engineering at Hokkaido Univ., Japan and has been involved with many researches on the topic of PBD for concrete structure.

ARTICLE

Performance Based Code and ACMC

Prof. Tamon UEDA
Hokkaido Univ., Japan

The performance based code is the latest type and most suitable for any code, especially for international code. The concept of performance base is one of the principles of ISO [1]. The performance based concept is to specify the required performance and to achieve the required performance. The required performance should be universally adaptable, while the appropriate method for achieving the required performance may depend on local conditions. With this concept, any national and regional code can apply suitable methods for design, construction and maintenance of a structure, if it is proved that the structure satisfies the required performance. Especially this concept is necessary for the part of the world, such as Asia, in which the big diversity of economical and technological level, climatic and social condition and material and facility availability exists.

There have been a long history of structural code and various practical codes in the world. The technical contents such as shear design for concrete members and durability design for frost damage in concrete are quite different even among the existing codes. Despite this difference, the ultimate objective of structural codes would be the same. The required performance (or performance requirement) is the common language to express the ultimate objective. In the past, the required performance has not been explicitly described in many codes. For example, the allowable stress design does not show directly the assurance of safety, while the ultimate strength design does not show the assurance of serviceability. However, experienced structural engineers know that both ASD and USD would assure both safety and serviceability indirectly. The limit state design presents ultimate limit state and serviceability limit state, which are to assure safety and serviceability.

The performance-based design is with more general methodology than the rest of the design methodologies (ASD, USD and LSD) (see Fig. 1). PBD clearly describes the required performance often in wording easily understood by ordinary people. Presently, the following required performance is considered in various codes with PBD:

*Safety**
*Serviceability**
*Maintainability and Repairability (or Restorability)**
**: Durability*
Constructability
Sustainability (or Environmentability)
Economy

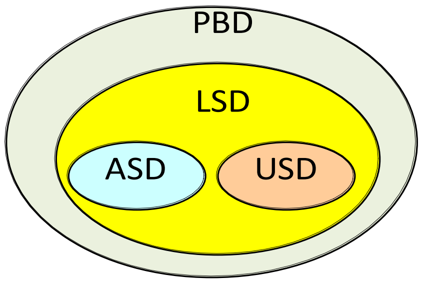


Fig. 1: Comparison of Various Design Methods

"Safety" is the ability of a structure to ensure that no harm would come to users of the structure and people in the vicinity of the structure under any action. Sometimes safety for important asset is included. Safety should be assured under any action, while the assurance of the other required performance can be considered under only selected actions.

"Serviceability" is the ability of a structure to provide adequate services and functionality in use under the effects of considered actions. Serviceability can be defined in various aspects related to comfort of the people in/on and in the vicinity of a structure, such as comfortable ride/walk, comfortable stay, vibration/noise control, odor/humidity control, aesthetics and visual safety and function of a structure, such as shielding and permeability. In the past, serviceability was often related to crack control and deflection control as serviceability limit state in LSD. However, crack and deflection control does not indicate clearly the concerned service and/or function of a structure. Of course, various services and functions can be ensured technically by crack and deflection control. Clear description of serviceability by relating it to service and function of a structure has been searched only a decade ago.

"Maintainability" is the ability of a structure to ensure technically and economically feasible maintenance during its service life. Configuration and material of a structure should be chosen for better maintainability. "Reparability (or Restorability)" is the ability of a structure to be repaired physically and economically when damaged under the effects of considered actions. Generally damage, caused by action, in a structure is controlled to achieve reparability. Reparability is important especially for seismic action.

"Constructability" is the ability of a structure to be constructed in a technically and economically feasible way to achieve the required performance after completion. Construction method and material should be selected for better constructability.

"Sustainability (or Environmentability)" is the ability of a structure to minimize negative impact and to maximize positive impact to natural and social environment during its service life. Long life of a structure is one of options to achieve better sustainability. fib new model code will deal with sustainability (or environmentability) for the first time.

"Economy" is not necessarily explained. It has been required even without description in structural codes. Recently not only initial cost but also life cycle cost has been considered for economy.

"Durability" is the ability of a structure to lessen material property deterioration speed to an acceptable level and a slightly different required performance, which is related to safety, serviceability and reparability during service life. The material property deterioration is occurred due to actions, such as environmental influences and repeated mechanical loadings. The deteriorated property often downgrades the structural performance, so that safety, serviceability and reparability could be degraded to unacceptable level. Safety, serviceability and reparability during service life should be examined, considering the material deterioration. One of the options to ensure those required performance during service life is to minimize the material deterioration, so that the degradation of structural performance can be neglected. The prevention of corrosion initiation in steel reinforcement is an example of this option. Another option is to allow the material deterioration to occur but to assure that the degraded structural performance would be better than the required performance. The design against fatigue effects is an example of this option.

Among the required performance, the design criteria of "yes or no" ("OK or NG") can be provided for safety, serviceability and reparability. Generally these criteria are specified by limit state, such as member failure in bending, crack width limit for water tightness and threshold value of chloride concentration for corrosion initiation. For constructability the criteria for material property, such as acceptable range for slump flow of flowable concrete, can be specified. The design criteria are to achieve the minimum performance. For the other required performance the better (or best) performance is generally sought rather than the minimum performance, because the design criteria cannot be specifically provided.

Asian Concrete Model Code is the first structural code which is equipped with the performance based concept fully. The present version of ACMC only deal with safety, serviceability and reparability (or restorability) as the required performance since only those three required performance can be examined by the design criteria. The required performance is the basis of not only design (Part 1 of ACMC) but also materials and construction (Part 2) and maintenance (Part 3). ACMC has been also providing models of international code. ISO/TC71/SC4 (Performance requirements for structural concrete) has issued ISO 19338 "Performance and assessment requirements for design standards on structural concrete". SC4 has been discussing on the revision of ISO 19338 through which the performance based concept, durability design and maintenance are expected to be implemented based on the technical contents of ACMC.

References

[1] ISO TMB: ISO/TMB Policy and Principles Statement Global Relevance of ISO Technical Work and Publications, 2004

The 5th ACF President and Vice Presidents Meeting

11 September, 2009
Hosted by IABSE 2009 Local Organizing Committee.

After the 4 th ACF President and Vice President Meeting at Hanoi, Vietnam the 5 th meeting was held at Bankok, Thailand on September 11, 2009.
Many important issues were discussed and other themes for better service were sought during the meeting. The meeting was hosted by IABSE 2009 LOC and attendees express sincere appreciation for heartwarming hospitality. More detailed information of the meeting and its agenda can be found in ACF homepage.

President
Prof. Jongsung Sim
Hanyang University, Korea
Vice President (Policy)
Dr. Le Quang Hung
VCA, Vietnam
Vice President (Technical)
Prof. Tamon Ueda
Hokkaido University, Japan
Treasurer
Prof. Ekasit Limsuwan
Chulalongkorn University, Thailand
General Secretary
Prof. Cheolwoo Park
Kangwon University, Korea

1. Introduction
On 11 th September 2009, the 5 th ACF President and Vice President Meeting was held in Centara Grand Hotel, Bankok, Thailand.

2. Attendees
The ACF member who attended this meeting were Jongsung Sim (President, Korea), Le Quang Hung (Vice-President, Vietnam), Tamon Ueda (Vice-President, Japan), Ekasit Limsuwan (Treasurer, Thailand), Cheolwoo Park (Secretary, Korea), Francis X. Supartono (past ACF Newsletter Chief Editor, Indonesia), Jang-Ho Jay Kim (present ACF Newsletter Chief Editor, Korea)

3. Agenda
1. Opening Remarks and Welcome Address by the President of ACF
The President of ACF, Jongsung Sim opened the 5 th ACF President and Vice Presidents Meeting. He addressed his appreciation of IABSE 2009 LOC for hosting this meeting and giving a chance of the special seminar.

2. Welcome Address
Prof. Limsuwan, The Treasurer, expressed welcoming of ACF President and Vice President Meeting attendees.

3. Presentation of the Handouts and Approval of Meeting Agenda
Prof. Cheolwoo Park, The Secretary of ACF, distributed handouts and gave brief explanations and also the meeting agenda was approved per President's request. The 4 th ACF President and Vice President Meeting documents included the followings, as well as the draft meeting agenda in the front:
3a. The 4 th P&VP Meeting Minutes
3b. Budget Plan
3c. RM Membership fee payment documents
3d. One-day Seminar on "Practical Guideline for Investigation. Repair and Strengthening of Cracked Concrete Structures"
3e. Practical Guideline for Investigation, Repair and Strengthening of Cracked Concrete Structures -2009-
3f. Proposal on the activities of ACF by Japan Concrete Institute
3g. Handout: Newsletter Vol. 3 No.1 2009
President Jongsung Sim and Secretary Cheolwoo Park jointly explained the main issues that have been discussed during the last P&VP meeting. This process should be very helpful for all the attendees to understand and recall the memories on the activities of ACF.

4. Expansion of Membership
Attendees discussed about the expansion of RM, CM, and IM members.
Final decision of contacting key persons representing respective countries for their intension to be RM:
- President Sim: Mongolia, Egypt, and Philippine
- Vice President Hung: Russia, China, Laos, and Cambodia
- Vice President Ueda: Sri Lanka, and Bangladesh
- The RM representatives of each current RM country should be cleared
- Registration fee of ACF Conference will include two year IM Membership fee from 2010 ACF Conference. This issue should be discussed with Dr. Chern before the ACF Conference
-Some issues regarding the EC member expansion that needs EC approval can be handled by EC members over an e-mail discussion since the EC meeting is held every two year.

5. Budget Plan
As President Sim reported the budget plan, every attendees expressed no disagreement on the suggested plan.

6. Additional chance for ACF promotion
- Special booth at APFIS 2009 Conference at Dec 2009 in Korea
- Promotional session at CECAR 2010 at Oct 2010 in Sydney Australia

7. Working Group's Report
- Work TG groups activity was reported by Vice President Ueda
- ICCMC Level 3 document can be opened through internet
- The activities of TG 4, 5 and 6 will be reported at the EC meeting in 2009 in Korea and ACF Conference in 2010
- ACF will assign publication and document numbers for better organization

8. ACF Conference Updates
Before the P&VP meeting the secretary Park sent Dr. Chern an e-mail asking the status of ACF Conference preparation but no replay was made from Taiwan. This will be further verified later on by contacting another key person of the Conference LOC.

9. Adjournment
President Sim closed the meeting officially.
Drafted by Prof. Cheolwoo Park, Secretary of ACF, on September 2009.

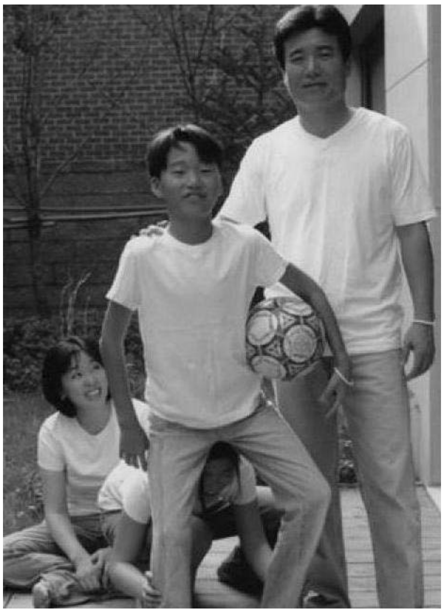
Eulogy of Prof. Ha-Won Song.

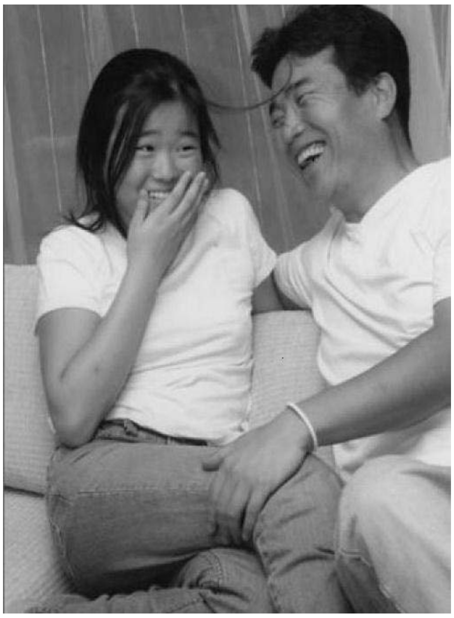
ACF E-Newsletter is sadly informing its readers about the passing away of Prof. Ha-Won Song who fought bravely with his lung cancer for a year before his death on July 25, 2009. He is survived by his wife, a daughter, and a son. He was an inspiration to all of us for his active participations in ACF, ICCMC, and ISO. He will be deeply missed by all of his peers and friends. His credentials are as follows.

Education
BS Yonsei Univ, Korea, Civil Engrg 1983.
MS Yonsei Univ, Korea, Civil Engrg 1985.
MS UC Berkely, USA, Civil Engrg 1987.
PhD Univ of Texas at Austin, USA, Civil Engrg 1990.

Work Experience
Tokyo Univ, Japan, Civil Engrg, Professor. 1990~1994.
Yonsei Univ, Korea, Civil Engrg. Professor 1994~2009.

International Activity
ACF, Executive Member and Treasurer 2006~2009.
ICCMC Vice-Chairman 2004~2009.
ISO/TC71 Chairman 2004~2009.





Farewell Our Friend!

We'll Miss You Very Much!

Performance-Based Design with Application to Seismic Hazard

By Margaret Tang Eduardo Castro, Flavio Pedroni, Andrzej Brzozowski, and Mohammed Ettouney. Published June 2008 in STRUCTURE® Magazine of NCSEA

The development and use of Performance Based Design (PBD) of buildings has been in progress for several years, primarily within the seismic and blast communities. Within the engineering community as a whole, the use of PBD is being considered for applications to specific design issues such as progressive collapse, as well as full-scale infrastructure projects such as bridge designs.

Seismic PBD was introduced in FEMA 273/274, published in October 1997, which was then reissued in November 2000 as FEMA 356 - Prestandard and Commentary for the Seismic Rehabilitation of Buildings. It is generally accepted that these efforts constituted the first generation of seismic PBD. ASCE 41-06 - Seismic Rehabilitation of Existing Buildings has since superseded both versions of the FEMA standard.

Since 2002, there has been an ongoing effort by FEMA to generate a second generation of seismic PBD. This updated version incorporates details of analytical and design techniques, and quantifies performance measures and uncertainties. This is compared to the discrete qualitative measures offered by the first generation. Additionally, the second generation utilizes component and system fragilities, which relate structural performance metrics to the probability of occurrence or exceedance.

One of the main advances that the second generation seismic PBD paradigm offers is that it acknowledges the uncertainty present in seismic design of buildings, or any other infrastructure. The uncertainties in defining the seismic hazard, performing the design process, and estimating consequences are all included within the PBD paradigm. This is in sharp contrast with prescriptive designs. Admittedly, uncertainties are also accommodated to a certain extent in prescriptive designs: Allowable Stress Design (ASD) utilizes factors of safety and Load and Resistance Factor Design (LRFD) accounts for load factors and strength reduction factors, as the name implies. Yet PBD allows for far more freedom in prescribing desired degrees of exceedance levels and probabilistic levels for the building and events on hand. For example, a particular building stakeholder might decide that a non-exceedance probability of 95% is needed for the performance of the building during a seismic event. A stakeholder for a different building might decide that an 85% non-exceedance probability is more appropriate. The ability to determine an appropriate uncertainty level can be one of the major advantages of PBD.

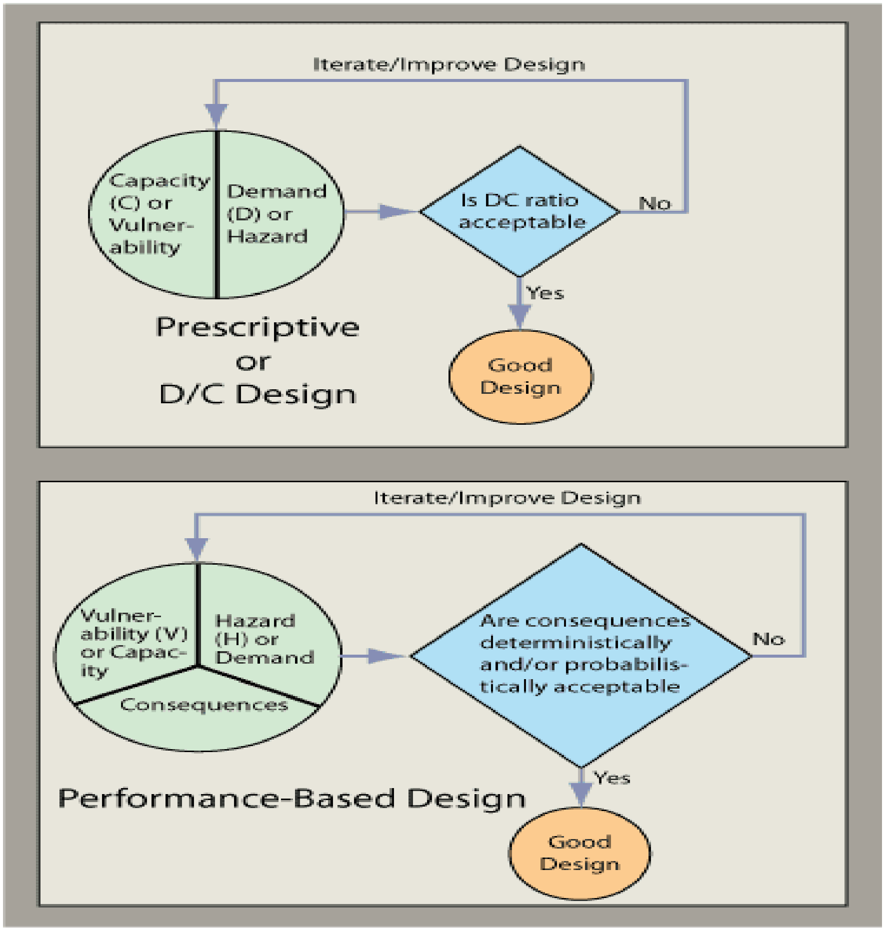


Figure 1: Prescriptive Design vs. Performance Based Design Paradigms.

Prescriptive vs. Performance Design Paradigms

A central difference between the traditional prescriptive design method and PBD is in the design objectives, as illustrated in Figure 1. While prescriptive designs require achieving an acceptable demand-to-capacity (D/C) ratio, the objective of PBD is to achieve a specified level of performance, as correlated to appropriate consequences, which may be measured in several ways including as monetary cost. Each of these methods requires design iterations until either an acceptable D/C ratio (for prescriptive design) or a desired performance level (for PBD) is achieved.

Another difference between the prescriptive design and PBD paradigms lies in their computational underpinnings. For prescriptive design, this relates to capacity and demand, and is based on structural reliability methods. PBD is based on risk methods that consider hazards, vulnerabilities and consequences. In this context, hazards and vulnerabilities are analogous to demand and capacity, respectively. However, PBD also accounts for the consequences associated with the hazards and vulnerabilities.

The third major difference between these two approaches lies in the steps that are taken in addressing the design considerations. For traditional prescriptive methods, the seismic hazard level and the acceptable level of damage in the structure is determined by prevailing building and design codes. In performance based design, both of these considerations are addressed during the design process, along with anticipated consequences and uncertainties in the design and analysis process. These decisions are made based on a desired level of performance, rather than a predetermined set of codes.

Design decisions in PBD are based largely on the building stakeholders, namely, the building owner. It is these stakeholders that will determine the initial cost investment in design and construction, and this will drive the level of performance and the associated consequences. PBD requires more effort in the early phases of design but it offers many advantages: 1) potential cost savings in the long run, 2) the option of continued operations and immediate occupancy after seismic events (which can be of importance for sensitive facilities), and 3) a clear quantitative picture on how the facility will perform during a seismic event, and what the consequences of such performance would be (i.e. no surprises to the stakeholders).

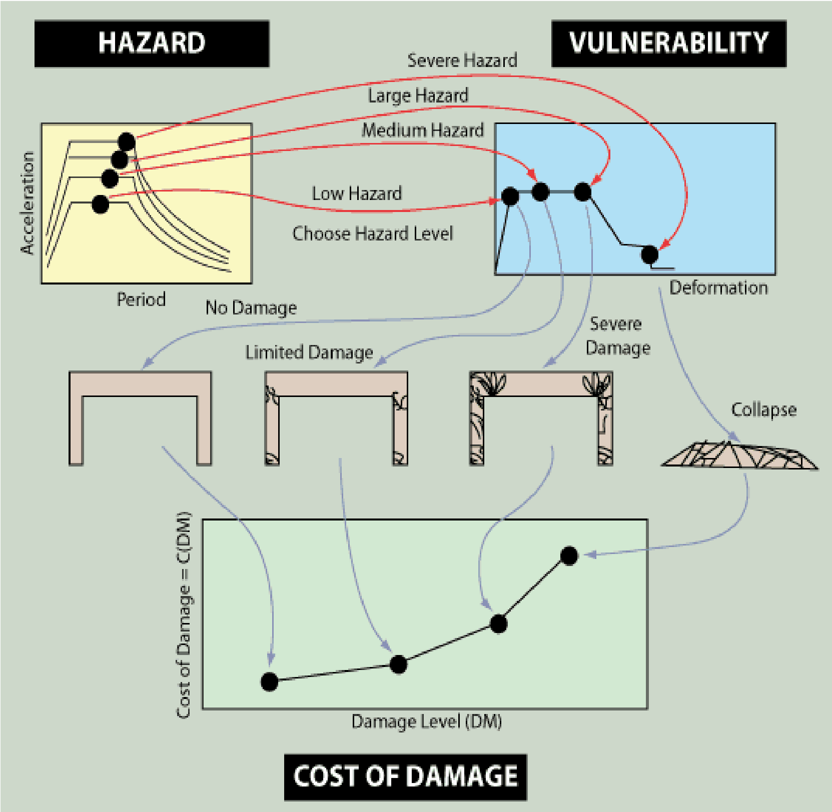


Figure 2: Performance Based Design Steps.

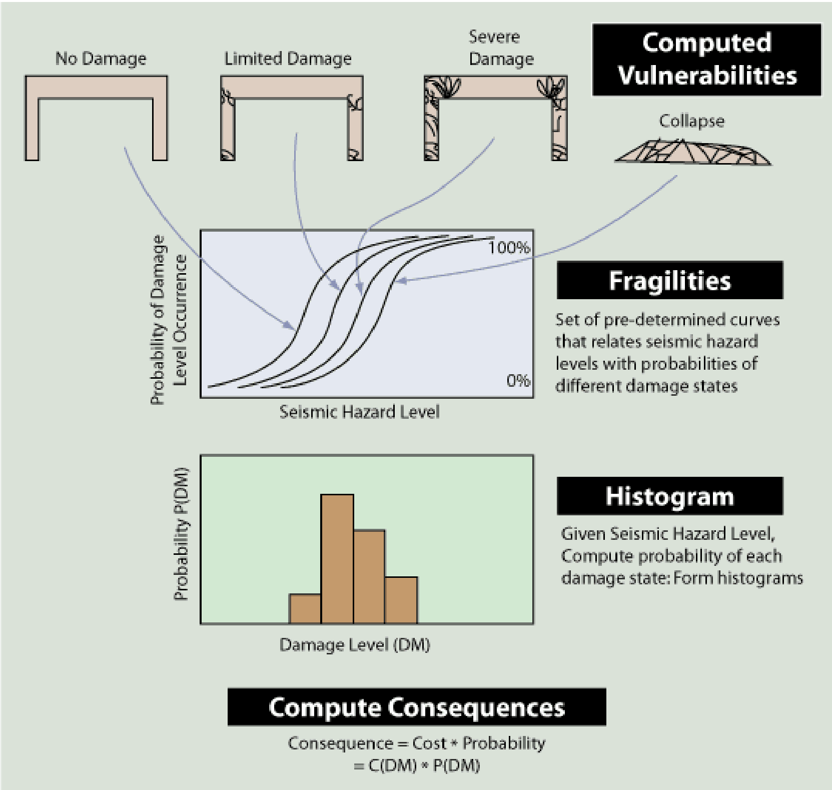


Figure 3: Computation of Risk..

Elements of Performance Based Design

The three basic steps of PBD are the estimation of hazard, the evaluation of vulnerability, and the computation of consequences, shown schematically in Figure 2.

When using PBD, determining the design hazard level requires evaluation of the seismic event and the probability of occurrence. This can range in complexity from choosing only the hazard level and the shape of the design spectra to a more involved process, such as generating an ensemble of seismic acceleration time histories. In most situations, the designer needs to address issues such as return period (the duration of a seismic event at a given level) and maximum ground acceleration. In the second generation seismic PBD effort, the probability of the chosen seismic hazard is an integral part of the design input needs. This is necessary to compute the anticipated consequences of the design, as shown in Figure 3. Another feature of second generation seismic PBD is that it can be based either on a single scenario, such as a unique earthquake level, or on multiple earthquake levels with varied return periods. This latter approach is obviously more time consuming, since design calculations must be performed for each of the scenarios. However, the advantage of the multiple scenario approach is that it gives a more complete picture over the total life of the building. As noted earlier, prescriptive design methods do not address probabilities of occurrence or consequences, as these are implicitly addressed through the development of the design codes.

After the seismic input is defined, the building design process starts. The key differences between the two design approaches are in the acceptance criteria, the analysis techniques, and the analysis objectives. In traditional prescriptive design, the acceptance criteria is generally prescribed simply to ensure life safety, while PBD allows for varied acceptance criteria based on the determination of an acceptable level of earthquake damage to the structure.

In prescriptive design, evaluation of the building performance during a seismic event is usually performed using linear analysis, and the primary objective is to determine whether specific acceptance limits are met. In PBD, nonlinear analysis is preferred in order to compute damage types and levels, which will ultimately be used in determining the consequences of a particular design.

Computing types, levels, and probabilities of structural or non-structural damage due to an earthquake are not easy tasks. This is one area which is currently undergoing extensive research and development. An emerging technique for relating earthquake damage to uncertain inputs and computing the damage uncertainties is the use of fragility curves. Figure 3 shows how fragilities are used in a PBD context. Component seismic fragilities have been under development for some time. Efficient, practical and general methods for system level fragility, on the other hand, are just starting to develop.

Considering consequences of seismic events in the design of buildings is perhaps the most important difference between prescriptive design and PBD. In the context of PBD, consequences generally relate to the building owner; the consequences to the neighborhood or other regional effects are beyond the scope of current PBD efforts. Consequences can be quantified in numerous ways; FEMA considers two types in particular: monetary and casualty. In order to compute the consequences, the probability of different types of damage as estimated by fragility curves is combined with the predetermined relationship between damage level and associated costs. The estimated cost of the earthquake event can then be computed as shown in Figure 3. Computing cost based on uncertainties is one of the many definitions of risk, demonstrating that PBD is a risk-based paradigm. After the consequences of the seismic event are computed based on the chosen performance levels, the building stakeholders (owner, architect, engineer, users, insurance companies, etc.) must decide if it is an acceptable cost (risk). If the costs proved to be too high, the performance levels are adjusted, and the whole procedure is repeated until an acceptable level of consequences is reached.

Future of Performance Based Design

PBD for earthquake engineering has been gaining interest for several years. Other fields of application include multi-hazard engineering, structural health monitoring, and life-cycle analysis.

Multi-hazard engineering is an ideal application of PBD as it requires the consideration of more than one hazard or extreme event at any given time, in an effort to increase safety and reduce subsequent costs. This can include seismic, wind, flood, bomb blasts, and

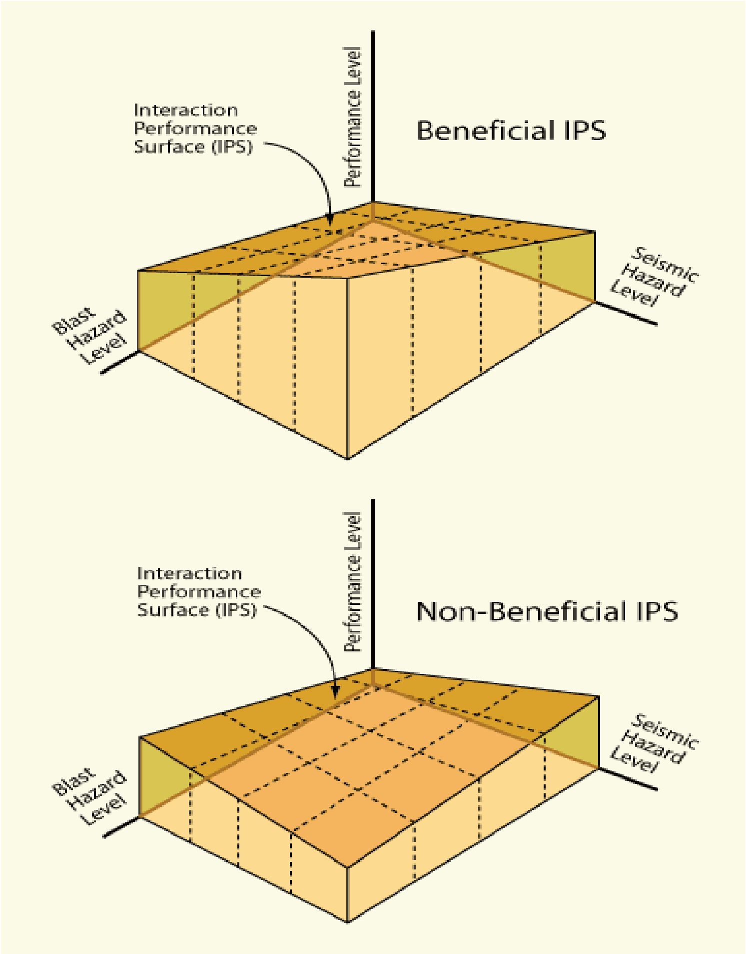


Figure 4: PBD and Multi-Hazard Design Considerations.

progressive collapse (Figure 4). Prescriptive design methods are not applicable to this type of problem, as they tend to address scenarios with a single hazard or extreme event. Additionally, nonlinear analysis is recommended in order to accurately depict the performance of the structure in a multi-hazard scenario.

Structural health monitoring is emerging as an essential tool for preserving the health of infrastructures. Several sensors are placed on a structure in order to collect data on its performance over time. This data is useful in determining the response of a structure as a result of different stresses or hazards, which can ultimately be employed in PBD. Conversely, PBD techniques provide valuable information about damage in a structure due to a seismic event or other hazard. This can be useful in determining where to place the sensors in order to most effectively monitor any potential hotspots.

Life-cycle analysis, as the name implies, is the evaluation of performance over the life of a structure as a result of anticipated loads, stresses and hazards. It is closely tied to performance based design, as the latter is, at its most basic level, the relationship between a hazard and the anticipated response of the structure. The knowledge of life-cycle behavior is of immense importance to asset managers in their decision making efforts (e.g. inspection, prioritizing, budgeting, maintenance).

Performance based design offers numerous advantages as compared to traditional design methods. The challenges of implementing performance based design include smooth multidisciplinary integration and the added expertise of professionals. The advantages of PBD make meeting these challenges a worthwhile goal.

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Flavio Pedroni is a Senior Associate at Weidlinger Associates, in the Structures Division, working with commercial clients and academic institutions in conventional design.

Andrzej Brzozowski is a Senior Associate at Weidlinger Associates, in the Structures Division. He has been involved in numerous projects, with extensive experience in conventional and tensile structures.

Mohammed Ettouney is a Principal in the Applied Science Division at Weidlinger Associates, Inc. in New York, NY. He has been involved in numerous projects involving seismic, blast, vibration and progressive collapse issues, as well as structural health monitoring. Mohammed may be reached via email at ettouney@wai.com.

What's ACF objective ?

- Initiation and support of international collaborative activities for development of research and technology relating to various aspects of concrete and concrete structures.
- Dissemination of useful information on concrete and concrete structures by way of publications, conferences, symposia, workshops and/or seminars.
- Promotion of updating and revising concrete codes/standards on structural design, materials, construction and maintenance through development of new knowledge to meet the latest needs.
- Interaction with the members and keeping them aware of the activities of the Federation.