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Guidelines for simplified seismic assessment and rehabilitation of concrete buildings

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

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 5, *Simplified design standard for concrete structures*.

Introduction

The aim of this International Standard 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 International Standard 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. This International Standard 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 International Standard 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 lie 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.

This International Standard 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 this International Standard. Changes to boxed values shall not be made without thorough analyses and sound supporting studies.

A great effort was made to include self-explanatory tables, graphics, and design aids to simplify the use of this International Standard and provide foolproof procedures. Notwithstanding, the economic implications of the conservatism inherent in approximate procedures as a substitute for 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 International Standard can 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 sufficient information to perform the seismic assessment and rehabilitation of the structural concrete building that complies with the limitations established in Clause 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 damage under seismic loadings. The rules of design as set forth in this International Standard are simplifications of more elaborate requirements.

Although the guidelines contained in this International Standard 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 for sound and experienced engineering. In order to attain the intended results on assessment and rehabilitation design, this International Standard 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 this International Standard replace, in most cases, more elaborate procedures such as those prescribed in the national code or, if no national code exists, in internationally recognized full fledged codes, and the possible economic impact is compensated for 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 these guidelines is necessary but may not guarantee the sought for performance, as current knowledge of structural behavior under seismic loads, and of the loads themselves, is still incomplete.

2 Normative references

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

ISO 15673:2005, *Guidelines for the simplified design of structural reinforced concrete for buildings*

3 Terms and definitions

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

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

NOTE For the application of these guidelines its value can be approximated to 10 m/s^2.

3.2
adherence
force acting on the interface of two solid materials

3.3
admixture
material other than water, aggregate, or hydraulic cement, 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 cementitious materials to form a hydraulic cement concrete or mortar

3.5
anchorage
devices 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
structural member for which ratio of axial load to axial gross capacity is equal to or less than 0,1.

3.8
bearing capacity of the soil
maximum permissible stress on the foundation soil that provides adequate safety against bearing failure of the soil

NOTE Its value is defined at the working stress level.

3.9
bending moment
product of a force and the distance to a particular axis, producing bending effects in a structural element

3.10
boundary elements
structural elements embedded at the ends of structural walls strengthened by transverse reinforcement to confine the longitudinal reinforcement

NOTE Boundary elements may require an increase in thickness of the wall.

3.11
caisson
foundation pile of large diameter, built partly or totally above ground and sunk below ground usually by digging out the soil inside

3.12
carbonation
process of conversion of calcium hydroxide in hardened cementitious material into calcium carbonate due to reaction with carbon dioxide diffused into the cement paste from the atmosphere

3.13
cement
material as specified in the corresponding referenced ISO standards, which, when mixed with water, has hardening properties

3.14
center of mass
geometric plan location of the resultant force due to the action of gravity on the mass of the floor is located, supposing the floor diaphragm as an infinite rigid body in its own plane

3.15
center of rigidity
geometric plan location of the resultant of the resistance forces due to structural vertical elements stiffness, calculated, supposing that the floor diaphragm is an infinite rigid body in its own plane in such a way that when applying a horizontal force in any direction, rotation of the diaphragm takes place with no distortion of the original shape of the floor

3.16
corrosion
process of disintegration of the reinforcing steel bars due to chemical or electromechanical change caused in presence of moisture

3.17
column
structural member in which the ratio of axial compressive loads to axial gross capacity is more than 0,1

3.18
collector elements
structural elements that carry the forces within a horizontal diaphragm to the lateral-force resisting system

3.19
combined footing
footing that transmits to the supporting soil the load carried by several columns or structural concrete walls

3.20
compression reinforcement
reinforcement provided to resist compression stresses in the member section

3.21
concrete
mixture of cementitious materials with fine aggregate, coarse aggregate, and water, with or without admixtures, to form a hardened material with specific strength properties

3.22
concrete mix design
choice and proportioning of the ingredients of concrete

3.23

concrete specified compressive strength, f_c'

compressive strength of cylindrical concrete specimens 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 the corresponding result has units of megapascals (MPa).

3.24

confinement hook

hook at the ends of a stirrup, hoop, or crosstie having a bend of 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, hoop or crosstie

3.25

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.

3.26

cover, concrete

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

3.27

crack

break, with or without quite separating in two parts, of concrete, usually near or at the surface

3.28

creep

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

3.29

crosstie

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.

3.30

curing

process in which concrete is kept damp for a period of several days, starting from the moment it is cast, in order to prevent evaporation of water within the cementitious paste to ensure that the hardening process attains 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.

3.31

dead load

permanent load

load in which variations over time are rare or of small magnitude

NOTE All other loads are variable loads (see also nominal loads).

3.32
deformed reinforcement
steel reinforcement that has deformations in its surface to increase its bond to the concrete

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

3.33
depth of member, h
vertical dimension of a cross section of a horizontal structural element or cross section dimension parallel to the direction of transversally applied loads to vertical structural elements

3.34
design load combinations
combinations of factored loads and forces as specified in these guidelines

3.35
design strength
product of the nominal strength and a strength reduction factor ϕ

3.36
development length
length of embedded reinforcement required to develop the design strength of reinforcement at a critical section

3.37
development length for a bar with a standard hook
minimum length to be provided 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

3.38
differential settlement
non-uniform vertical displacement of the foundation

3.39
drift
difference between the horizontal displacements of two floor levels

3.40
durability
characteristics of a structure to resist gradual degradation of its serviceability in a given environment for the design service life

3.41
effective depth of section, d
distance measured from extreme compression fiber to centroid of tension reinforcement

3.42
embedment length
length of embedded reinforcement provided beyond a critical section

3.43
fatigue
weakening of a material by load cycles, with or without load reversals

3.44
factored loads and forces
specified nominal loads and forces multiplied by the load factors prescribed in these guidelines

3.45
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 specified fire resistance, measured in hours.

3.46
flange
top or bottom part of an "I" or "T" shaped section

3.47
flexural
pertaining to the effect of flexure

3.48
flexural reinforcement
reinforcement provided to resist the tensile stresses induced by flexural moments acting on the member section

3.49
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.

3.50
formwork
temporary construction to contain concrete in a plastic state while it is cast and setting, and which provides the final shape of the element as the concrete hardens

3.51
foundation
part of the structure that transmits loads to the underlying soil

NOTE A retaining wall is a special kind of foundation that resists the pressure exerted by the soil on sloping or vertical excavations

3.52
foundation beam
beam that rests on the foundation soil and spans between footings, used either to support walls or to limit differential settlement of the foundation

3.53
foundation mat
continuous slab laid over the ground as part of the foundation and that transmits to the underlying soil the loads from the structure

3.54
frame system
system in which seismic shear forces are resisted by shear and flexure in members and joints of a frame

3.55
girder
main horizontal support beam, usually supporting other beams

3.56
gravity loads
loads that act downward and are caused by the acceleration of gravity, g, acting on the mass of the elements

3.57
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.

3.58
joist
beam used in parallel series directly supporting floor and ceiling loads, and supported in turn by larger girders, beams, or bearing structural concrete walls

3.59
lap splice
splice between two reinforcing bars obtained by overlapping them through a specified length

3.60
lateral-force resisting system
portion of the structure composed of members proportioned to resist forces related to earthquake or wind effects

3.61
lightweight aggregate concrete
concrete made with coarse granular material that weighs less than the granular material used in normal weight concrete

NOTE This type of concrete is not covered by these guidelines.

3.62
limit state
condition beyond which a structure or member becomes unfit for service and is judged either to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state)

3.63
live loads
all forces that are variable within the structure's normal operation, not including construction or environmental loads

3.64
load effects
forces and deformations produced in structural members by the applied loads

3.65
load factor
factor that accounts for deviations of the actual load from the nominal load due to uncertainties both in load calculation and load effect analysis, and to account for the probability that more than one extreme load will occur simultaneously

3.66
loads
forces or other actions that result from the weight of all building materials, pedestrians, environmental effects, differential movement, and restrained dimensional changes

3.67
longitudinal reinforcement
reinforcement that is laid parallel to the longitudinal axis of the element, generally to account for flexural effects

3.68
mass
quantity of matter in a body

3.69
modulus of elasticity
ratio of normal stress to corresponding strain for tensile or compressive stresses below proportional limit of material

3.70
negative moment
flexural moment that produces tension stresses at the upper part of the section of a horizontal or nearly horizontal element, and that requires placing negative flexural reinforcement in the upper part of the element section

3.71
negative reinforcement
in horizontal or nearly horizontal elements, the flexural reinforcement required for negative moment and that is placed in the upper part of the section of the element

3.72
nominal loads
magnitudes of the loads specified in these guidelines (dead, live, soil, wind, snow, rain, flood, and earthquake), before applying magnifying or reducing factors

3.73
nominal strength
capacity of a structure or member to resist the effects of loads, as determined by computations using specified material strengths and dimensions and the formulas set forth by these guidelines

NOTE Specified material strengths are derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modelling effects and differences between laboratory and field conditions

3.74
overturning
action resulting when the moment produced at the base of vertical lateral force resisting elements is larger than the resistance provided by the building weight and foundation resistance to uplift

3.75
pedestal
upright compression member with a ratio of unsupported height to average least lateral dimension of less than 3

3.76
performance level
limiting damage state for a building, considering structural and nonstructural components

3.77
pile
slender timber, concrete or structural steel element embedded in the ground to support loads

3.78
plain reinforcement
smooth surfaced steel reinforcement, or reinforcement that does not conform to the definition of deformed reinforcement

3.79
positive moment
flexural moment that produces tension stresses at the lower part of the section of a horizontal, or nearly horizontal element, and that requires placing positive flexural reinforcement in the lower part of the element section