

SUPPLEMENTARY PAPER ON TECHNICAL GUIDANCE NOTE 6 (TGN 6) STRUCTURAL STRENGTH REDUCTION FACTORS

1. Background

Strength reduction factor issue has been discussed during the Technical Sub Committee (TSC) meeting to provide an equivalency to the Accord accepted solutions for the consideration of strength reduction factors in existing buildings. The RSC has developed an independent implementation guidance based on the outcome of the discussion, which may aid industry in completing their remediation plan in a timely manner.

The strength reduction factor, also known as Φ (phi) factor, is used in reinforced concrete design & analysis. For different reinforced concrete members various values of Φ factors are used. Following are the reasons to use Φ (phi) factor:

- Possible variations in dimensions.
- Possible variations in material strength.
- Possible inaccuracies in the strength equations.
- To ensure a good level of safety of reinforced concrete structures.

The above-mentioned variation may be raised due to various reasons including poor workmanship, lack of understanding, low strength material ingredients etc.

Accord practice was to apply the strength reduction factor Φ as per BNBC 2006 for new and existing building where no section is available for evaluation of strength of existing structures. A technical guidance note was developed by the Technical Sub Committee in order to provide an equivalency to the Accord accepted solutions for structural strength reduction factors in existing buildings. It is agreed and decided that engineers can use ACI 318-11 in lieu of BNBC 2006 requirements for existing building evaluation. This supplementary paper to address and provide the technical specifications and implementation guidance on consideration of strength reduction factor Φ for existing structure evaluation.

2. Standard Requirement/s:

The strength reduction factor Φ is considered as per BNBC 2006 for new and existing building design and evaluation. The strength reduction factor Φ for different kinds of strength shall be as specified in Table 6.6.1.



Table 6.6.1
Values of Strength Reduction Factor, ϕ

Kind of strength	ϕ
Flexure, without axial load	0.9
Axial tension with or without flexure	0.9
Axial compression with or without flexure ¹ Members with spiral reinforcement	0.75
Other members	0.70
Shear and torsion	0.85
Bearing on concrete	0.70
¹ For low values of axial compression, the strength reduction factor shall be increased in accordance with the provision of Sec 6.3.5 of BNBC 2006.	

3. Alternative Solution:

For existing buildings, designers may use ACI 318-11 in lieu of BNBC 2006 requirements, if the required dimensions and material properties are determined through measurements and testing, and if calculations can be made in accordingly, it shall be permitted to increase ϕ from those specified in Table 6.6.1, but ϕ shall not be more than:

Table -1
Strength Evaluation

Kind of strength	ϕ
Tension-controlled sections	1.0
Compression-controlled sections, Members with spiral reinforcement	0.9
Other reinforced members	0.8
Shear and/or torsion	0.8
Bearing on concrete	0.8

4. Implementation Guidance:

Determination of required dimensions and material properties are followed:

1. Dimensions of the structural elements shall be established at critical sections. Critical sections are where each type of stress calculated for the load in question reaches its maximum value.



2. Locations and sizes of the reinforcing bars, welded wire reinforcement, or tendons shall be determined by measurement. It shall be permitted to base reinforcement locations on available drawings if spot checks are made confirming the information on the drawings. For individual elements, amounts, size, arrangement, and location should be determined at the critical sections for reinforcement or tendons, or both, designed to resist applied load. Nondestructive investigation methods are acceptable. In large structures, determination of these data for approximately 5 percent of the reinforcement or tendon in critical regions may suffice if these measurements confirm the data provided in the construction drawings.
3. If required, concrete strength shall be based on results of cylinder tests from the original construction or tests of cores removed from the part of the structure where the strength is in question. For strength evaluation of an existing structure, cylinder or core test data shall be used to estimate an equivalent $f'c$. The method for obtaining and testing cores shall be in accordance with ASTM C42M. ACI committee 214 has developed two methods for determining $f'c$ from cores taken from an existing structure. These methods are described in ACI 214.4R and rely on statical analysis techniques. The procedures described are only appropriate where the determination of equivalent $f'c$ is necessary for the strength evaluation of an existing structure and should not be used to investigate low cylinder strength test results in new construction.
4. If required, reinforcement or prestressing steel strength shall be based on tensile tests of representative samples of the material in the structure in question.
5. If the required dimensions and material properties are not determined through measurements and testing, and if calculations cannot be made in accordingly, the Table 6.6.1 should be used for the consideration of strength reduction factor ϕ for existing structure evaluation.

5. Recommendation:

If the required dimensions and material properties are determined through measurements and testing as per the implementation guidance, and if calculations can be made in accordingly, then follow Table 1 otherwise follow Table 6.6.1 for the consideration of strength reduction factor ϕ for existing structure evaluation.

6. References:

- BNBC-2006 : Bangladesh national building code, 15 November 2006
 ACI 318-11: Building Code Requirements for Structural Concrete and Commentary.
 BNBC 2020: Bangladesh national building code, 11 February 2021

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