ACI 370R-14

Report for the Design of Concrete Structures for Blast Effects

Reported by ACI Committee 370

American Concrete Institute
Always advancing

First Printing
July 2014
ISBN: 978-0-87031-898-6

Report for the Design of Concrete Structures for Blast Effects

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at http://concrete.org/Publications/DocumentErrata.aspx. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided "as is" without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

Report for the Design of Concrete Structures for Blast Effects

Reported by ACI Committee 370

Eric B. Williamson*, Chair

William L. Bounds*, Secretary

Adeola K. Adediran*
Abi Assadi*
Darrell D. Barker*
Bal K. Cherwoo*
Savita Goel
David Kerins

Theodor Krauthammer*
Paul F. Mlakar*
Madhav G. Nene*
Barendra K. Talukdar*
Joseph W. Tedesco*
James W. Wesevich*

Stanley C. Woodson
David Z. Yankelevsky*
William H. Zehrt, Jr.*

Eve E. Hinman
Sam A. Kiger
Jaap Weerheijm

Consulting Members
Quentin A. Baker

*Contributed to the writing of the report.

This report addresses the design of structures to resist blast effects due to explosions. It describes the state of the practice for the guidance of structural engineers charged with the design of civil facilities that may be subjected to blast loads. This report addresses the steps commonly followed in this practice, including determination of the threat, calculation of structural loads, behavior of structural systems, design of structural elements, design of security windows, design of security doors, and design of utility openings. These steps can applied to the design of new structures or to the retrofitting of existing structures.

Keywords: blast; blast analysis; blast-resistant buildings; blast-resistant design; ductility; dynamics; explosions; retrofit for blast; shock; overpressure.

CONTENTS

ACI 370R-14 was adopted and published June 2014.

CHAPTER 1—INTRODUCTION

The design of concrete structures for blast resistance has been of great interest to the military and other federal agencies for several decades. In addition, certain specialized segments within the engineering community have also had to consider blast loads on structures as a result of potential accidents. For example, the petrochemical industry has designed for blast resistance in their facilities for many years. Even though there is considerable history in the design of structures to resist blast effects resulting from accidents or intentional acts, it is only recently that the general structural engineering community has shown a strong interest in the response of structures subjected to explosions and other high-rate loading phenomena, such as impact.

Following the attacks on the World Trade Center in New York and the Pentagon in Washington, DC, on September 11, 2001, the vulnerability of the nation's infrastructure to terrorism became a top priority for many state and federal government agencies as well as private consulting engineers. Though the significance of these attacks greatly increased engineering interest in the design of structures to resist extreme loads, statistics show that US interests have been targeted by terrorists with increasing frequency during the last several decades (U.S. Department of State, 2003), leading to significant financial and personal losses. As a result, the engineering community has learned important lessons that have allowed for improved methods of analysis and design to be developed. For example, lessons learned from the Oklahoma City bombing in 1995 and the U.S. embassy attacks in Tanzania and Nairobi in 1998 shaped present design guidelines for prevention of progressive collapse.

While the field of blast- and impact-resistant design is not as mature as other fields, such as seismic-resistant design, historical events such as those described are important to note because they help shape current practice and research interests. Just as the field of seismic-resistant design has advanced by learning lessons from past incidents, engineers working in protective design can similarly benefit from being aware of historical events and corresponding data. Although such information is typically outside the scope of work routinely undertaken by design engineers, awareness of these issues is important for understanding potential threats and associated loads that may result. While historical data can be used with reasonable confidence for predicting natural loads such as earthquakes and floods, the same claim cannot be made for man-made loads associated with potential terrorist threats. Thus, the intent of the discussion herein is to bring awareness to engineers and designers that many factors can influence the loads to which a structure may potentially be subjected, and it is only through awareness and consideration of the factors that affect the threat environment that engineers can estimate design loads.

1.1—Overview of report

Given the trends in terrorism and the required protection of building occupants at petrochemical facilities, it is clear that structural engineers must be able to design structures