

Japan Academy Prize to:

Tsuneo OKADA
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for “Study on Seismic Performance Evaluation and Upgrade
 of Existing Vulnerable Buildings”

***Outline of the work:***

Dr. Tsuneo Okada, a pioneer in earthquake engineering, has long led the development of seismic performance evaluation and upgrade of vulnerable reinforced concrete buildings. One of the best achievements of his research activities can be summarized in the concept of formulating the structure’s seismic index (*Is*). This index digitally evaluates the seismic performance of existing reinforced concrete buildings in a rational and simple manner. It is basically defined as a product of the strength index, the ductility (or deformability) index, and the reduction factors, which are the key parameters for describing the structural response to earthquake excitations. The concept of *Is*-index was first proposed and developed in the 1970s through his experimental and analytical studies. Then, it was incorporated into the *Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings* published by the Japan Association for Special Buildings Safety (now the Japan Building Disaster Prevention Association) in 1977. The standard has been widely applied to existing buildings in Japan since its publication. Because of practical applications, the implementation of this concept has accelerated the development of new field of research on seismic evaluation and rehabilitation of different types of structures and reinforced concrete buildings. This research trend has encouraged the establishment of the new fields of “seismic evaluation” and “seismic rehabilitation” that are now widely accepted as major research categories by the earthquake engineering community. The implementation of research results and the development of new technologies for the practical evaluation and redesign of vulnerable buildings have also contributed significantly to improving the safety and resilience of cities. This concept and evaluation methodology were also applied to a large number of existing buildings before and after severe earthquakes, and their damage statistics were carefully examined. Then, Dr. Okada showed that the observed damage distribution can be reproduced by a probabilistic approach and proposed a fundamental seismic index for structures to successfully survive in the event of devastating earthquakes. The proposed criteria were adopted by a standard revised in 1990. This was crucial to evaluating the results and looking for actions to be performed on target buildings. Currently, it is recognized as a screening standard for judging intact buildings in Japan. The same concept was applied to buildings damaged by the 1985 Mexico earthquake and the 1992 Turkey Erzincan earthquake to investigate the relationship between observed damage and index value. The findings confirmed that the concept is equally applicable to buildings constructed under different social and

technical backgrounds than Japan.

The development of seismic evaluation and upgrade methodology for existing buildings has contributed socially and timely to mitigating catastrophic damage to structures. The 1995 Hyogo-ken Nanbu or Kobe earthquake severely hit the urban area of Kobe City. Design and construction of buildings based on outdated seismic codes seemed to be a major reason for catastrophic damage in Kobe City. Dr. Okada and his team worked closely with the Architectural Institute of Japan and the Ministry of Education (now the Ministry of Education, Culture, Sports, Science and Technology) to extensively investigate damage to reinforced concrete school buildings in the affected area. As a result, they noted that most of the damaged buildings did not meet the judging criteria. Therefore, if the buildings had received a seismic assessment before the event, they would have had to be upgraded. Recognizing the serious vulnerability of older buildings, the Japanese government immediately enacted the *Act on Promotion of Seismic Retrofitting of Buildings* in 1995, using the essence of seismic assessment methodology developed by Dr. Okada. Since the new Act was applied to existing buildings nationwide, the development of methodology has contributed significantly to improving the safety of Japanese cities. In catastrophic earthquakes such as the 2004 Niigata-ken Chuetsu earthquake and 2011 Great East Japan (Tohoku) earthquake, buildings seismically upgraded before these earthquakes showed little or no damage, while those that were not upgraded were severely damaged. Dr. Okada's contributions to the development of seismic performance evaluation and rehabilitation techniques, and the determination of criteria for identifying intact buildings, have had a significant impact on mitigating damage to buildings and loss of life due to earthquakes in Japan.

List of Main Publications

Books

1. 日本特殊建築安全センター（現・日本建築防災協会）（編）．既存鉄筋コンクリート造建築物の耐震診断基準付解説．1977．[1章 総則 (pp. 1, 29–31)・2章 耐震指標の定義 (pp. 1, 32)・3.1章 構造耐震指標の算定 一般／3.2章 保有性能基本指針 (pp. 1–16, 33–104)・5章 耐震性能総合診断 (pp. 27, 127–129) 執筆・原案作成部会主査担当]
2. SCREEN 開発作業部会．鉄筋コンクリート造建築物の耐震診断プログラム SCREEN Edition-2. 日本建築防災協会．1980．[主査担当]
3. 日本コンクリート工学協会（編）．既存鉄筋コンクリート構造物の耐震補強ハンドブック．技報堂出版．1984．[序 (pp. i–iii)・資料編資料1 (pp. 427–446) 執筆担当]
4. 梅村 魁（編著）．鉄筋コンクリート建物の動的耐震設計法．技報堂出版．1973．[I.1編 設計例における耐震設計の考え方 (pp. 9–19)・I.3編 設計例2 (pp. 145–248)・II.3編 耐震壁の強度と剛性 (pp. 321–340)・II.4編 地震被害と構造設計 (pp. 341–438) 執筆担当]
5. 梅村 魁（編著）．鉄筋コンクリート建物の動的耐震設計法 続(中層編)．技報堂出版．1982．[1.1編 耐震設計の進め方 (pp. 1–13)・1.3編 設計例2 (pp. 109–221)・2.5編 耐震設計 (pp. 443–467)・2.6編 震害建物とその教訓 (pp. 469–514) 執筆担当]
6. 日本建築学会関東支部（編著）．耐震構造の設計—構造計算のすすめ方・7．1981．[6章 鉄筋コンクリート構造 (pp. 249–312) 執筆担当]
7. 日本建築学会（編）．鉄筋コンクリート造建物の終局強度型耐震設計指針(案)・同解説．

1988. [1章 総則 (pp. 1-5, 23-28) 執筆担当]
8. 岡田恒男, 田中礼治, 松崎育弘, 坂本 功, 河村壮一. あと施工アンカー 設計と施工. 技術書院. 1990.
 9. 日本建築学会 (編). 建築耐震設計における保有耐力と変形性能 (1990). 1990. [序論 (pp. 1-19)・鉄筋コンクリート構造 (pp. 339-473) 執筆担当]
 10. 伊藤 滋, 岡田恒男, 矢野克巳 (監修). 日本建築家協会都市災害特別委員会 (編). 建築家のための耐震設計教本. 彰国社. 1997.
 11. 岡田恒男, 土岐憲三 (編著). 地震防災のはなし 都市直下地震に備える. 朝倉書店. 2006.

Papers and Reports

I. Development and implementation of earthquake disaster mitigation technologies through seismic evaluation and rehabilitation of existing vulnerable buildings

1. T. Okada and B. Bresler. Seismic safety of existing low-rise reinforced concrete buildings—Screening method. Proceedings of the Review Meeting of the U.S.–Japan Cooperative Research Program in Earthquake Engineering with Emphasis on the Safety of School Building (Honolulu). The Japan Earthquake Engineering Promotion Society, pp. 210–246, 1975.
2. T. Okada and B. Bresler. Strength and ductility evaluation of existing low-rise reinforced buildings-screening method. Earthquake Engineering Research Center, Report No. EERC–76/01, University of California, Berkley, CA, 1976.
3. 岡田恒男, 宮沢正躬, 阿部 陞, 森本興一郎, 福島順一. 既存鉄筋コンクリート造建築物の耐震診断および補強法 (大成ERP法—その1, 2). 日本建築学会大会学術講演梗概集 (構造系). Vol. 52, pp. 1859–1862, 1977.
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6. 中埜良昭, 岡田恒男. 信頼性理論による鉄筋コンクリート造建築物の耐震安全性に関する研究. 日本建築学会構造系論文報告集. No. 406, pp. 37–43, 1989.
7. 岡田恒男, 壁谷澤寿海, 中埜良昭, 前田匡樹, 田才 晃, 加藤大介, 市之瀬敏勝, 北山和宏. 鉄筋コンクリート造学校校舎の耐震診断指標値と被災度. 第10回日本地震工学シンポジウム論文集. Vol. 1, pp. 177–182, 1998.
8. T. Okada, T. Kabeyasawa, Y. Nakano, M. Maeda and T. Nakamura. Improvement of seismic performance of reinforced concrete school buildings in Japan (Part 1 and Part 2). Proceedings of the 12th World Conference on Earthquake Engineering (Auckland, 2000). The New Zealand Society for Earthquake Engineering, 2000 (CD-ROM).

II. Development and implementation of earthquake damage assessment technologies of buildings

1. 岡田恒男, 広沢雅也, 平石久廣. 震災構造物の復旧技術の開発 (その1: 鉄筋コンクリート造建物). 建築防災. Vol. 69, pp. 4–15, 1983.
2. T. Okada, M. Hirose, H. Hiraishi and M. Yoshimura. Draft of guidelines for post-earthquake

inspection and evaluation of earthquake damage in reinforced concrete buildings and its application to the Namioka town hospital buildings. Proceedings of the 3rd Workshop on Seismic Performance of Existing Buildings, US/Japan Cooperative Research Program, Department of Structural Engineering, Cornell University, Ithaca, NY, 1985.

3. M. Murakami, T. Okada, M. Ohkubo, S. Otani, K. Takiguchi and H. Hiraishi. Post-earthquake inspection and evaluation of earthquake damage in reinforced concrete buildings. Proceedings of the 7th Japan Earthquake Engineering Symposium (Tokyo), Vol. 7, pp. 2071–2076, 1986.
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III. Experimental and analytical researches and their applications for the above achievements I and II

[Development of computer-actuator on-line test methodology and its application to experimental researches]

1. 高梨晃一, 宇田川邦明, 関松太郎, 岡田恒男, 田中 尚. 電算機-試験機オンラインシステムによる構造物の非線形地震応答解析 その1 システムの内容. 日本建築学会論文報告集. Vol. 229, pp. 77–83, 1975.
2. 久野雅祥, 岡田恒男, 関松太郎. 鉄筋コンクリート立体模型の振動破壊実験: その1 一層純ラーメン. 日本建築学会大会学術講演梗概集 (構造系). Vol. 51, pp. 1309–1310, 1976.
3. T. Okada and M. Seki. A simulation of earthquake response of reinforced concrete buildings. Proceedings of the 6th World Conference on Earthquake Engineering (New Delhi, 1977), Vol. III, pp. 2723–2728, 1977.
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6. 岡田恒男, 勅使川原正臣, 関松太郎. 電算機・アクチュエーターオンラインシステムによる鉄筋コンクリート造2層骨組の地震応答シミュレーション (その2, 3). 日本建築学会大会学術講演梗概集 (構造系). Vol. 55, pp. 1547–1550, 1980.
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[Shake table tests of small scaled structure models under earthquake excitations]

1. 堀内昇二, 藤岡あゆみ, 篠崎邦江, 山本昌士, 隈澤文俊, 岡田恒男. 鉄筋コンクリート造超小型立体模型による振動破壊実験 (その1~4). 日本建築学会大会学術講演梗概集C. pp. 639–646, 1988.
2. F. Kumazawa and T. Okada. Shaking table tests of reinforced concrete small scaled model

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【Earthquake response observations of weakly designed structure models】

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【Post-earthquake reconnaissance and global contribution to enhancing earthquake resilience of cities】

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2. 海外技術協力事業団. ビルマ地震調査団報告書: ビルマ国における耐震構造技術の確立と地震観測の拡充整備に関する予備調査. 1971. [pp. 16–28, 32–39, 72–91 執筆担当]
3. T. Okada, M. Murakami, T. Minami and Y. Nakano. Seismic capacity of reinforced concrete buildings which suffered 1985.9.19–20 Mexico earthquake. Proceedings of the 9th World Conference on Earthquake Engineering (Tokyo-Kyoto, 1988), Vol. VII, pp. 291–296, 1988.
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