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AIJ Standard for Structural Calculation of Reinforced Concrete Structures

revised 2010

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Architectural Institute of Japan

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Introduction

The AIJ Standard for Structural Calculation of Reinforced Concrete Structures was first published in 1933 together with the Standard Specification for Concrete and Reinforced Concrete Work. The former document was intended to help practicing engineers in the design calculations for reinforced concrete building structures. The Standard was revised on many times, starting in 1947 when it was completely rewritten in accordance with the newly-established Japanese Architectural Standard No. 3001[1)], which incorporated the concept of two-stage allowable stress design for long-term and short-term loadings. Since then, the Standard has been revised in 1958, 1962, 1971, 1975, 1979, 1982, 1988, 1991, 1999, and 2010 to adopt into practice the results of advances in research work and the development of new materials. In particular, the extensive revision in 1971 reflected the results of numerous investigations and lessons from the 1968 Tokachi-oki Earthquake, which led to a more rational provision for shear design. The current Standard still follows the fundamental philosophy set forth in the 1971 edition, after some editorial changes related to revisions of other standards in 1975 and 1988, and revisions for footing calculations in 1979 and for slab calculations in 1982, for another editorial changes to abide by JASS5 and JIS codes in 1988, for allowable stress of SD35 and SD40 reinforcement in 1991, and for shear capacity and bond/splice/anchorage with SI unit conversion in 1999. Concept of performance based design was incorporated in 2010.

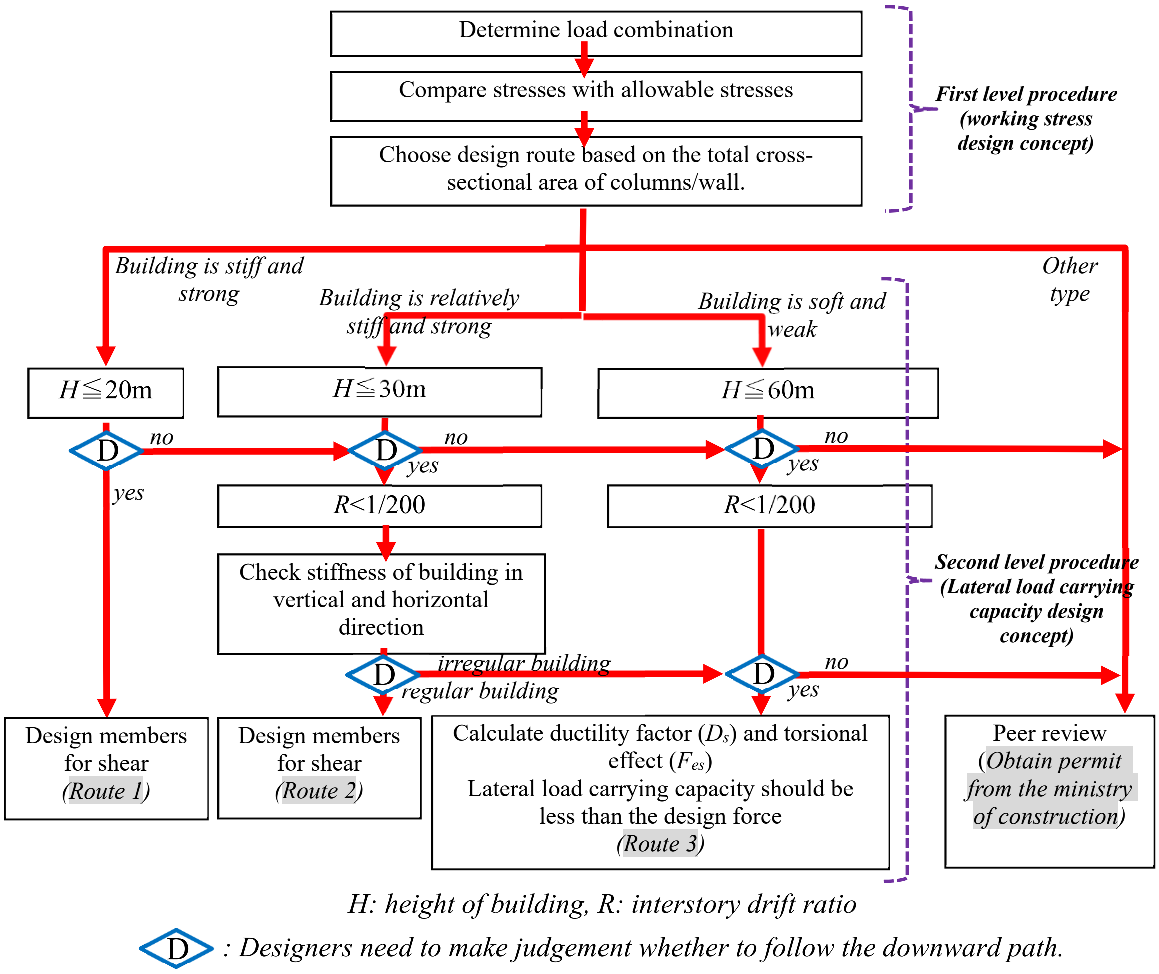

Figure 1. Design flow of reinforced concrete buildings in Japan

The Building Standards Law of Japan was revised in June 1981 and the revised design procedure was introduced especially for earthquakes. The current Building Standards Law in Japan allows multiple structural design procedures for buildings shorter than 60 m. They are, for example, "*Lateral Load Carrying Capacity Procedure*" and "*Capacity Spectrum Design Procedure*". Ordinary reinforced concrete buildings are normally designed with Lateral Load Carrying Capacity Procedure which comprises of two levels of procedure as shown in Figure 1. In the first level procedure for minor to intermediate earthquakes, serviceability and repairability are confirmed using working stress design concept for two stages; long-term and short-term loadings. Long-term loading corresponds to service load condition which considers only gravity load effects from dead and live loads. Short term loading corresponds to load condition under the minor and intermediate seismic events which considers 20% of the self-weight in lateral direction (base shear coefficient of 0.2) superposed to the service load condition. In the second level procedure for large-scale earthquakes, safety is confirmed by using lateral load carrying capacity concept. The second level procedure considers the type of structure (strength resisting type, ductility resisting type, or intermediate type) and the lateral load carrying capacity.

In order to design ordinary buildings, "*Commentary on Structural Regulations of the Building Standard Law of Japan*" (Ministry of Land, Infrastructure, Transport, and Tourism)[2)] has been used heavily as a legal document and treats some documents published by the Architectural Institute of Japan as supplemental materials. The AIJ Standard for Structural Calculation of Reinforced Concrete Structures mainly deals with the first-level design and "*AIJ Standard for Lateral Load-Carrying Capacity Calculation of Reinforced Concrete Structures (Draft)*"[3)] deals with the second-level design. The English translation of the AIJ Standard for Structural Calculation of Reinforced Concrete Structures was promoted by the Structures Committee to respond to the increasing demand from overseas. The Architectural Institute of Japan expects wide and successful use of this publication. However, it must be noted that the Architectural Institute of Japan is responsible for the original Japanese text only. Wherever the meaning of the English translation is dubious or in contradiction with the Japanese text, the original Japanese text of the Standard should be referred to.

The 2010 edition contains the following revisions.

1. The subtitle of the "allowable stress design method" of this Standard was removed. And Art. 1 "Scope of application" was revised to accommodate the deletion of the subtitle.

In the 1999 edition, there is a subtitle "allowable stress design method" in the Standard. However, this subtitle may mislead the international community, such as the International Organization for Standardization, to interpret that "the standard lacks the concept of performance". Hence the subtitle was deleted in the 2010 edition and definitions were added to the terminology of the performance objectives of serviceability, repairability, and safety in Art. 1. These terminologies are used throughout the Standard.

2. Allowable stresses were revised.

Allowable stresses for reinforcing steel bar grade SD 490 were added and some other allowable stresses were revised to conform to the government ordinances and notices.

3. Performance objectives for damage control were introduced for the shear design of columns and beams.

Based on the lessons of the 1968 Tokachi-oki Earthquake, since the 1971 edition, shear design provisions have been improved to avoid brittle shear failure of columns and beams by amplifying the design shear force obtained by structural analysis. However, because the ultimate shear capacity is checked in the second-level design anyway, the check of shear capacity in the first-level design is redundant if the designer follows the current requirements of Building Standard Law Enforcement Order (second-level design). The 2010 edition added the new performance objective of damage control for shear, and involves evaluating the expected residual width of shear cracks under short-term loading only when the designer assesses the ultimate shear capacity in the second level design.

4. Performance objectives for damage control were introduced for flexural bond design of columns and beams.

In the 1999 edition, provisions to prevent bond splitting failure during large-scale earthquakes (second-level design) were introduced. However, the check of bond capacity is redundant if the designer follows the current requirements of Building Standard Law Enforcement Order (second-level design). The 2010 edition restored allowable stress design for bond under conventional short-term loading for damage control (first-level design). The resulting provision is similar to the procedure used before the 1999 revision.

5. Provisions on anchorage were relaxed

The 1999 revision defined development length for hooked bars based on embedment depth rather than the total length. This procedure was too strict for non-seismic anchorage such as a beam or a slab supported by girder. Therefore, the provision was relaxed for non-seismic members, allowing shallower depth but requiring similar total length. In addition, provisions for anchorage were simplified for seismic members and eased for some types of reinforcing details.

6. Provisions for shear walls were extended.

After the 1971 revision, no major revisions were made for shear walls. Some parts were obsolete or ambiguous and the following revisions were made. (a) Requirements regarding enlarged boundary columns were relaxed. Requirements regarding beams crossing through multi-story shear walls were also relaxed. (b) A modeling method was defined for determining the allowable shear level of columns with wing walls, beams with spandrels and hanging walls, and walls without boundary columns. (c) A modeling method was defined for determining the shear capacity of shear walls with different reinforcement ratios in orthogonal directions. (d) Several provisions were changed or added for shear walls with openings. A modeling method was defined for shear capacity calculation of shear walls with tall- and narrow-shaped openings and/or with multiple openings. Reinforcement detailing around shear wall openings was improved and rationalized. A provision for reinforcement detailing of boundary columns next to wall openings was added.

7. The structural design example was replaced with a new example.

The design example was replaced with a more realistic example of a building with beams with spandrel walls and columns with wing walls designed by non-linear static pushover analysis. Arts. 8 and 9 were also revised on the premise that non-linear static push-over analysis is used in structural design.

8. Appendix 7. "Cracks and deformation under long-term loading" was revised.

The formulas for predicting stress in slab reinforcement considering floor slab crack width and the formulas for long-term deflection were revised. (English translation edition has no appendices.)

9. Notes on the second-level design are listed as an appendix.

A checklist and commentary on structural modeling methods are presented for calculating the lateral load carrying capacity, which is related to the second-level design defined in the Building Standard Law Enforcement Order.

It is noted that the English translation has main text and minimum amount of commentary but no appendices.

References:

1) Architectural Institute of Japan : Commentary on Structural Calculation of Buildings (the Japanese Architectural Standard No.3001), 1948. (in Japanese)
2) National Institute for Land and Infrastructure Management and Building Research Institute (Supervisor) : Commentary on Structural Regulations of the Building Standard Law of Japan, 2015. (in Japanese)
3) Architectural Institute of Japan : AIJ Standard for Lateral Load-Carrying Capacity Calculation of Reinforced Concrete Structures (Draft), 2016

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*: - 2013 **: - 2018 ***: 2018 -

Translators of the English Version

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