

CHAPTER 9 MAINTENANCE OF UPGRADED CONCRETE STRUCTURES

9.1 General

- (1) Concrete structures upgraded with continuous fiber sheets and continuous fiber strands shall be appropriately maintained throughout their service life to ensure that they continue to satisfy performance requirements.
- (2) Upgraded concrete structures shall be maintained through a systematic combination of prediction of deterioration, inspections, evaluations and judgements, countermeasures and records.

[Commentary]

The maintenance of concrete structures upgraded with continuous fiber sheets and continuous fiber strands should be implemented in accordance with the Recommendations for Maintenance of Concrete Structures. For this reason, this chapter is prepared to complement the Recommendations for Maintenance of Concrete Structures, with additional knowledge acquired since 1995 when the Recommendations were issued.

- (1) As a rule, concrete structures upgraded with continuous fiber sheets and continuous fiber strands should maintain performance requirement throughout their service life after upgrading.
- (2) To achieve the objective stated in (1), maintenance should be conducted through a systematic combination of the items listed below.
 1. Repairs to prevent anticipated deterioration:

Anticipated deterioration at the time of upgrading design should be repaired during maintenance, and more accurate predictions of deterioration should be made.
 2. Inspections:

Inspections consist of initial, daily, periodic, detailed and extraordinary inspections. These should be based on the performance requirements of the owner and the predictions of deterioration of the performance.

3. Evaluations and judgements:

There are two stages of evaluations and judgements: those based primarily on visual inspections, and those based on detailed inspections. In the visual inspections, a judgement is made as to whether detailed inspections are required or not. In the detailed inspections, the need for countermeasures is judged and the type of countermeasure is selected.

4. Countermeasures:

These include stricter inspections, service restrictions, repair of continuous fiber sheets and continuous fiber strands, additional upgrading, improvement of appearance, dismantling and disposal.

5. Records:

To implement suitable maintenance, the results of design, construction, inspection, evaluations and judgements, repair of continuous fiber sheets and continuous fiber strands, additional upgrading and so on are recorded and the records should be stored.

The ease of maintenance is affected by the upgrading plans, and by design and construction. More specifically, the placement of inspection routes, and monitoring equipment ensure the ease of maintenance. These increase the initial investment, but it can be expected to reduce maintenance costs during the service life of the structure and to increase the reliability of the structure. For this reason, it would be best to give thorough consideration to ease of maintenance in the upgrading plan, and in design and construction.

9.2 Inspections and evaluations

- (1) Inspections shall be conducted visually or using appropriate inspection equipment, with consideration given to both performance requirements and the mechanism of deterioration.
- (2) Based on the results of inspections, the performance requirements from the owner shall be evaluated; if the requirements are not satisfied, necessary countermeasures shall be taken.

[Commentary]

(1) (2) Deterioration of the concrete structures upgraded with continuous fiber sheets or continuous fiber strands consists of deterioration of the continuous fiber sheets or continuous fiber strands, deterioration of the resin, deterioration as a composite material (interfacial deterioration) and deterioration of bond to the concrete. The cause may be not only a single factor but a combination of factors. The visual features of this deterioration mechanism may include the following:

Swelling, peeling, lifting, softening, discoloration, whitening, choking, cracking, wearing, erosion, pinholes, scratches, deformation, and embrittlement,

The following changes in properties may also occur:

Changes in weight, changes in volume, changes in mechanical properties (hardness, bond strength to concrete, tensile strength, modulus of elasticity, elongation, etc.), changes in physical properties (electrical properties, thermal properties, optical properties, etc.)

Inspections may reveal the deterioration mechanism for each required performance element and, in order to obtain data on visual features and changes in properties, a combination of visual inspections and inspections using suitable inspection equipment should be conducted.

In concrete structures upgraded with continuous fiber sheets, the continuous fiber sheets can be expected to block or limit the intrusion of various external substances. Improved durability by attachment of the sheets can be anticipated with respect to the salt attack, carbonation, freezing resistance, alkali aggregate reaction, chemical attacks, fatigue and other deterioration for the existing concrete structure.

9.3 Countermeasures

Countermeasures shall be conducted to satisfy the level of performance requirements, based on the results of evaluation and judgement.

[Commentary]

Countermeasures include stricter inspections, service restrictions, repair of continuous fiber sheets and continuous fiber strands, additional upgrading, improvement of appearance, dismantling and disposal. They should be selected based on the results of evaluation and judgement.

For minor deterioration, countermeasures should consist primarily of stricter inspections and repair of continuous fiber sheets and continuous fiber strands. The method of countermeasures should be selected depending on the appeared features of the deterioration mechanism and the extent of changes of physical properties, but the following methods can be considered:

For swelling, peeling, lifting, etc.:	Resin fill
For cracking, wearing, erosion, etc.:	Patching

When serious deterioration or deterioration over a wide area is observed, primarily additional upgrading should be conducted. In such cases, as a rule, the existing continuous fiber sheets and continuous fiber strands should be removed and the upgrading plan examined again.