

# Design Against Blast

Load definition  
and structural  
response

EDITOR:  
S. Syngellakis



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# Design Against Blast Load Definition And Structural Response Wit Transactions On State Of The Art In Science And Engineer

**N Noddings**



## **Design Against Blast Load Definition And Structural Response Wit Transactions On State Of The Art In Science And Engineer:**

**Design Against Blast** S. Syngellakis, 2013 Terrorist attacks and other destructive incidents caused by explosives have in recent years prompted considerable research and development into the protection of structures against blast loads For this objective to be achieved experiments have been performed and theoretical studies carried out to improve our assessments of the intensity as well as the space time distribution of the resulting blast pressure on the one hand and the consequences of an explosion to the exposed environment on the other *Bulletin of the Atomic Scientists*, 1970-06 The Bulletin of the Atomic Scientists is the premier public resource on scientific and technological developments that impact global security Founded by Manhattan Project Scientists the Bulletin s iconic Doomsday Clock stimulates solutions for a safer world

**Bulletin of the Atomic Scientists**, 1970-06 The Bulletin of the Atomic Scientists is the premier public resource on scientific and technological developments that impact global security Founded by Manhattan Project Scientists the Bulletin s iconic Doomsday Clock stimulates solutions for a safer world **Modern Protective Structures** Theodor

Krauthammer, 2008-02-01 In today s world reasonably predictable military operations have been replaced by low intensity conflicts less predictable terrorist activities carried out by determined individuals or small groups that possess a wide range of backgrounds and capabilities Because of the threats posed by this evolving type of warfare civil engineers and emergency personnel face new challenges in designing facilities to protect lives and property and in conducting effective rescue operations and forensic investigations Addressing these needs Modern Protective Structures develops realistic guidelines for the analysis design assessment retrofit and research of protected facilities After introducing a comprehensive risk management approach the author provides a general background on explosive devices and their capabilities as well as explosive effects and the processes that generate them He then discusses the effects of conventional and nuclear explosions The book subsequently considers the significant design differences between conventional and nuclear loads and between existing design procedures and state of the art information from recent research It also summarizes existing blast resistant design approaches and describes the dynamic responses of structural systems to blasts shocks and impacts Additional coverage includes the behavior of specific structural connections the traditional concept of P I diagrams and progressive collapse The book concludes with a systematic and balanced protective design approach Tackling the analytical design assessment and hazard mitigation issues associated with short duration dynamic loads this book examines how impulsive loads affect various types of buildings and facilities It provides the necessary material to help ensure the safety of persons assets and projects *Handbook for Blast Resistant Design of Buildings* Donald O. Dusenberry, 2010-01-26 Unique single reference supports functional and cost efficient designs of blast resistant buildings Now there s a single reference to which architects designers and engineers can turn for guidance on all the key elements of the design of blast resistant buildings

that satisfy the new ASCE Standard for Blast Protection of Buildings as well as other ASCE ACI and AISC codes The Handbook for Blast Resistant Design of Buildings features contributions from some of the most knowledgeable and experienced consultants and researchers in blast resistant design This handbook is organized into four parts Part 1 Design Considerations sets forth basic principles examining general considerations in the design process risk analysis and reduction criteria for acceptable performance materials performance under the extraordinary blast environment and performance verification for technologies and solution methodologies Part 2 Blast Phenomena and Loading describes the explosion environment loading functions needed for blast response analysis and fragmentation and associated methods for effects analysis Part 3 System Analysis and Design explains the analysis and design considerations for structural building envelope component space site perimeter and building system designs Part 4 Blast Resistant Detailing addresses the use of concrete steel and masonry in new designs as well as retrofitting existing structures As the demand for blast resistant buildings continues to grow readers can turn to the Handbook for Blast Resistant Design of Buildings a unique single source of information to support competent functional and cost efficient designs

#### **Protecting Buildings from Bomb Damage**

National Research Council, Division on Engineering and Physical Sciences, Commission on Engineering and Technical Systems, Committee on Feasibility of Applying Blast-Mitigating Technologies and Design Methodologies from Military Facilities to Civilian Buildings, 1995-10-26 This book provides a brief overview of worldwide terrorist activity and reviews technologies and methods for designing blast resistant buildings These techniques primarily developed by the military have applicability and relevance to the design of civilian structures The volume recommends that a program of applied research and technology transfer be undertaken to hasten the availability and utility of these techniques to the civilian building community

#### **Structures Under Shock and Impact XV**

S. Syngellakis, G. Schleyer, 2018-10-23 Discussing the increasing need to protect civilian infrastructure and industrial facilities against unintentional loads arising from accidental impact and explosion events as well as terrorist attack this book contains papers presented at the 15th International Conference on Structures under Shock and Impact This successful conference series has been regularly held since it began in 1989 in Cambridge Massachusetts While advances have been made over this period many challenges remain such as to develop more effective and efficient blast and impact mitigation approaches than currently exist The primary focus remains the survivability of physical facilities and the protection of people as well as reducing economic losses and impact on the environment with emphasis on innovative protective technologies to support the needs of an economically growing modern society The application of this technology ranges from the safe transportation of people in several modes and the transportation of dangerous or combustible materials to defences against natural hazard threats such as flood wind storm tsunami and earthquake Large scale testing is prohibitive and small scale laboratory testing results in scaling uncertainties Continuing research is therefore essential to improve knowledge on how these structures behave under a variety of load

actions some of which interact making it even more complex and difficult to define Consequently more use of advanced numerical simulations for load and structural response calculations is common practice in industry and research Such calculations can directly be used in design and risk assessment calculations but also be applied as input to more simplified design tools and design codes Whether numerical or analytical modelling techniques are employed experimental validation is vital for there to be acceptance of the approach to be used The published research aims for the exchange of ideas and results to promote a better understanding of the critical issues relating to the testing behaviour modelling and analyses of protective structures against blast and impact loading

**Structures Under Shock and Impact XVI** S. Syngellakis,G.

Schleyer,2020-08-19 The increasing need to protect civilian infrastructure and industrial facilities against unintentional loads arising from accidental impact and explosion events as well as terrorist attacks is of major importance While advances have been made in recent years many challenges remain such as to develop more effective and efficient blast and impact mitigation approaches than those that currently exist The primary focus remains the survivability of physical facilities and the protection of people as well as reducing economic losses and impact on the environment with emphasis on innovative protective technologies to support the needs of an economically growing modern society The application of this technology ranges from the safe transportation of people and dangerous materials to defences against natural hazards such as floods wind storms tsunamis and earthquakes Large scale testing is prohibitive and small scale laboratory testing results in scaling uncertainties Continuing research is therefore essential to improve knowledge on how these structures behave under a variety of load actions some of which interact making it even more complex and difficult to define Consequently more use of advanced numerical simulations for load and structural response calculations is common practice in industry and research Such calculations can directly be used in design and risk assessment calculations but also be applied to more simplified design tools and design codes Whether numerical or analytical modelling techniques are employed experimental validation is vital for there to be acceptance of the approach to be used The included papers presented at the 16th International Conference on Structures under Shock and Impact highlight new research ideas and results to promote a better understanding of the critical issues relating to the testing behaviour modelling and analyses of protective structures against blast and impact loading

*Structures Under Shock and Impact XII* G. Schleyer,C. A. Brebbia,2013 Of interest to engineers from civil military nuclear offshore aeronautical transportation and other backgrounds this book contains the proceedings of a well established conference on the subject that was first held in 1989 Topics covered include Impact and Blast Loading Characteristics Protection of Structures from Blast Loads Energy Absorbing Issues Structural Crashworthiness Hazard Mitigation and Assessment Behaviour of Steel Structures Behaviour of Structural Concrete Material Response to High Rate Loading Seismic Engineering Applications Interaction Between Computational and Experimental Results Innovative Materials and Material Systems Fluid Structure Interaction The shock and impact behaviour of structures presents

challenges to researchers not only because it has obvious time dependent aspects but also because it is difficult to specify the external dynamic loading characteristics and to obtain the full dynamic properties of materials. It is crucial that we find ways to share the contributions and understanding that are developing from various theoretical, numerical and experimental studies as well as investigations into material properties under dynamic loading conditions. This book helps to meet that need.

**Structural Dynamics in Earthquake and Blast Resistant Design** B. K. Raghu Prasad, 2020. Focusing on the fundamentals of structural dynamics required for earthquake blast resistant design, *Structural Dynamics in Earthquake and Blast Resistant Design* initiates a new approach of blending a little theory with a little practical design in order to bridge this unfriendly gap, thus making the book more structural engineer friendly. This is attempted by introducing the equations of motion followed by free and forced vibrations of SDF and MDF systems, D'Alembert's principle, Duhammel's integral, relevant impulse, pulse and sinusoidal inputs and most importantly support motion and triangular pulse input required in earthquake and blast resistant designs respectively. Responses of multistorey buildings subjected to earthquake ground motion by a well known mode superposition technique are explained. Examples of real size structures as they are being designed and constructed using the popular ETABS and STAAD are shown. Problems encountered in such designs while following the relevant codes of practice like IS 1893:2016 due to architectural constraints are highlighted. A very difficult constraint is in avoiding torsional modes in fundamental and first three modes; the inability to get enough mass participation and several others. In blast resistant design the constraint is to model the blast effects on basement storeys below ground level. The problem is in obtaining the attenuation due to the soil. Examples of inelastic hysteretic systems where top soft storey plays an important role in expending the input energy provided it is not below a stiffer storey as also required by IS 1893:2016 and inelastic torsional response of structures asymmetric in plan are illustrated in great detail. In both cases the concept of ductility is explained in detail. Results of response spectrum analyses of tall buildings asymmetric in plan constructed in Bengaluru using ETABS are mentioned. Application of capacity spectrum is explained and illustrated using ETABS for a tall building. Research output of retrofitting techniques is mentioned. Response spectrum analysis using PYTHON is illustrated with the hope that it could be a less expensive approach as it is an open source code. A new approach of creating a fictitious imaginary boundary to obtain blast loads on below ground structures devised by the author is presented with an example. Aimed at senior undergraduates and graduates in civil engineering, earthquake engineering and structural engineering, this book explains in a simple manner the fundamentals of structural dynamics pertaining to earthquake and blast resistant design. Illustrates seismic resistant designs such as ductile design philosophy and limit state design with the use of capacity spectrum. Discusses frequency domain analysis and Laplace transform approach in detail. Explains solutions of building frames using software like ETABS and STAAD. Covers numerical simulation using a well known open source tool PYTHON.

Blast and Ballistic Loading of Structures John Hetherington, Peter Smith, 2014-04-21. This book brings together in a

concise format the key elements of the loads produced from explosive sources and how they interact with structures Explosive sources include gas high explosives dust and nuclear materials It presents quantitative information and design methods in a useable form without recourse to extensive mathematical analysis

**Earthquake-Resistant Structures** Abbas Moustafa, 2012-02-29 This book deals with earthquake resistant structures such as buildings bridges and liquid storage tanks It contains twenty chapters covering several interesting research topics written by researchers and experts in the field of earthquake engineering The book covers seismic resistance design of masonry and reinforced concrete structures to be constructed as well as safety assessment strengthening and rehabilitation of existing structures against earthquake loads It also includes three chapters on electromagnetic sensing techniques for health assessment of structures post earthquake assessment of steel buildings in fire environment and response of underground pipes to blast loads The book provides the state of the art on recent progress in earthquake resistant structures It should be useful to graduate students researchers and practicing structural engineers

**Simulating Blast Effects in Steel Skeletal Structures** Emily Leigh Guzas, 2010 This research embodies a synergistic application of sophisticated commercial finite element codes and internally developed software tools The contribution to the state of the art is the development of a new approach to constitutive modeling within a computationally expedient framework which enables the consideration of blast effects in steel skeletal structures composed of wide flange members This research is split into three main parts 1 development of an air blast load generation code derived from openly available sources to calculate spatially and temporally varying blast loads on a structure for a given explosive scenario 2 formulation and implementation of a blast beam column element macro element that encapsulates the effects of an explosion on the capacity of a single steel wide flange member and 3 testing of the blast beam column element approach as implemented in a nonlinear explicit dynamic finite element code through various validation and application examples Regarding the first part of the research blast loading from explosive air burst is modeled using a series of empirical parameters and equations derived from open literature sources where loads are represented by overpressure time histories that are applied in a spatially varying manner over a finite element domain Sensitivity studies carried out for dynamic behavior of a plate and girder subjected to blast loading with variations in load parameters show that structural response is sensitive to small changes in load definition Regarding the second part of the research a new method for modeling the reserve capacity of a blast damaged structural component is derived that uses bounding surface plasticity models defined in stress resultant space to represent the effects of the blast by way of a plastic reduction matrix Each bounding surface is created by generating numerical failure data for a given component and explosive scenario through a series of virtual load tests using a high resolution model of a wide flange member in LS DYNA and then fitting the data to a continuous function For each test a member that has already been damaged by blast loading within a dynamic nonlinear finite element analysis is statically loaded to failure in separate collapse analyses each with a unique combination of proportional moment thrust

loading Given a specific blast location and explosive yield the locus of all force points moment and axial loads at failure defines the bounding surface for this member for a particular blast where this bounding surface is approximated by a continuous function that is a linear combination of real valued spherical harmonic functions Regarding the third part of the research an automated process is implemented to create a library of bounding surface plasticity models representing the reserve capacity for various wide flange members under different explosive scenarios The library of bounding surfaces is coupled to a developed nonlinear explicit dynamic finite element code written in C that includes the blast beam column element The code does not explicitly model the explosion itself but rather calculates a series of parameters that define the explosion location relative to a given member and then accesses the library of bounding surfaces to find the bounding surface with parameters that most reasonably approximate the actual physical explosive scenario and member geometry Finally the macro element based code is used to predict the post blast collapse load of a structural system in a few representative test problems in order to assess accuracy of results and computational savings

Design of Blast Resistant Buildings in Petrochemical Facilities Society of Civil Engineers. Task Committee on Blast Resistant Design,1997 Providing guidelines in the structural design of blast resistant petrochemical facilities this book offers coverage for OSHA requirements design objectives siting considerations and load determination It also covers types of construction dynamic material strengths allowable response criteria analysis methods and design procedures

**Explosion-Resistant Buildings** M. Y. H. Bangash,T. Bangash,2005-12-16 This excellent book highlights all aspects of the analysis and design of buildings subject to impact explosion and fire It is a definitive reference book and contains 10 chapters from a wide international prospective Three dimensional finite element and discrete element techniques are included They are applied to buildings such as the World Trade Center WTC Twin Towers and the Federal Building in Oklahoma on the basis of the designers drawings data and other information Many small case studies are also included The book has a comprehensive bibliography and a large appendix providing background analysis and computer subroutines of recently developed programs

**Blast Effects on Buildings** David Cormie,Geoffrey Mays,P. D. Smith,2009 Reflects developments in the field of blast engineering since the early 1990s Combining coverage of the design standards codes and materials with an appreciation of the needs and demands of the designer this book provides the engineer with a comprehensive source of reference for the main elements of blast engineering design in modern practice

*Evaluation of Model Techniques for the Investigation of Structural Response to Blast Loads* Massachusetts Institute of Technology. School of engineering. Department of civil engineering,Harold D. Smith,Robert W. Clark,Richard P. Mayor,1963

**Structural Dynamics in Earthquake and Blast Resistant Design** BK Raghu Prasad,2020-08-31 Focusing on the fundamentals of structural dynamics required for earthquake blast resistant design Structural Dynamics in Earthquake and Blast Resistant Design initiates a new approach of blending a little theory with a little practical design in order to bridge this unfriendly gap thus making the book more structural engineer friendly

This is attempted by introducing the equations of motion followed by free and forced vibrations of SDF and MDF systems D'Alembert's principle Duhammel's integral relevant impulse pulse and sinusoidal inputs and most importantly support motion and triangular pulse input required in earthquake and blast resistant designs respectively Responses of multistorey buildings subjected to earthquake ground motion by a well known mode superposition technique are explained Examples of real size structures as they are being designed and constructed using the popular ETABS and STAAD are shown Problems encountered in such designs while following the relevant codes of practice like IS 1893 2016 due to architectural constraints are highlighted A very difficult constraint is in avoiding torsional modes in fundamental and first three modes the inability to get enough mass participation and several others In blast resistant design the constraint is to model the blast effects on basement storeys below ground level The problem is in obtaining the attenuation due to the soil Examples of inelastic hysteretic systems where top soft storey plays an important role in expending the input energy provided it is not below a stiffer storey as also required by IS 1893 2016 and inelastic torsional response of structures asymmetric in plan are illustrated in great detail In both cases the concept of ductility is explained in detail Results of response spectrum analyses of tall buildings asymmetric in plan constructed in Bengaluru using ETABS are mentioned Application of capacity spectrum is explained and illustrated using ETABS for a tall building Research output of retrofitting techniques is mentioned Response spectrum analysis using PYTHON is illustrated with the hope that it could be a less expensive approach as it is an open source code A new approach of creating a fictitious imaginary boundary to obtain blast loads on below ground structures devised by the author is presented with an example Aimed at senior undergraduates and graduates in civil engineering earthquake engineering and structural engineering this book Explains in a simple manner the fundamentals of structural dynamics pertaining to earthquake and blast resistant design Illustrates seismic resistant designs such as ductile design philosophy and limit state design with the use of capacity spectrum Discusses frequency domain analysis and Laplace transform approach in detail Explains solutions of building frames using software like ETABS and STAAD Covers numerical simulation using a well known open source tool PYTHON

*Blast Loading, Structural Response and Design*, 2005 Blast Protection of Buildings American Society of Civil Engineers, 2011 Blast Protection of Buildings provides minimum requirements for planning design construction and assessment of new and existing buildings subject to the effects of accidental or malicious explosions The Standard includes principles for establishing appropriate threat parameters levels of protection loadings analysis methodologies materials detailing and test procedures It provides a comprehensive presentation of current practice in the analysis and design of structures for blast resistance Commentaries on the requirements are also included The Standard supplements existing building codes standards and laws but is not intended to replace them

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