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Guidelines for simplified seismic assessment and rehabilitation of concrete buildings

Norme pour l'évaluation sismique simplifiée et la réhabilitation des structures en béton

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Guidelines for simplified seismic assessment and rehabilitation of concrete buildings

Norme pour l'évaluation sismique simplifiée et la réhabilitation des structures en béton

ICS 91.080.40

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Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 28841 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 05, *Simplified design standard for concrete structures*.

Introduction

The aim of these International Guidelines is to provide rules for the earthquake resistant assessment and rehabilitation design and execution for existing structural concrete buildings for which simplified procedures may be applied instead of more sophisticated and thorough analyses, in light of the simplicity, symmetry, and other characteristics of the structure under study. This document is developed for countries that do not have existing national standards on this subject and to offer, to local regulatory authorities anywhere, an alternative for the study of relatively small and simple buildings that abound in both rural and urban environments. The analysis and design rules are based in simplified worldwide-accepted strength models. The document is self-contained; therefore actions (loads), simplified analysis procedures and design specifications are included, as well as minimum acceptable construction practice guidelines.

The minimum dimensional guidelines contained in this document are intended to account for undesirable side effects that will otherwise require more sophisticated analysis and design procedures. Material and construction guidelines are aimed at site mixed concrete as well as ready-mixed concrete, and steel of the minimum available strength grades.

The earthquake resistance guidelines are included for rehabilitation of concrete buildings in the numerous regions of the world which lay in earthquake prone areas. The earthquake resistance of rehabilitated buildings is based upon the employment of structural concrete walls (shear walls) that limit the lateral deformations of the structure and provide for its lateral strength.

The document contains guidelines that can be modified by the national standards body due to local design and construction requirements and practices. These guidelines that can be modified are included using ["boxed values"]. The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these elements for use in the national application of the document.

A great effort was made to include self-explanatory tables, graphics, and design aids to simplify the use of the document and provide foolproof procedures. Notwithstanding, the economic implications of the conservatism inherent in approximate procedures as a substitution to sound and experienced engineering should be a matter of concern to the designer that employs the document, and to the owner that hires him.

Guidelines for simplified seismic assessment and rehabilitation of concrete buildings

1 Scope

This document can be permitted to be used as an alternative to the development of a building code, or equivalent document in countries where no national design codes are available by themselves, or as an alternative to the building code in countries where specifically considered and accepted by the national standards body or other appropriate regulatory organization, and applies to the assessment of earthquake resistance capability and to the seismic rehabilitation design and construction for existing structural concrete buildings.

The purpose of these guidelines is to provide a registered civil engineer with sufficient information to perform the seismic assessment and rehabilitation of the structural concrete building that complies with the limitations established in 5., for both undamaged structures that are deemed not to comply with the required characteristics for an adequate response at a specified performance level, and for structures that have undergone damages under seismic loadings. The rules of design as set forth in the present document are simplifications of more elaborate requirements.

Although the guidelines contained in this document were drawn to produce, when properly employed, a reasonable assessment of the seismic vulnerability of an undamaged structure, a reasonable assessment of a structure damaged by a seismic event and a structural rehabilitation of the assessed concrete structure with an appropriate margin of safety, these guidelines are not a replacement of sound and experienced engineering. In order to attain the intended results on assessment and rehabilitation design, the document must be used as a whole, and alternative procedures should be employed only when explicitly permitted by the guidelines. The minimum dimensioning guides as prescribed in the document replace, in most cases, more elaborate procedures as those prescribed in the national code or, if no national code exists, in internationally recognized full fledged codes, and the eventual economic impact is compensated by the simplicity of the procedures prescribed here.

The professional applying the procedures set forth by these guidelines should meet the legal requirements for structural designers in the country of adoption and have training and a minimum appropriate knowledge of structural mechanics, statics, strength of materials, structural analysis, and reinforced concrete design and construction.

While buildings rehabilitated in accordance with these guidelines are expected to perform within the selected performance levels for the applicable design earthquakes, compliance with this guidelines are necessary but may not guarantee the sought for performance, as current knowledge of structural behavior under seismic loads, and of the loads themselves, is yet incomplete.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 679, Methods of testing cements - Determination of strength

ISO 680, Cement - Test methods - Chemical analysis

ISO 863, Cement - Test methods - Pozzolanicity test for pozzolanic cements

ISO 3010, Bases for design of structures - Seismic actions on structures

ISO 4354, Wind actions on structures

ISO 6274, Concrete - Sieve analysis of aggregates

ISO 6782, Aggregates for concrete - Determination of bulk density

ISO 6783, Coarse aggregates for concrete - Determination of particle density and water absorption - Hydrostatic balance method

ISO 6934-1, Steel for the prestressing of concrete Part 1: General requirements

ISO 6934-3, Steel for the prestressing of concrete -- Part 3: Quenched and tempered wire

ISO 6934-4, Steel for the prestressing of concrete -- Part 4: Strand

ISO 6934-5, Steel for the prestressing of concrete -- Part 5: Hot-rolled steel bars with or without subsequent processing

ISO 6935-1, Steel for the reinforcement of concrete - Part 1: Plain bars

ISO 6935-2, Steel for the reinforcement of concrete - Part 2: Ribbed bars

ISO 6935-3, Cor: 2000 Steel for the reinforcement of concrete - Part 3: Welded fabric

ISO 7033, Fine and coarse aggregates for concrete - Determination of the particle mass-per-volume and water absorption - Pycnometer method

ISO 9194, Bases for design of structures - Actions due to the self-weight of structures, non-structural elements and stored materials – Density

ISO 9597, Cements - Test methods - Determination of setting time and soundness

ISO 10144, Certification scheme for steel bars and wires for the reinforcement of concrete. Welded-wire fabric

ISO 3766,2003 Construction drawings -- Simplified representation of concrete reinforcement.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
acceleration of gravity
g
the acceleration produced by gravity at the surface of earth

NOTE For the application of this guidelines its value can be approximated to $g \approx [10]$ m/s^2

3.2
adherence
the force acting on the interface of two solid materials

3.3
admixture
material other than water, aggregate, or hydraulic cement, used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties

3.4
aggregate
granular material, such as sand, gravel, crushed stone, and iron blast-furnace slag, used in conjunction with a cementing medium to form a hydraulic cement concrete or mortar

3.5
anchorage
a device used to anchor a non-structural element to the structural framing

3.6
bar diameter, nominal
approximate diameter of a steel reinforcing bar, often used as a class designation

NOTE For deformed bars, it is common practice to use the diameter of a plain bar having the same area.

3.7
beam
horizontal, or nearly horizontal, structural member supported at one (such as a cantilever) or more points, but not throughout its length, transversely supporting a load, and subjected primarily to flexure

3.8
bearing capacity of the soil
the maximum permissible stress on the foundation soil that provides adequate safety against bearing failure of the soil, or settlement of the foundation of such magnitude as to impair the structure

NOTE Its value is defined at the working stress level.

3.9
bearing – elastomeric
device constructed partially or wholly from elastomer to transmit loads and accommodate movements between a bridge and its supporting structure

3.10
bending moment
product of a force and the distance to a particular axis, producing bending effects in a structural element

3.11
boundary elements
portions along wall edges strengthened by longitudinal and transverse reinforcement

NOTE Boundary elements do not necessarily require an increase in thickness of the wall.

3.12
bridges
structures carrying a road, path or railway over an obstacle

3.13
caisson
a foundation pile of large diameter, built partly or totally above ground and sunk below ground usually by digging out the soil inside

3.14
carbonation
the process of conversion of calcium hydroxide in hardened cementitious material into to calcium carbonate due to reaction with atmospheric carbon dioxide

3.15
cement
material as specified in the corresponding referenced ISO standards, which, when mixed with water, has hardening properties, used either in concrete or by itself

3.16
center of mass
is the geometric place where would be located in plant all the mass of the floor supposing the floor diaphragm as an infinite rigid body in its own plane

3.17
center of rigidity
is the geometric place located in plant and established supposing that the floor diaphragm is an infinite rigid body in its own plane, where applying an horizontal force, in any direction, no diaphragm rotation is presented around a vertical axis

3.18
corrosion
the process of deteriorating of concrete or reinforcement due to chemical or electromechanical change caused in presence of moisture

3.19
column
vertical member used primarily to support axial compressive loads

3.20
collector elements
elements that serve to transmit the inertia forces within the diaphragm to members of the lateral-force resisting system

3.21
combined footing
footing that transmits to the supporting soil the load carried by several columns or structural concrete walls

3.22
compression reinforcement
reinforcement provided to resist compression stresses induced by flexural moments acting on the member section

3.23
concrete
mixture of portland cement and any other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without admixtures

3.24
concrete mix design
the choice and proportioning of the ingredients of concrete

3.25
concrete specified compressive strength of, f'c
compressive cylinder strength of concrete used in design and evaluated in accordance with the appropriate ISO standard, expressed in megapascals (mpa).

NOTE Whenever the quantity f_c' is under a radical sign ($\sqrt{f_c'}$), the positive square root of numerical value only is intended, and result has units of megapascals (mpa).

3.26
confinement hook
a hook on a stirrup, hoop, or crosstie having a bend not less than 135° with a six-diameter (but not less than 75 mm) extension that engages the longitudinal reinforcement and projects into the interior of the stirrup or hoop

3.27
confinement stirrup or tie
closed stirrup, tie or continuously wound spiral

NOTE A closed stirrup or tie can be made up of several reinforcement elements each having confinement hooks at both ends. A continuously wound spiral should have a confinement hook at both ends.

3.28
corrosion
gradual removal or weakening of metal from its surface that requires the presence of humidity and oxygen, and is helped by the presence of other materials

3.29
cover, concrete
the thickness of concrete between surface of any reinforcing bar and the nearest face of the concrete member

3.30
crack
a separation or delamination or splitting roughly parallel and near to surface

3.31
creep
the unrecoverable strain caused to a material subjected to constant stress for a long duration

3.32
crosstie
a continuous reinforcing bar having a 135° hook at one end and a hook not less than 90° at least a six-diameter extension at the other end

NOTE The hooks should engage peripheral longitudinal bars. The 90° hooks of two successive crossties engaging the same longitudinal bars should be alternated end for end.

3.33
curing
keeping the concrete damp for a period of time, usually several days, starting from the moment it is cast, in order to the cement to be provided with enough water to harden and attain the intended strength

NOTE Appropriate curing will greatly reduce shrinkage, increase strength of concrete, and should reduce surface cracking. Curing time will depend on temperature and relative humidity of surrounding air, the amount of wind, the direct sunlight exposure, the type of concrete mix employed, and other factors.

3.34
deformed reinforcement
steel reinforcement that have deformations in its surface to increase its bond to the concrete

NOTE The following steel reinforcement should be considered deformed reinforcement under this guidelines: deformed reinforcing bars, deformed wire, welded plain wire fabric, and welded deformed wire fabric conforming to the appropriate ISO standards.

3.35
depth of member
h
the vertical size of a cross section of a horizontal structural element

3.36
design load combinations
combinations of factored loads and forces as specified in this guidelines

3.37
design strength
the product of the nominal strength multiplied by a strength reduction factor ϕ.

3.38
development length
length of embedded reinforcement required to develop the design strength of reinforcement at a critical section

3.39
development length for a bar with a standard hook
the shortest distance between the critical section (where the strength of the bar is to be developed) and a tangent to the outer edge of the 90° or 180° hook

3.40
differential settlement
when the foundation of different parts of a structure settle different amounts

3.41
drift
is the difference between the horizontal displacements of two levels

3.42
durability
characteristic of a structure to resist gradual degradation of its serviceability in a given environment for the design service life

3.43
effective depth of section
d
distance measured from extreme compression fiber to centroid of tension reinforcement

3.44
embedment length
length of embedded reinforcement provided beyond a critical section

3.45
fatigue
the weakening of a material by repeated or alternating loads

3.46
factored loads and forces
specified nominal loads and forces multiplied by the load factors prescribed in this guidelines

3.47
fire protection of reinforcement
amount of concrete cover necessary for protection of the reinforcement against the effects of the high temperatures produced by fire

NOTE The concrete cover is a function of the number of hours of exposure to the fire.

3.48
flange
top or bottom part of an i or t shaped section separated by the web

3.49
flexural
pertaining to the flexure bending moment

3.50
flexural reinforcement
reinforcement provided to resist the tensile stresses induced by flexural moments acting on the member section

3.51
footing
that portion of the foundation which transmits loads directly to the soil

NOTE May be the widening part of a column, a structural concrete wall or several columns, in a combined footing.

3.52
formwork
a temporary construction to contain concrete in a plastic state while it is cast and setting, and that forms the final shape of the element as the concrete hardens

3.53
foundation
any part of the structure that serves to transmit loads to the underlying soil, or to contain it

3.54
foundation beam
a beam that rests on the foundation soil and spans between footings, used either to support walls or to limit differential settlement of the foundation

3.55
foundation mat
a continuous slab laid over the ground as part of the foundation and that transmits to the underlying soil the loads from the structure

3.56
frame system
system in which seismic shear forces are resisted by shear and flexure in members and joints of the frame

3.57
girder
main horizontal support beam, usually supporting other beams

3.58
gravity loads
loads that act downward and are caused by the acceleration of gravity, g, acting on the mass of the elements that cause the dead and live loads

3.59
hook
bend at the end of a reinforcing bar

NOTE They are defined by the angle that the bend forms with the bar as either 90°, 180° or 135° hooks.