PERFORMANCE DESIGN REVIEW & VERIFICATION TECHNIQUES

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Abstract

This paper is presented to discuss the building official's role in reviewing performance-based designs and methods used to verify compliance with adopted codes. Architects and engineers may have an option in a jurisdiction of submitting a performance-based design in accordance with the ICC Performance Code for Buildings & Facilities (Performance Code) or the alternative methods of the International Building Code's (building code) when authorized by the building official. Background is provided regarding application of the Performance Code and building code provisions which allow use of alternative method submittals as a means to deviate from prescriptive provisions when submitting a design to the building official for a building permit. Specific codes are utilized above for technical and consistent basis in this paper, but the concepts may apply to other documents as well.

The concepts, examples and techniques presented apply to performance-based designs submittals based upon the Performance Code and alternative methods of the adopted building code. An example of how-to-apply the concepts, recommendations and issues discussed in this paper are included for a project in a large jurisdiction where alternative methods have frequently been accepted. A Guide for Alternative Methods of the Building Code (Guide) is attached to this paper which provides recommendations for submittal for alternative methods to a building official.

Utilization of the information discussed in this paper can improve an architect's and engineer's abilities to submit performance-based designs using the Performance Code or alternative methods to the building code. Either code or a combination of the two can be used to accomplish project objectives while complying with codes adopted by the jurisdiction. The building official will need to develop support programs authorized by the governmental jurisdiction to effectively provide the services necessary to meet the intent of the codes discussed and the service objectives of the development community.

1. Recommended Performance-Based Design Support Programs

The building official's recommendation to adopt a Performance Code can provide a tool to facilitate a proactive environment with architects, engineers and the developers to encourage creative and innovative designs in the jurisdiction. The Performance Code provides an administrative process with the designation of responsibilities, submittal requirements and the building official's methods to verify compliance. In order to effectively utilize the Performance Code, the building official may need to expand the capabilities of the building department by using the following techniques to effectively carry out the responsibilities intended by the Performance Code. The use of this program is also recommended for acceptance of performance-based designs under the alternative methods option to the building code. In particular, establishment of the following capabilities are recommended to provide services expected of the development community by use of:

1. Private-enterprise plans examiners to supplement current plans examination staff when an increase in qualified staff is not authorized. This can be accomplished by contract with the supplemental conditions specified. This process should provide access to expertise needed to review performance-based designs with qualification criteria in Appendix D of the Performance Code.
2. Peer review as an independent method to evaluate design concepts, new technologies and designs where insufficient authoritative documentation is provided in the performance-based design. This review is meant to supplement and not replace plans examination by the building department.
3. Third-party special inspection process through private enterprise may be needed to supplement the department's normal inspection process for continuous or specialized activities beyond the capability of the building department. All enforcement responsibilities should remain with the building department.
4. Quality assurance measures to qualify firms and establish accountability of private enterprise services to supplement plan examination and provide special inspection services. This process should be base upon internal staff processes with auditing as a method of verifying compliance and consistency.
5. Operation and maintenance manual as a tool to clarify verification and certification requirements
during a building or facility's operation and maintenance phase.

6. Cost recovery or enterprise funding process which allows services to grow with increases of development activities. This process can provide the accounting mechanism to collect all fees and to pay for all costs associated with the department in providing services. A budgeted funding level is needed to provide expected service levels in proportion to the volume of work requiring services in the jurisdiction. The funds should only be used to pay for services authorized by the fund objectives and not for other general interest activities. Performance-based design reviews require a higher level of services and sufficient processes are necessary to be established with sufficient fees to cover the cost of services necessary to meet the agreed upon department's objectives. These activities may change during the fiscal year and authorization may need to be adjusted to provide support services based upon increases of fees collected to pay for services.

7. Open communication processes to provide public information to architects, engineers, contractors, material suppliers, owners and the public in general. This can be accomplished through an internet web page, pamphlets and regularly published news letters.

8. A record system that provides ready access to existing building records for evaluation of existing building designs, reports and necessary information to perform the functions required by Performance Code's use for existing buildings.

2. Community Objectives Regarding Development Services

A jurisdictional governing body's involvement is necessary to establish a progressive and pro-growth environment with the development community which can as a result provide a progressive opportunity to meet objectives of the development community. With the support and empowerment of the governing body, a building official can partner with the development community to develop the necessary support programs to meet mutual objectives that facilitate innovation through use of the Performance Code. Through support of the governing body, a building department can become proactive in obtaining solutions with and providing services to the development community.

The adoption of the Performance Code is a tool to establish performance levels in the built environment; thereby, reducing risk of future building failures which can be a significant benefit for the government entity and the community at large. The building official needs to obtain the governing body's, the jurisdiction's manager and development community's support in order to have authorization to develop supportive programs that are necessary to provide services intended in the Performance Code and alternative methods discussed in this paper. Active partnering techniques are recommended to keep focus and mutual support of these programs on a long range basis.

3. Use Of Performance Code And Alternative Methods

Whether a performance-based design is submitted as an alternative method to the provisions of the building code or in accordance with the Performance Code provisions, the building official should require that the applicable Performance Code provisions be met as discussed above in the Performance Code section. In particular when alternative methods provisions are used, the applicable administrative and acceptable methods provisions stated in Chapter 1 of the Performance Code should be applied to implement the alternative methods requirements discussed in this paper.

The Performance Code provides many benefits as discussed in that it is intended for performance-based designs and provides the administrative process to clarify responsibilities, define submittal requirements and review/verification processes available to the building official. This document requires the use of authoritative documents and design guide(s) as a basis of design and standards of practice accepted in the industry for the type of design proposed.

Simply stated, the benefit of using the alternative methods section of the building code is an opportunity for the architect or engineer to submit a proposal to the building official as an alternative to or a deviation from prescriptive code provisions where the code limits the design to a single solution or outcome. The decision to use alternative methods is a choice of architects and engineers. Once a choice is made to use an alternative method, the attached Guide [Guide for Alternative Methods of the Building Code] provides the steps to systematically evaluate the proposal. Well prepared and submitted design documents, including
alternative methods, allows the building official and staff to objectively evaluate the written submittals. This can improve communication with the building official in an objective and professional manner. Using this process can be a win-win situation for both parties because the architect and/or engineer can meet their project objectives and the building official can do his job within his authority in a timelier manner.

The demonstration of equivalency with provisions of the building code can be very difficult in some cases and the use of a performance-based design submitted in accordance with the Performance Code may be a preferred option to obtain approval. Although the Performance Code has limited adoptions by jurisdictions, several jurisdictions are authorizing use of the document under the provisions of alternative methods as an accepted process. The example project in this paper used this technique.

4. Performance Code

The Performance Code was developed in the United States from 1996 to 2000 by the ICC Performance Building Code Committee and the ICC Performance Fire Code Committee to overcome prescriptive restrictions by employing objective based-provisions. Comments were received at a Public Forum in November 1999 to combine the two-committee reports and publish a single code with building and fire performance code provisions into one document for buildings and facilities. The two committees completed this joint task at their May 2000 meeting, and a final draft was published in August 2000. Sequential to the public review and comment during the 2001 ICC code change process, the first edition of the Performance Code was published in December 2001. The code book publication includes a user's guide that is advisory with explanation of code provisions and guidance for applications. The 2003 edition of ICC Performance Code for Buildings and Facilities should be published in the spring of 2003.

Performance-based design is defined in the Performance Code as an engineering approach to design elements of a building based on agreed upon performance goals and objectives, engineering analysis and quantitative assessment of alternatives against the design goals and objectives using accepted engineering tools, methodologies and performance criteria. The development of a building design approach in accordance with the Performance Code requires a higher level of knowledge than prescriptive building codes. Qualification characteristics for design and review of performance-based designs are included in the Performance Code Appendix D.

The Performance Code provides the architect and engineer considerable latitude in using performance-based design approaches that deviate from restrictive provisions contained in prescriptive codes currently used in the United States. There are additional responsibilities that are placed on the architect and engineer when performance-based designs are employed which includes providing a higher level of documentation of the design approach and analysis in accordance with recognized national or international authoritative documents and design guides including standards. In local, state and other jurisdictions, where the Performance Code is adopted, the provisions can apply as specified in the code and the adopting language. However, in jurisdictions where the Performance Code is not adopted, the building official may allow certain performance provisions to be applied through alternative methods as stated in the building code. When alternative methods are proposed for a project, a meeting with the building official is suggested early in the design process to discuss the applicable procedures, documentation and the degree of substantiation needed to obtain approval.

The benefit of using the Performance Code is to allow more flexibility, innovation and cost effectiveness to be integrated into a performance-based design approach by architects and engineers in order to meet the client's objectives without being restrained by prescriptive code provisions that allow a single solution. This option provides for creativity and application of performance code provisions to meet a project objective, but also allows the use of prescriptive codes on the remaining portions of the building. The Performance Code contains several pages of administrative guidance and submittals requirements, which hopefully will standardize requirements between jurisdictions and improve the understanding by architects and engineers of the submittal requirements needed to obtain approval. Through improved understanding, this should reduce the mystery of project submittal requirements, which has been a hindrance in many jurisdictions relative to alternatives methods.

Architects and engineers have the responsibility to demonstrate to the building official how a performance-based design will comply with the project's applicable codes as a system to assure that the design will meet
the codes objectives for a safe built environment. This is accomplished in part through a performance-based design analysis and documentation based upon accepted authoritative documents and design guides which demonstrate compliance with both project and performance code objectives. An authoritative document is generally defined as a document that includes the standard of professional care normally observed within a specific discipline, and its content is promulgated through an open consensus process or a review by professional peers conducted by recognized authoritative professional societies, codes or standards organizations, or governmental bodies. In general the review of peers for engineering documents would include qualified engineers, educators, and/or researchers, which provides a validation in their ability to generate outcomes consistent with that intended by the developer when used in accordance with specified conditions. For further explanation, the term “authoritative document” is defined and used in the Performance Code.

The Performance Code specifies numerous administrative performance objectives and requirements for use of the document as follows:

1. The process to use the document.
2. Responsibilities of the owner, architects, engineers and building officials.
5. Design documentation which includes concept reports, design and analysis reports, construction documents and an operations and maintenance manual for use during the life of the building.
6. Review options for the building official which include contract / third party review and peer review.
7. Construction verification and documentation of compliance with approved documents and use of special inspection and testing.
8. Use of conditional certificates of occupancy, compliance with maintenance and operations manual conditions and application future remodeling / additions and change of use.

The burden of demonstrating compliance with the Performance Code rests with an individual principle architect or engineer, who is responsible to lead the design team, coordinate and verify compliance the design through the responsible design team members. The building official's role is to verify compliance through use of the various techniques discussed in this paper in the design and construction phases. Further information is available in the Performance Code and its User's Guide.

5. Building Code

A model building code is intended to be adopted by state, local and other jurisdictions and once adopted becomes law requiring compliance. The building code used in this paper provides an opportunity to deviate from the prescriptive provisions by demonstrating equivalency with the provisions.

The term alternative methods is used in this paper to mean "Alternative Materials, Design, and Methods of Construction and Equipment" from Subsection 104.11 of the International Building Code (IBC) 2000 edition which is provided as follows: “The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety”. Similar language is used in the Uniform Building Code (UBC) 1997 edition which was used for the example project. There should be evidence or proof provided to substantiate the proposal, and the details of the approval are intended to be recorded in the files of the building official. The attached Guide is provided to clarify the intended approach needed to meet this provision.

The term prescriptive code is generally defined as a code that provides specific design, construction, and maintenance requirements for building, energy conservation, fire prevention, mechanical, plumbing, etc. Prescriptive codes are mostly prescriptive with single solution provisions and include very few performance provisions where the designer can select options compatible with their design circumstances. An example
is that a structural frame of a type I building shall have a 3 hours fire resistive rating in accordance with the UBC. The example project in this paper is provided to address this prescriptive provision where the UBC requirements are not compatible with the owner’s objectives. The use of a performance-based design using the Performance Code provisions allowed the design team to demonstrate an acceptable level of performance rather than equivalence with the 3 hour fire resistance rating provision of the UBC which is very difficult to demonstrate since a level of performance is not specified.

The shortcoming of the building code’s alternative methods section is the very limited how-to-apply-guidance and submittal requirements contained in the codes brief provisions. As a result jurisdiction submittal requirements and building officials willingness-to-accept alternative methods submittals vary substantially between jurisdictions, which cause hardships to architects and engineers when attempting to use the provision. These issues affect many architects, engineers, and building officials’ ability to effectively accomplish their job functions.

6. Example Project

The example project below involves a large hotel and casino complex and uses alternative methods provisions to demonstrate that a performance-based design is equivalent to the prescriptive requirements of the UBC for fire proofing of the steel frame and exiting. Several of the Clark County Building Department (Building Department) guides were used in the project to verify that the required levels of safety were obtained and would continue to be maintained for the ride attraction in the tower. The guides provide similar functions to the Performance Code and are not provided as specific references in this paper for simplicity.

The example project is the Paris Hotel & Casino’s Eiffel Tower II located on the Las Vegas Strip in the Clark County, Nevada jurisdiction. The owner’s objectives included an appearance of a one-half scale version of the Paris, France’s Eiffel Tower, exposed steel appearance extending above the casino roof level, a restaurant at one third the height of the tower and an observation deck on top of the tower with elevator service from the casino level. The project design team had several challenges in meeting the owner’s objectives due to the limitations of open space on the site, which led to the tower being placed directly above the casino.

Characteristics of the Eiffel Tower II, the design activities, and the evaluations of alternative methods are provided for information to demonstrate many of the issues involved in the process which were required to address the owner's objectives and the UBC requirements. There were numerous meetings of members of the design team, owner and the Building Department to address applicable issues involved. The order of the paragraphs is used to simplify this paper's presentation and is not necessarily the specific order of the design team and the Building Department activities.

In order to address project objectives, a fire protection engineer (Schirmer Engineering Corporation) was retained by the executive architect (Liedenfrost, Horowitz and Associates) to conduct a performance based analysis for structural fire proofing and to establish an alternate means of egress in the top two-thirds of the tower. Schirmer developed the performance-based design criteria to limit the structural frame steel temperature from reaching critical temperatures and to maintain structural stability of the tower in order to provide occupants safe evacuation or to await rescue assistance in a safe environment in the upper level of the Eiffel Tower II.

Schirmer’s analysis and documentation included numerous fire scenarios, which could pose a serious threat to the structure and tower occupants. Fire exposure was characterized by fuel type, fire size, energy release rate, location relative to exposed structural member, flame temperature, fire plume temperature and heat flux. The thermal response to structural frame members was evaluated to determine steel temperatures for the contemplated exposures. The predicted steel temperatures from fire scenarios were used as input for structural analysis to evaluate structural stability. John A. Martin and Associates, the structural engineer of record performed the structural analysis.

The fire protection engineer and architect submitted a proposal to eliminate exterior fire proofing and a reduction of stairways from two to one above the restaurant to service the observation deck as a performance-based design using a draft of the Performance Code before it was published and adopted. This first proposal was not acceptable to the building official; however, the administrative process identified
in the draft code was applicable for a performance-based design in accordance with Clark County Codes and procedures. The design submitted to the Building Department for the Eiffel Tower II was approximately 540 feet high with an observation deck at the 490-foot elevation, a restaurant located about 40 feet above the casino roof at approximately the 200-foot elevation, and three legs of the tower were located within the casino. Two elevators served the observation deck and restaurant level from the casino floor level. A single exterior open exit stairway was proposed to serve the observation deck above the restaurant level where it has access to two enclosed exit stairways to the ground level. Since the casino was open to the high rise hotel and significant other areas of the complex, the life safety system provisions were incorporated into the Eiffel Tower II design as verified by Life Safety Report and Master Exit Plan submittals in accordance with Building Department guidelines.

The primary structural frame members of the tower are 14 5/8 inch by 14 5/8 inch by 1 inch thick ASTM A572 tube steel chords with 8 inch by 8 inch by 5/8 inch thick ASTM A500 steel truss members. The three tower legs penetrating into the casino are protected as required by the UBC; however, the casino, casino roof, the tower restaurant and one leg adjacent to Las Vegas Boulevard were considered for risk of fire and heat transfer exposure, even though most of the tower’s structural frame above the casino roof is open to the atmosphere. A performance-based design was developed to address structural stability of the tower and safeguards against fire impacts with the various loads and scenarios discussed in this paper.

This resulted in a submittal of two performance-based designs as alternative method proposals for structural fireproofing and observation deck egress in accordance with the UBC adopted in Clark County. The Building Department’s processes were supplemented by published guides as discussed in the project description.

The owner’s representative, design team members and the building official agreed that a peer review should be conducted as an independent review. A peer review was then performed by independent engineers with expertise in structural engineering and heat transfer to evaluate the design approach, fire and material science applications, fire hazard and thermal response of the structure, and the design proposal for equivalence to the UBC using alternative methods for evaluation of the fireproofing proposal. The peer review analysis and findings as submitted by a written report verified the performance-based design approach but recommended fireproofing in certain limited areas where fire exposure could impact structural steel stability.

The use of two elevators to service the Eiffel Tower II’s observation deck was proposed to provide the emergency egress; however, this system was determined by the building official to be an amusement ride attraction under Clark County Code. Therefore, amusement ride and building requirements with operations and maintenance conditions were required in the design to provide a safe environment for users. An egress time analysis, a primary and secondary communication system, operational and maintenance requirements and related verification elements were used to substantiate the egress alternative methods approach. Related elements affecting safe operations and maintenance are incorporated in the project’s Operations and Maintenance Manual for continued use. These Clark County’s requirements are very similar to the Performance Code provisions for an operations and maintenance manual.

The final report and design documents submitted by the design team required one-hour fireproofing in specified areas of the structure to meet the design objectives and alternative methods requirement of the UBC. The final reviews of the performance-based design included the alternative methods report, final design documents and the conditions stated in the peer reviewers’ report. The project design documents were all approved and applicable permits were issued. The Eiffel Tower II and its affected systems will be evaluated annually prior to reissuing an operation permit for the amusement ride attraction. This operation permit is similar in concept to the Performance Code’s conditional certificate of occupancy.

Conclusions

The use of alternative methods provides an opportunity for architects and engineers to deviate from strict prescriptive code provisions that restrain the designer’s ability to meet owner’s objectives, providing certain procedures are followed and the building official is in agreement. The attached Guide provides specific procedural recommendations to be incorporated in a written report so that the building official can
objectively review the submittal to verify that alternative method requirements are met.

Utilization of the concepts described in this paper should better prepare an architect and engineer for use of the Performance Code as an alternative method to a prescriptive building code or the direct use of the Performance Code when adopted. Either code could be used as described to accomplish project objectives while complying with codes adopted by state, local or other jurisdictions. The use of performance-based design approaches are currently used by a number of firms; however, further training of most architects and engineers is required for their use of performance-based designs to meet project objectives for complex and unique buildings.

The example project provides an overview to demonstrate many of the elements discussed in the paper including a performance-based design approach utilized by experienced professionals. The guidelines for submittal of design documents, the use of operations and maintenance manuals and the acceptance of performance-based designs illustrated in the example project are very similar in approach to the Performance Code provisions. Many of the challenges incurred in the example project could have been reduced if the Performance Code had been published and adopted prior to the design of the project.

Biography

Robert D. (Bob) Weber is a registered professional engineer and was the Building Official and Director of the Clark County Building Department for over 22 years. After leaving Clark County in 2001, he formed R. D. Weber & Associates, which specializes in consulting services for building codes, design solutions for buildings, and regulatory program development. Bob chaired the ICC Building Performance Code Drafting Committee and was a member of the ICBO, ICBO-ES, and IFCSI Boards of Directors. He holds a Bachelor’s degree in Mechanical Engineering and a Master’s degree in Business Administration.

References

The International Code Council’s (ICC) Performance Code and building code publications and the Clark County Development Services Department (formerly Clark County Building Department) guides can be accessed through their internet website addresses as noted below:

www.iccsafe.org/codes/
www.co.clark.nv.us/department_services/index.htm
GUIDE FOR ALTERNATIVE METHODS OF THE BUILDING CODE

When proposing Alternative Materials, Design, and Methods of Construction and Equipment as authorized in the building code, the applicant architect or engineer should prepare a Written Report. This report should describe and include the proposed alternatives with the applicable data listed below when making a submittal to a building official:

- State specific code provisions for which alternative is requested and why request is being submitted.
- Describe by code section the elements of those provisions for which an alternative is desired.
- Define the measure of equivalency for the proposed alternative in terms of quality, strength, effectiveness, fire resistance, durability and safety.
- Compare the proposed alternative versus the code requirements in terms of quality, strength, effectiveness, fire resistance, durability, safety and impacts affecting the building and users of the building.
- Demonstrate that proposed alternative is compatible with balance of code requirements.
- When applicable, specify how authoritative document(s) are used to substantiate proposal.
- Provide assumptions, references, and documentation of evaluation methods utilized. This includes intended use, input data, anticipated outputs, and limitations of computer models and other analytical tools or methods.
- Specify the standards of acceptance to demonstrate compliance and specify when and where special inspection and testing are required.
- Where land use restrictions and building setbacks are required, deed restrictions may be an appropriate method to ensure continued compliance.
- State where the alternate proposal is incorporated within construction plans and prepare plan amendments as necessary. The architect or engineer has the responsibility to coordinate all construction documents and ensure compatibility between documents.

The report and design documents shall be dated, signed and stamped by the architect or engineer according to the plan submittal procedures.