

17 GUIDANCE FOR EVALUATION AND MODIFICATION OF EXISTING STRUCTURES

17.1 GENERAL APPROACH

In all cases other than structural maintenance, the Responsible Engineer shall carry out an appraisal of the existing structure and foundations in order to:

- (a) Understand the structural system and load path, i.e. the way in which the building carries vertical and lateral loads to the ground. It is noted that the actual load paths may not be the same as those of the original design. Elements such as partition walls which were not considered by the original designer may actually carry loads and the appraising engineer must establish this. Alterations to the original construction may have been carried out.
Understand the current state of the structure, foundations and the materials forming it. Establish if there are any defects, if it has been damaged, if materials have deteriorated, and, if so, the extent of deterioration.
- (b) Assess the state of fire protection systems and corrosion protection systems.
- (c) Establish possible future additional loads which could be applied to the structure and establish suitable load paths for them.
- (d) Devise suitable details for connecting new structure to existing structure.
- (e) Devise any strengthening systems which may be necessary to enable the existing structure to carry different loads. The structural capacity of the members may be assessed using advanced design codes containing accurate methods.

Where suitable evidence is not available, the Responsible Engineer shall arrange for tests of original materials as necessary in order to establish design strengths in accordance with relevant standards and procedures.

In some situations, load tests of major components such as floor slabs may be necessary; however, results of such tests may be inconclusive or there may be a risk of damage. Therefore, such tests should be approached with caution.

The new structure, connections of new to existing and any necessary strengthening works shall be designed using established engineering principles and the requirements of the Code.

17.2 STRUCTURAL ASSESSMENT SURVEY

All possible evidence about the structure from various sources should be gathered and examined, as follows:

- (a) Existing drawings and documents. The best source of information is record drawings and specifications of the original design.
- (b) Historical studies and verbal information. Descriptions of older buildings of historical interest may be found in guidebooks, newspaper archives or historical studies. Useful information may be obtained from discussion with local people, for example village heads or archaeologists.
- (c) Structural survey. Having obtained information from initial desk studies, a site visit and structural survey should be carried out. Detailed guidance on carrying out structural surveys is given in the references in Annex A2.5.
- (d) Detailed site investigations, opening up of the superstructure and trial pits to examine foundations should be specified as necessary following the initial inspection.

17.2.1 Original materials

The materials used in the existing structure should be identified, initially from information on record drawings and by inspection. If material properties cannot be established to a reasonable level of accuracy, then it may be necessary to take samples for destructive

testing. The locations for taking samples must be carefully chosen to minimise damage, to avoid significant weakening of the parent structure and to provide sufficient and reliable data, particularly on chemical compositions and weldability of iron and steel. A better range of properties may be obtained from thicker sections where this is practical. Suitable methods of making good after taking samples shall be specified.

The references given in Annex A2.5 provide information on identifying old types of steel, wrought and cast iron.

17.2.2 Appraisal report

An appraisal report shall be prepared. It should describe the findings of the document studies, site surveys, material tests and any analysis and design check calculations carried out. Plain language and simple diagrams shall be used for the executive summary upon which decisions will be made. The report shall be written in a systematic way, see references in Annex A2.5 for detailed guidance on contents.

The appraisal report is a useful document in determining the probable scope of intended use or re-use of existing building.

17.3 DESIGN AND ANALYSIS ISSUES

17.3.1 Structural appraisal analysis and design check

If there is ongoing structural maintenance, i.e. restricted to repair and restoration of corroded or damaged members, a structural assessment should not normally be required.

In all other cases, as given in clause 17.1 a reasonable understanding of the structural system shall be established, including elements not formed part of the original structural design. This process requires forensic engineering intuition and experience.

More detailed discussion and guidance on this subject is given in the references listed in Annex A2.5.

Load factors and combinations used for the appraisal analysis should be taken from clause 4.3.3. In certain situations, there may be evidence to justify lower load factors.

Load factors and combinations for design of any new additions shall be taken from clause 4.3.1.

The possibility of fatigue loading on original elements should be considered.

17.3.2 Overall stability of existing and new structure

The structural appraisal must demonstrate that the existing structure, together with any additional structure, maintains an adequate factor of safety on overall stability against overturning or global buckling.

17.3.3 Details for connection of new to old structure

Suitable connection details shall be designed. Care shall be taken to ensure that existing structural elements are not unacceptably weakened by cutting, drilling or welding.

17.3.4 Upgrading of original structure

If it is necessary to strengthen the existing structure, then the design of suitable details to connect strengthening members to existing members shall allow for transfer of the required proportion of load into the new members.

A compatibility analysis should be carried out. Temperature effects should be considered.

It may be necessary to relieve dead and any other load on a member whilst it is being strengthened or repaired. This is especially important if heat from welding will be applied to existing members. The sequence of welding to enhance the strength should be

carefully specified to maintain symmetry of load effects and minimise distortion as far as possible.

Methods for transfer of load may include use of temporary jacks and brackets, use of permanent flat jacks or relief of load on existing structure by springing.

Surfaces of existing material which are to be strengthened or repaired shall be thoroughly cleaned to remove all foreign substance matters except surface protection in good condition. The parts of surfaces which are to be welded shall have all finishes removed for a clear distance of 50 mm from the proposed welds.

17.3.5 Considerations for design against extreme events (fire, accident, terrorism)

It may be difficult in practice or even economically not feasible to apply current standards on robustness or fire protection to older existing buildings. However, a suitable level of safety must be provided. Specific risk analysis and performance-based design may be required in order to justify an acceptable level of safety against fire and extreme events.

17.3.6 Serviceability issues

Similarly to clause 17.3.5, it may not be economically feasible to comply with current deflection or vibration guidelines. A performance-based justification of acceptable levels of deflection and vibration may be required.

17.4 LOAD TESTS

As stated in clause 17.1, load tests should be approached with caution. They should not be specified unless there is a reasonable expectation of success. If it is decided to carry out load tests, then the principles of such tests shall be in accordance with section 16 of the Code. However, in order to avoid damage, careful consideration shall be given to the magnitudes of the applied test loads.

To ensure the safety of test personnel and the public, the test arrangements shall be designed to fail safely in the event of failure of the element under test. References in Annex A2.3 provide further guidance on load tests.