

## Flexural Strength of Concrete

### 1. WHAT is Flexural Strength?

It is the ability of a beam or slab to resist failure in bending. It is measured by loading unreinforced 150 x 150 mm concrete beams with a span three times the depth (usually 450mm). The flexural strength is expressed as "Modulus of Rupture" (MR) in MPa.

Flexural strength is about 12 to 20% of compressive strength. However, the best correlation for specific materials is obtained by laboratory tests.

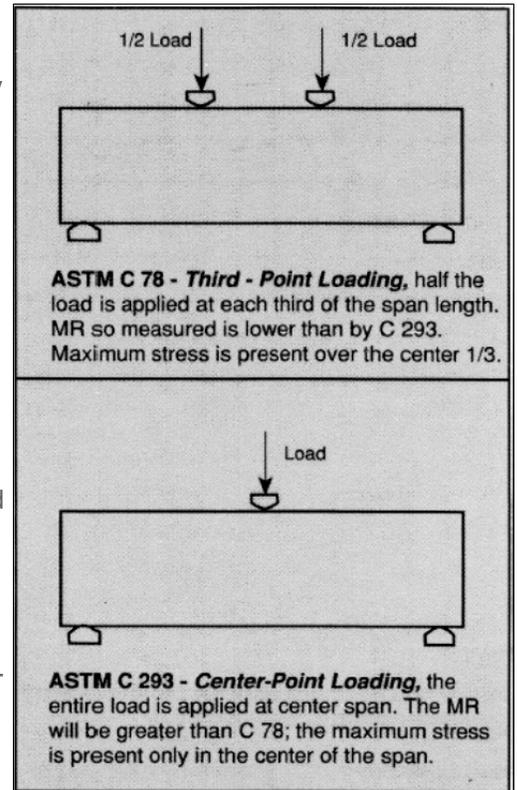
### 2. WHY Test Flexural Strength?

Designers of pavements use a theory based on flexural strength. Therefore, laboratory mix design based on flexure may be required, or a cement content may be selected from past experience to yield the needed design MR. Some also use MR for field control and acceptance of pavements. Very few use flexural testing for structural concrete. Agencies not using flexural strength for field control generally find the use of compressive strength convenient and reliable to judge the quality of the concrete as delivered.

### 3. HOW to Use Flexural Strength

Beam specimens must be properly made in the field. Consolidate by vibration in accordance with CSA A23.2-3C and tap sides to release air pockets. For higher slump, after rodding, tap the molds to release air pockets and spade along the sides to consolidate. Never allow the beam surfaces to dry at any time. Immerse in saturated lime water for at least 20 hours before testing.

Specifications and investigation of apparent low strengths should take into account the higher variability of flexural strength results. Standard deviation for projects with good control range from about 0.3-0.5MPa. Values over 0.7MPa indicate testing problems, and there is a high likelihood that testing problems, or moisture differences within a beam, will cause low strength.



6. Variation of Laboratory Concrete Flexural Strength Tests, W. Charles Greer Jr., ASTM, Cement, Concrete and Aggregates, Winter, 1985, American Society For Testing Materials, West Conshohocken, PA.  
7. "Concrete Mixture Evaluation and Acceptance for Airfield Pavements", Richard C. Meininger and Norm Nelson, NRMCA Publication No. 178, September 1991, NRMCA, Silver Spring, MD.  
8. Compression vs Flexural Strength for Quality Control of Pavements, Steve Kosmatka, CTTI PL 854, 1985, Portland Cement Association, Skokie, IL.  
9. "The Effect of Cement Content on the Flexure Test", Orrin Riley, ACI Concrete International, August 1994, American Concrete Institute, Farmington Hills, MI. Revised and revised 2019.

1. CSA A23.1 Concrete Materials and Methods of Concrete Construction, The CSA Group, Toronto, Ontario, Canada.  
2. CSA A23.2 Test Methods and Standard Practice for Concrete, The CSA Group, Toronto, Ontario, Canada.  
3. How Should Strength Be Measured For Concrete Paving? Richard C. Meininger, NRMCA TIL 420, and Data Summary, NRMCA TIL 451, NRMCA Silver Spring, MD.  
4. Concrete Strength Testing, Peggy Carrasquillo, Chapter 14, ASTM STP 169C, Significance of Tests and Properties of Concrete and Concrete Making Materials, American Society For Testing Materials, West Conshohocken, PA.  
5. "Studies of Flexural Concrete, Part 3, Effects of Variations in Testing Procedures", Stanton Walker and D.L. Bloom, NRMCA Publication No. 75, NRMCA, Silver Spring, MD.

Where a correlation between flexural and compressive strength has been established, core strengths by CSA A23.2-14C can be used for compressive strength to check it against the desired value using the CSA A23.1 85 percent criteria. It is impractical to saw beams from a slab for flexural testing. Sawing beams will greatly reduce measured flexural strength and should not be done. Some use has been made of measuring indirect tensile strength of cores by CSA A23.2-13C, but experience is lacking on how to apply the data.

Another procedure for in-place strength investigation uses compressive strength of cores calibrated by comparison with acceptable placements on either side of the concrete in question.

#### 4. WHAT are the Problems with Flexure?

Flexural tests are extremely sensitive to specimen preparation, handling, and curing procedure. Beam specimens are very heavy, and allowing a beam to dry will yield lower strengths. Beams must be cured in a standard manner, and tested while wet. A short period of drying can produce a sharp drop in flexural strength.

The concrete industry and inspection agencies are much more familiar with traditional cylinder compression tests for control and acceptance of concrete.

Flexure can be used for design purposes, but the corresponding compressive strength should be used to order and accept the concrete. Any time trial batches are made, both flexural and compressive tests should be made so that a correlation can be developed for field control.