Strength Evaluation of Existing Concrete Buildings

Reported by ACI Committee 437

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The strength of existing concrete buildings and structures can be evaluated analytically and supplemented where necessary with load testing. The recommendations in this report indicate when such an evaluation may be needed, establish criteria for selecting the evaluation method, and indicate the data and background information necessary for an evaluation. Methods of determining material properties used in the analytical and load test investigations are described in detail. Analytical investigations should follow the principles of strength design. Working stress analysis can supplement the analytical investigations by relating the actual state of stress in structural components to the observed conditions.

Keywords: cracking; deflection; deformation; deterioration; gravity load; load; load test; reinforced concrete; strength; strength evaluation; test.

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ACI 437R-19 supersedes 437R-03 and was adopted and published May 2019.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This report defines the process of structural evaluation to determine the structural adequacy of existing concrete structures as defined by ACI 562. The procedures can be applied generally to new concrete structures, provided that appropriate evaluation criteria are agreed upon before the start of the investigation. This report covers structural concrete, including conventionally reinforced cast-in-place concrete, precast-prestressed concrete, precast post-tensioned concrete, and post-tensioned cast-in-place concrete.

1.2—Scope

1.2.1 *Background and limitations*—Engineering judgment based on rational, scientific principles is critical in the strength evaluation of concrete structures. Such judgment of a qualified licensed design professional is needed for proper application of relevant code provisions to the case being studied. An assessment of structural safety can be achieved with the information and data from field investigations, scientific computations based on sound principles, as well as subjective engineering judgment from the licensed design professional. This is particularly true for structures deteriorated from prolonged exposure to the environment or damaged in an extreme event, such as a fire, earthquake, or explosion.

Similarly, there are no generally recognized criteria for evaluating serviceability of an existing concrete structure. Such evaluation requires engineering judgment based on scientific principles, and close consultation with the owner regarding the intended use of the structure and expected level of performance.

ACI 562 discusses potential conclusions resulting from a strength evaluation; however, the determination of one or more of the following conclusions regarding the integrity of a concrete structure is possible from a strength evaluation:

a) The structure or structural element has an adequate margin of safety according to the provisions of the applicable building code.

b) The strength determined by evaluation is less than that required for factored loads but greater than required for service loads (load factors equal to or greater than 1.0 for all load cases). In this case, the structure or structural element is not adequate. In some cases, restricted use of the structure that limits the applied loads in recognition of the computed strength may be permitted.

c) The design strength of the structure is less than required for service loads under the applicable building code. In such cases, the owner should be notified and consideration given to the installation of shoring, severe restriction of use, or evacuation of the structure until remedial work can be done.

1.2.2 *Applications*—The procedures recommended in this report apply to strength evaluation of existing concrete buildings or other structures, including the following circumstances:

a) Structures that show damage from excess or improper loading, explosions, vibrations, fire, or other causes

b) Structures where there is evidence of deterioration or structural weakness, such as excessive cracking or spalling of the concrete, reinforcing bar corrosion, excessive member deflection or rotation, or other signs of distress

c) Structures that are suspected of not satisfying building code requirements in terms of design, materials, or construction

d) Structures where there is doubt as to the structural adequacy and the original design criteria are not known

e) Structures undergoing expansion or a change in use or occupancy and where the new design criteria exceed the original design criteria

f) Structures that require performance testing following remediation (repair or strengthening)

g) Structures that require testing by order of the building official

1.2.3 *Exceptions*—This report does not address the following conditions:

a) Performance testing of structures with unusual design concepts

b) Product development testing where load tests are carried out for quality control or approval of mass-produced elements

c) Evaluation of soil conditions

d) Load assessment for strength evaluation of environmental engineering concrete structures (refer to ACI 350 for additional information)

e) Liquefied gas containment structures (refer to ACI 376 for additional information)

1.2.4 *Categories of structural evaluation*—There are numerous different characteristics or levels of performance of an existing concrete structure that can be evaluated. These include:

a) Stability of the entire structure

b) Stability of individual components of the structure

c) Strength and safety of individual structural elements

d) Stiffness of the entire structure

e) Stiffness of individual structural elements

f) Susceptibility of individual structural elements to excessive long-term deformation

g) Dynamic response of individual structural elements

h) Fire resistance of the structure

i) Serviceability of the structure

j) Durability of the structure

This report deals with the evaluation of an existing concrete structure for stability, strength, and safety. Although not intended to be an in-depth review of durability, this report addresses durability-related aspects and notes significant features that could compromise structural performance, either at the time of the investigation or later.

1.2.5 *Procedure for a strength evaluation*—Most strength evaluations have many basic steps in common. Each evaluation, however, should address the unique characteristics of the structure in question and the specific concerns that have arisen regarding its structural integrity. Generally, the evaluation will consist of:

a) Defining the existing condition of the structure, including:

i. Reviewing available information

ii. Conducting a condition survey

iii. Determining the cause and rate of progression of existing distress