Guidelines for Design of Structures for Vertical Evacuation from Tsunamis

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Guidelines for Design of Structures for Vertical Evacuation from Tsunamis

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FEDERAL EMERGENCY MANAGEMENT AGENCY
National Earthquake Hazard Reduction Program

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
National Tsunami Hazard Mitigation Program

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Foreword

This publication was equally funded by the National Oceanic and Atmospheric Administration (NOAA), which leads the National Tsunami Hazard Mitigation Program (NTHMP) and by the Federal Emergency Management Agency (FEMA), which is responsible for the implementation portion of the National Earthquake Hazard Reduction Program (NEHRP).

FEMA initiated this project in September 2004 with a contract to the Applied Technology Council. The project was undertaken to address the need for guidance on how to build a structure that would be capable of resisting the extreme forces of both a tsunami and an earthquake. This question was driven by the fact that there are many communities along our nation's west coast that are located on narrow spits of land and are vulnerable to a tsunami triggered by an earthquake on the Cascadia subduction zone, which could potentially generate a tsunami of 20 feet in elevation or more within 20 minutes. Given their location, it would be impossible to evacuate these communities in time, which could result in a significant loss of life. Many coastal communities subject to tsunami located in other parts of the country also have the same potential problem. In these cases, the only feasible alternative is vertical evacuation, using specially design, constructed and designated structures built to resist both tsunami and earthquake loads.

The significance of this issue came into sharp relief with the December 26, 2004 Sumatra earthquake and Indian Ocean tsunami. While this event resulted in a tremendous loss of life, this would have been even worse had not many people been able to take shelter in multi-story reinforced concrete buildings. Without realizing it, these survivors were among the first to demonstrate the concept of vertical evacuation from a tsunami.

This publication presents the following information:

- General information on the tsunami hazard and its history;
- Guidance on determining the tsunami hazard, including the need for tsunami depth and velocity on a site-specific basis;
- Different options for vertical evacuation from tsunamis;
- Determining tsunami and earthquake loads and structural design criteria necessary to address them; and,
- Structural design concepts and other considerations.

This publication is the first of two documents on this issue. The second, currently under development, will present information on how the use of this design guidance can be encouraged and adopted at the State and local levels.

FEMA is grateful to the Project Management Committee of Steve Baldridge, John Hooper, Ian Robertson, Tim Walsh, and Harry Yeh. We are also grateful to the Project Review Committee, the members of which are listed at the end of the document, and to the staff of the Applied Technology Council. Their hard work has provided this nation with a first document of its kind, a manual on how citizens may for the first time be able to survive a tsunami, one of the most terrifying natural hazards known.

– Federal Emergency Management Agency

Preface

In September 2004 the Applied Technology Council (ATC) was awarded a "Seismic and Multi-Hazard Technical Guidance Development and Support" contract (HSFEHQ-04-D-0641) by the Federal Emergency Management Agency (FEMA) to conduct a variety of tasks, including the development of design guidance for special facilities for vertical evacuation from tsunamis, which ATC designated the ATC-64 Project. The effort was co-funded by FEMA and the National Oceanic and Atmospheric Administration (NOAA).

The developmental process involved a variety of activities including review of relevant research and state-of-the-practice documentation and literature, preparation of technical guidance and approaches for tsunami-resistant design, identification of relevant tsunami loads and applicable design criteria, development of methods to calculate tsunami loading, and identification of desired architectural and structural system attributes for vertical evacuation facilities.

The resulting guidance for design of special facilities for vertical evacuation from tsunami, as presented herein, addresses a range of relevant issues. Chapter 1 defines the scope and limitations of the guidance. Chapter 2 provides background information on tsunami effects and their potential impacts on buildings in coastal communities. Chapters 3 through 7 provide design guidance on characterization of tsunami hazard, choosing between various options for vertical evacuation structures, locating and sizing vertical evacuation structures, estimation of tsunami load effects, structural design criteria, and design concepts and other considerations. The document concludes with a series of appendices that provide supplemental information, including examples of vertical evacuation structures from Japan, example tsunami load calculations, a community design example, development of impact load equations, and background on maximum flow velocity and momentum flux in the tsunami runup zone.

ATC is indebted to the members of the ATC-64 Project Team who participated in the development of this document. The Project Management Committee, consisting of Steven Baldridge (Project Technical Director), Frank Gonzalez (who participated in early portions of the project), John Hooper, Ian Robertson, Tim Walsh, and Harry Yeh, were responsible for the development of the technical criteria, design guidance, and related recommendations. Technical review and comment at critical developmental

stages were provided by the Project Review Panel, consisting of Christopher Jones (Chair and ATC Board Representative), John Aho, George Crawford, Richard Eisner, Lesley Ewing, Michael Hornick, Chris Jonientz-Trisler, Mark Levitan, George Priest, Charles Roeder, and Jay Wilson. Peter N. Mork and Bernadette Hadnagy provided ATC report production services. The affiliations of these individuals are provided in the list of Project Participants.

ATC also gratefully acknowledges the input and guidance provided by Michael Mahoney (FEMA Project Officer), Robert Hanson (FEMA Technical Monitor), and William Holmes (ATC Project Technical Monitor).

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