# Comparative Study of Flexural Strength of In-Service Concrete Pavement

D. Shiva Raju
Asian Development Bank, INRM, New Delhi
shivarajute@gmail.com

C. S. R. K Prasad ,S. Shankar
Department of Civil Engineering, , NIT, Warangal, India.
Email: csrk_prasad@yahoo.com, shankarcvg@gmail.com

***Abstract* - One of the key developments required to characterize and improve the performance of (PCC) pavements is a better understanding of its in situ properties. Of great importance is the accurate estimation of in situ concrete strength, because it has a major impact on concrete performance. Damage identification of concrete structure has become a matter of primary importance in quality assessment and load capacity rating of the civil infrastructure, as well as in the planning of a maintenance schedule. There are currently many methods used to estimate in situ strength, each providing unique benefits. This investigation examined an experimental study of compressive strength and modulus of elasticity of in-service concrete pavement. The Compression test is conducted to determine the compressive strength further which is used in finding the flexural strength. The flexural strength is further used for calculation of life expectancy of the pavement.**

***Keywords: Concrete pavement; Life Expectancy; properties***

## I INTRODUCTION

Distresses of Cement Concrete pavement (CCP) is generally caused by a combination of self defect, environmental influence, and heavy load of repetitions. As concrete pavement influences by repetitive fatigue loadings, the fatigue properties and fatigue life of concrete have to be estimated for the consideration in design. For this purpose the evaluation of the service life is often necessary to measure its performance. Further, the damage identification of CCP has become a matter of primary importance in quality and load capacity. The flexural strength is expressed as "Modulus of Rupture" (MR) MPa. In this study the relation developed by (Raphael 1984). correlating flexural strength and compressive was used in finding flexural strength of concrete. In the present study measuring or comparing the strength of in-place concrete include: rebound hammer, penetration probe, pullouts, cast-in- place cylinders, tests of drilled cores, and load tests of the structural element. The core cutter samples were collected from the pavement, of which the flexural strength was determined. The portable mini core cutter was used to extract samples from the pavement. Figure 1 shows the Flexural-to-compressive strength relationship.

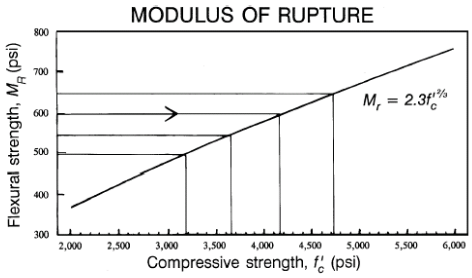


Figure 1. Flexural-to-compressive strength relationship

## II OBJECTIVES OF THE STUDY

The present study was undertaken with the following objectives.

1. To study the compressive and flexural strength of in-service concrete pavement.
2. To study the life expectancy of the pavement slab.



## III DESCRIPTION OF STUDY AREA

In order to make the "Comparative Study of Flexural Strength of In-service Concrete Pavement" the pavements were selected. These three pavements fall under the area of KUDA. The samples where collected under the wheel path.The Pavement stretches are

1. Battala Bazaar to MGM Hospital (Near Kasam. PullaiahColth Shop) (abbreviated as BB to MGM).
2. Pocham Maiden to Warangal Cross Road(Near Masjid) (abbreviated as PM to WGL).
3. Public Garden Road (abbreviated as PGR).

Mini core cutter (Twinstoneoy, type 32, made in Finland), is used to cut the cut the samples from the pavement. It runs by petrol, the accelerator provided on the side of the equipment used to accelerate the machine.

## IV EARLIER CORRELATIONS

Many investigations have been conducted in attempts to develop an accurate relationship between compressive, tensile, and flexural strength. The articles and opinions on the correlation between the different strength test types does not recommend any one test in particular. As for the correlation between the three test types, most of the following equations was be used, noting that the variance in the coefficients and equations can be attributed to regional, climatic, and material properties, among others. Though many investigations have been conducted, results have been conflicting (Raphael 1984). ACI has adopted the relationship that flexural

Figure1. Experimental setup

Figure.2. Closer view of the scale

Figure.3. Sample after testing

Strength is 7.5 times the square root of the specified concrete compressive strength. The various correlations developed by different researchers were used in the present study as presented below. The pictures of the samplers are shown in figure 1-3.

| | |
|---|---|
| Raphael, J.M. | MR = 2.3 * [fc ^(2/3)]<br>fst = 1.7 * [fc ^(2/3)] |
| ACI Code | MR = 7.5 * [fc ^(0.5)]<br>fst = 6.7 * [fc ^(0.5)] |
| Center for Transportation Research / Fowler, D.W. | fst = 0.72 x MR |
| Center for Transportation Research | MR (3rd Point) = 0.86 x MR (Center Point) |
| Narrow & Ulbrig | MR = fst + 250 |
| Grieb & Werner | fst = 5/8 MR (river gravel)<br>fst = 2/3 MR (crushed limestone) |

V CALCULATIONS

*A. Compressive strength*

Table.1. Showing the height, diameter, thickness and area of the specimen.

| Sl.No | ID of Sample | Ht. of sample (mm) | Dia of sample (mm) | Thickness of Pavement (mm) | Area ($mm^2$) | Breaking Load (kg) |
|---|---|---|---|---|---|---|
| 1 | BB-MGM 1 | 30 | 25 | 180 | 491.07 | 765 |
| 2 | BB -MGM 2 | 35 | 25 | 180 | 491.07 | 560 |
| 3 | PM-WGL 1 | 25 | 25 | 205 | 491.07 | 340 |
| 4 | PM-WGL2 | 43 | 25 | 205 | 491.07 | 500 |
| 5 | PG – 1 | 35 | 25 | 190 | 491.07 | 910 |
| 6 | PG – 2 | 25 | 25 | 190 | 491.0 | 970 |

Table 2. Showing the Name of the Specimen and Compressive strength

| Sl.No. | Name of the Specimen | Compressive strength |
|---|---|---|
| 1 | BB to MGM – 1 | 155.78 kg/cm2 |
| 2 | BB to MGM – 2 | 114.04 kg/cm2 |
| 3 | PM to WGL – 1 | 69.24 kg/cm2 |
| 4 | PM to WGL – 2 | 101.82 kg/cm2 |
| 5 | PG – 1 | 185.31 kg/cm2 |
| 6 | PG – 2 | 197.53 kg/cm2 |

**5.2 Corrected Compressive Strength**

**5.3 Flexural Strength**

Table 3 Showing the Corrected compressive strength

| Sl.No | ID of Specimen | Compressive strength ($N/mm^2$) | Corrected compressive Strength ($N/mm^2$) |
|---|---|---|---|
| 1 | **BB to MGM – 1** | 15.58 | 14.18 |
| 2 | **BB to MGM – 2** | 11.40 | 10.66 |
| 3 | **PM to WGL – 1** | 6.92 | 6.20 |
| 4 | **PM to WGL – 2** | 10.18 | 9.83 |
| 5 | **PG – 1** | 18.53 | 17.38 |
| 6 | **PG – 2** | 19.75 | 17.68 |

Table 4 Showing the Flexural strength

| Sl.No | ID of the Specimen | Flexural Strength(N /mm) |
|---|---|---|
| 1 | **BB to MGM – 1** | 2.63 |
| 2 | **BB to MGM – 2** | 2.17 |
| 3 | **PM to WGL – 1** | 1.51 |
| 4 | **PM to WGL – 2** | 2.06 |
| 5 | **PG – 1** | 3.01 |
| 6 | **PG – 2** | 3.04 |

The sample calculations for flexural strength is shown below.

Specimen Name: BB to MGM – 1

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 14.18^{(2/3)} = 2.63$ N mm

Specimen Name: BB to MGM – 2

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 10.66^{(2/3)} = 2.17$ N mm

Specimen Name: PM to WGL – 1

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 6.20^{(2/3)} = 1.51$ N mm

Specimen Name: PM to WGL – 2

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 9.83^{(2/3)} = 2.06$ N mm

Specimen Name: PG – 1

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 17.38^{(2/3)} = 3.01$ N mm

Specimen Name: PG – 2

$f_r = 0.445 f_c^{2/3}$ (SI units)

$= 0.445 \text{ X } 17.63^{(2/3)} = 3.04$ N mm

## VI Life Expectancy of Pavement Slab

The flexural strength given in table can be utilized for the calculation of pavement life, or to allow reduction in pavement thickness for a given life of the pavement. From the earlier studies the following two criteria have been used to relate life expectancy of the pavement.

AASHO Formula.

$$N^{2.5} \alpha \, f^4 \, h^5 \qquad (1)$$

Alcon bury Hill formula

$$N \, \alpha \, f^{3.2} \, h^{6} \qquad (2)$$

Where, N is the serviceability index, f is the flexural strength and h, the thickness of the slab. In the above equation 1, N is the serviceability index, f the flexural strength and h, the thickness of the slab. The Serviceability index (N) is show in Table 5.0

Table 5 Showing the Serviceability index (N)

| Sl.No | ID of Specimen | Serviceability index, N |
|---|---|---|
| 1 | **BB-MGM 1** | 19346.701 |
| 2 | **BB -MGM 2** | 13870.814 |
| 3 | **PM-WGL 1** | 10565.944 |
| 4 | **PM-WGL2** | 15942.831 |
| 5 | **PG – 1** | 25940.265 |
| 6 | **PG – 2** | 27768.565 |

## VII CONCLUSIONS

The flexural strength of sample three (BB to MGM-2, PM to WGL-1 & 2) is less compared to other samples.

- The flexural strength of sample six (PG-2 Road) is high compared to other samples extracted. The life expectancy of pavement from BB to MGM is 30% greater compared to pavement leading from PM to WGL.The life expectancy of pavement from BB to MGM is only 53% compared to pavement opposite to PG.
- The life expectancy of the pavement leading from PM to WGL is only 76% compared to the pavement leading from BB to MGM. The life expectancy of the pavement opposite to PG is 87% higher compared to the pavement leading from BB to MGM**.** The life expectancy of the pavement opposite to PG is 140% higher compared to the pavement leading from PM to WGL.

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