

# The Impact of Physical Properties of Concrete on performances of concrete under different Loading Condition

<sup>1</sup>Himanish De\*, <sup>2</sup>Sumit Kumar Banerjee, <sup>3</sup>Sukhendu Bikash Banerjee

<sup>1,2,3</sup> Department of Civil Engineering, Abacus Institute of Engineering and Management, West Bengal, India

**Abstract:** To understand fully the concrete behaviour, it is critical to realize what impact cement's physical boundaries has on concrete's behaviors. Fluctuating physical characteristics of the concrete make this hard to comprehend material completely; be that as it may, to accomplish a superior comprehension of the concrete, it must acclimate himself with intricate relationship of these physical qualities have according to the behaviour of concrete. Accompanying segments will portray impact of piece of the concrete, explicitly water-concrete proportion & coarse aggregates, the relieving term & technique utilised, & the size impact of cement.

**Keywords:** material, aggregates, water-concrete proportion, characteristics, physical qualities

## 1. PHYSICAL CHARACTERISTICS

### 1. 1 Compositions

Concrete is heterogeneous material. Base components are cement, water, fine aggregates and coarse aggregates. Every one of the components has its personal arrangement of the properties. For those reasons for that examination, impact of the fine aggregates on the concrete behaviour won't be explored on the grounds that it is accepted to be the most troublesome boundary to dissect. Likewise, admixtures are utilised habitually in advanced concrete creation, yet for the motivations behind this examination they won't be investigated because of the extra complexities engaged with their investigation.

#### 1. 1. 1 Water-Cement Ratio

Best impact on the concrete's quality is water-cement proportion. An excess of concrete will cause lost flexibility; an excessive amount of water will be a reason for a misfortune in quality. It is significant in the concrete blend configuration to maintain water-cement proportion to concrete's behaviour. In the segment, trial of different researchers will be looked into to accomplish the superior comprehension of connection between water-cement proportion & concrete behaviour.

Kaplan (1963) [16] found that the water-concrete proportion affected the size of the concern at breaking & at extreme in flexure, direct compression, sectioning tests, & compression. He likewise found that water-cement proportion had nothing in impact on resist breaking & at extreme for any tests performed. Kupfer et al's (1969) [19] examination of biaxial quality found moderately no adjustment in quality concerning water content.

Hughes & Bahramian (1965) [13] additionally researched the impact of water content on 3D squares & crystals. An examination of the quality of concrete crystals by concrete water proportion has appeared in Fig 4.1. These outcomes show a legitimately corresponding connection between the water content & a definitive compression, for all intents & purposes free of the coarse aggregate utilised. The quality correlation for the 3D shape examples was considerably less straight demonstrating the nearness of size impact when friction at surface is available. Hughes & Bahramian (1965) [13], when looking at the concrete shape & crystal results, accepted that if the frictional restriction were disposed of, the relationship would be entirely straight.

In the exploration of themselves, Zhen hai and Xiu qin (1987) [43] discovered that 3D shape quality expanded as for concrete substance & age. They found that immediate elasticity was impacted tectonically by water-cement proportion, not size of those samples. The outcomes likewise reaffirm Kaplan's (1963) [16] perception that water content had no impact on strain.

#### 1. 1. 2 Coarse Aggregates

Concrete that has one type of the coarse aggregate carries on uniquely in contrast to concrete with the another sort. Amount of the coarse aggregates additionally performs an enormous factor which decide how concrete sample carries on. Nearness of the coarse aggregates is the place concrete gets its actual nature of heterogeneity, tectonically in light of the fact that the coarse aggregate carries on so uniquely in contrast to the mortar encompassing it.

Gramberg (1965) [12] has a few figs demonstrating cracked lithographic limestone. Limestone is frequently utilised as a total in Florida concrete. As indicated by the photos in Gramberg's report, the tried limestone encountered an extremely perfect pivotal break. The limestone split in two, here & there three, sections; additionally, the breaks were exceptionally perfect & straight.

Hughes & Bahramian (1965) [13] tried a progression of crystals & concrete shapes, differing the sort of totals utilised. The outcomes indicated that a kind of total can be relatively powerless in a 3D shape however nearly concrete in a crystal, or the other way around. This suggests that there was no correlation between the coarse aggregate type and the quality of the concrete.

Kaplan (1963) [16] tried two about indistinguishable cements: one utilised limestone as the coarse aggregate; the other utilised rock. The two cements had a similar water-concrete proportion. The limestone accomplished the more noteworthy quality, as appeared in Fig 4.2. As indicated by Kaplan (1963) [16], coarse aggregates in concrete make compression focuses & interior strain. Kaplan likewise found that right when the concrete begins to break, tractable strains are estimated under the flexure, sectioning, & direct pliable tests were reliant on volume of the coarse aggregate. It was likewise obvious at about 95% of the extreme for all of the tests with exception of sectioning test. Moreover, cross over strain of the examples tried in compression was seen as contrarily relative to total volume. Actually, Kaplan additionally found that the coarse aggregates decreased strain limit under the flexure. As indicated by test outcomes, sort of the coarse aggregate utilised didn't show the significant impact on a definitive strain esteem. Tests which demonstrated that extreme compression esteems were subject to the kind of total for the direct strain, compression, & flexure.

The volume of coarse aggregate can be considered the equivalent. Kaplan discovered that the quality, form, bond, and flexible qualities of the coarse aggregate affected internal stresses and anxiety.

Kordina (1960) [17] found that Poisson's Ratio is subject to the kind of total utilised.

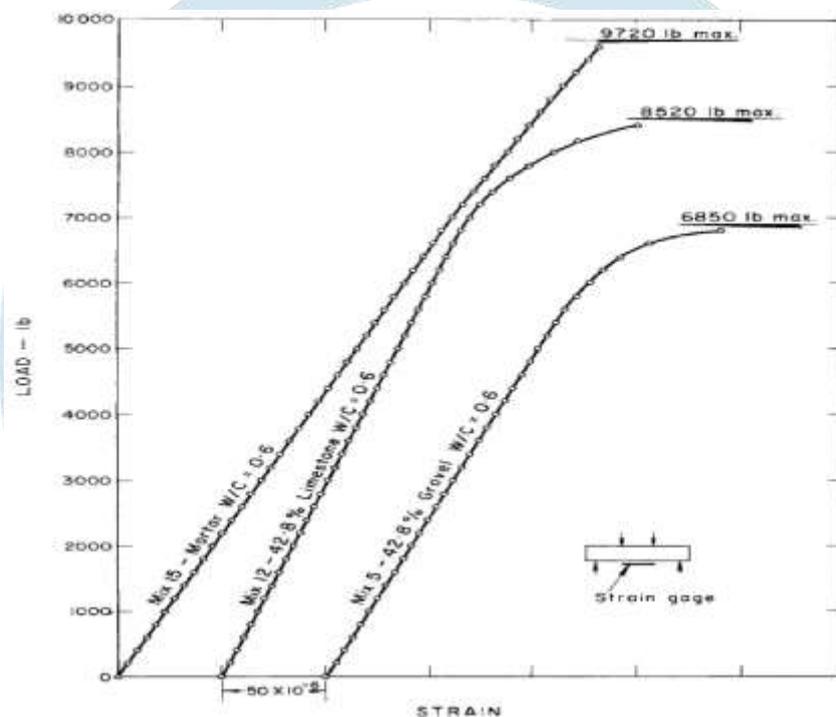


Fig 1.2: Load vs strain with varying coarse aggregate type (Kaplan 1963 [16]).

Iyengar et al (1965) [14] built up a biaxial quality envelope for both cement & mortar [Fig 4.3]. By comparing the two envelopes, one could conclude that the use of parallel compression improves the quality of the concrete since the coarse aggregate is closer.

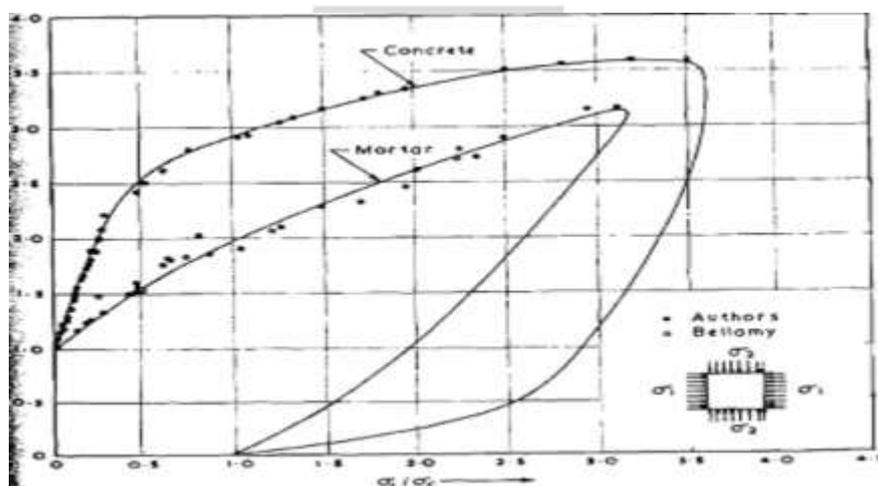


Fig 1.3 : Illustration of Biaxial strength envelopes of concrete & mortar (Iyengar et al 1965 [14]).

Tschegg et al (1994) [40] played out a progression of tests with characteristic rock & squashed rock. The test outcomes indicated that squashed rock is more grounded than regular rock, likely in light of the fact that concrete bonds better to squashed rock because of its unpredictable size & shape. Tschegg et al did a fascinating finding that when cement is under the biaxial compression test, distinction in quality between two kinds of the coarse aggregates is decreased so quality turns out to be about indistinguishable.

Carino & Record (1976) [5] plotted the tractable strain versus the mean ordinary worry at brokenness [Fig 4.4]. Irregularity is characterized as where the compression strain bend starts to stray from the linearity. Through understanding trial results, this was resolved that quality of concrete impacted capture of line of best fit, while coarse aggregate affected slant of line.

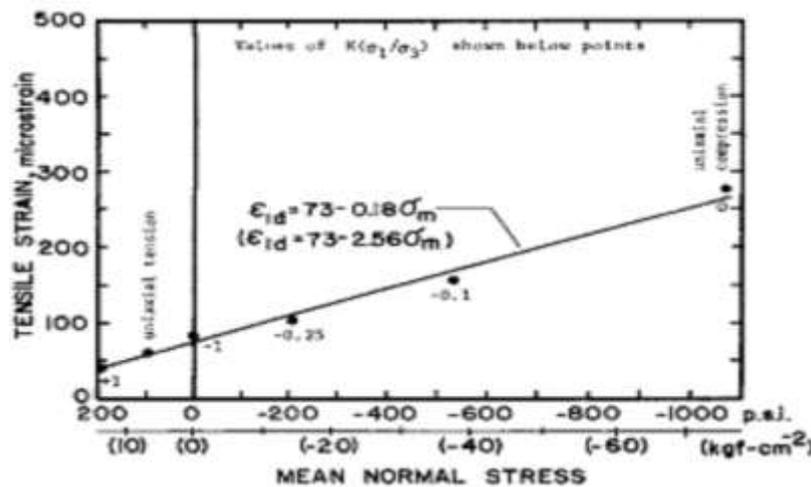


Fig 1.4: Graph of Tensile strain & mean normal stress at discontinuity (Carino & Slate 1976 [5]).

The bond that the coarse aggregate offer with the concrete glue is known as the interfacial progress zone, or the ITZ (Neville 1997 [30]). Buyukozturk et al (1971) [4] expressed that concrete leaves from flexibility when splits begin to create at the coarse aggregate mortar interface. It breaks exist before the loading ever happens because of the shrinkage impact. This bond causes the distinction in quality among cement & mortar. Stress focuses; strain fixations, & differential distortions are for most sections present at that interface. Not only that Buyukozturk et al guaranteed that at when total dividing diminishes, uniaxial quality additionally diminishes; notwithstanding, biaxial quality continues to exist moderately unaltered.

Neville (1997) [30] expressed that the modulus of versatility of cement is reliant on the volume of coarse aggregate & the modulus of flexibility of the total. Bond-compressions are brought about by distinction in modulus of versatility of the concrete and the coarse aggregate comparable modulus of flexibility make more grounded bonds. Little total size is ideal in high quality cement since it makes a lower bond compression. A more grounded bond quality is additionally accomplished by utilising lightweight total. Lightweight total has a harsh surface, making a "mechanical interlock" among total & mortar, in this way expanding the bond quality (Neville 1997 [30]). Lightweight total retains water all the more promptly. This water leaks out sometime in the future, rehydrating the dried-out cement at the ITZ, &, thus, expanding the bond quality. At the point when the modulus of flexibility approaches one another, concrete failure turns out to be more abrupt because of the way that concrete presently carries on more consistently. The estimations of modulus of flexibility for different totals, as gave by L'Hermite (1960) [20], are shown in Table 1.1. At the time of contrasting the modulus of flexibility of the mortar & normal limestone it has been seen why failure of the Florida concrete is such unexpected & hazardous.

Table 1.1 : Modulus of Elasticity of mortar & various coarse aggregates

| Types of the Material          | Modulus Of Elasticity In ( ksi ) | Modulus Of Elasticity in ( kg/cm <sup>2</sup> ) |
|--------------------------------|----------------------------------|---|
| The Mortar                     | 2845                             | 200000  |
| siliceous aggregate of river   | 2845                             | 630000  |
| Quartz                         | 11379                            | 800000  |
| Soft limestone                 | 782                              | 55000   |
| Average-limestone              | 3556                             | 250000  |
| Very hard-limestone [ marble ] | 9956                             | 700000  |

Ortiz (1985) [31] proposed a model for concrete dependent on two stages: mortar & coarse aggregate. Total experiences pliable worries at the right points with course of the loading conditions. Ortiz utilised hypothesis of the collaborating continuation to clarify why the stresses are appropriated inconsistent among the mortar & total. The Coarse aggregate's proclivity due to moving separated along the side is the thing that causes parallel malleable anxieties, which can lead to the axial cleavage break. As per Ortiz, total can experience monstrous plastic strain. These records for leftover worries in the total in the wake of emptying, which can make concrete fall flat. Inelastic behaviour of the concrete is because of distinction in the stress states among aggregates & mortar.

As per Zhen-hai and Xiu-qin ( 1987 ) [43], quality of cement shifts by the area due to the arbitrary appropriation of coarse aggregate, which additionally makes unconventionalities, which represent dispersed tractable test outcomes. Najjar & Drift (1989) guaranteed that the coarse aggregate profoundly affects the direction of longitudinal breaks. Zhen-hai and Xiu-qin's (1987) [43] shows that the outcomes are in understanding, as they observed that breaks seemed to follow ITZs.

## 1.2 CURING

Effect of curing in concrete behaviour will be examined in these area. Curing is the significant section of sample arrangement. Strategy & length of relieving profoundly affect concrete's quality. Damp curing, which is the favored technique, keeps mortar hydrated. Examples which have been sodden relieved are more grounded than these put away in the dry condition. More extended a sample fixes, more grounded this becomes, albeit following 28 days, pace of concrete gain decreases incredibly. Additionally, the sample which has been completely dried will be the lot more grounded than a damp sample.

It is essential to soggy fix concrete in such a case that it is permitted to dry before it has restored adequately, transient nonlinear strains will create all through the sample (Carreira & Chu 1986 [6]). Carreira and Chu expressed that elasticity of the dry sample is lower compared to a sodden sample. As per L'Hermite (1960) [20], curing is best during the beginning phases of concrete maturing, taking into consideration the underlying compaction of a sample, which will get merged after some time. As concrete ages, the modulus of versatility increments; additionally, L'Hermite (1960) [20] found that the modulus of flexibility is profoundly subject to the strategy for curing utilised. Tschegg et al (1994) [40] played out a progression of tests contrasting cement in dry stockpiling & cement in wet stockpiling. They inferred that in the compression concrete in the wet stockpiling were more vulnerable than concrete in dry stockpiling in any case, in strain, the dry cement was more fragile.

## 1.3 SIZE IMPACT

The size impact will be depicted & break down in these area. Size impact encountered by the concrete samples under the compression ordinarily alludes to distinction in quality among 3D shapes and cylinder, at which blocks show a more noteworthy quality. Numerous clarifications have been offered to portray this marvel. In actuality, the size impact might be to a greater degree a shape impact. Chamber quality ordinarily doesn't shift with size as long as the sample isn't excessively slim (del Viso et al 2008 [7]). Then again, shapes of shifting size display enormous contrasts in compressive strength.

Del Viso et al, ( 2008 ) [7] played out the broad examination on size impact of the concrete. It was found at a definitive burden that the strain of 3D square examples expanded as the size diminished. In looking at Fig 4.5, size impact additionally seems to influence young's modulus of the concrete samples. Del Viso et al, ( 2008 ) [7] expressed that the size impact is relatively reduced in bigger examples; in addition, size impact is disseminated as length increments.

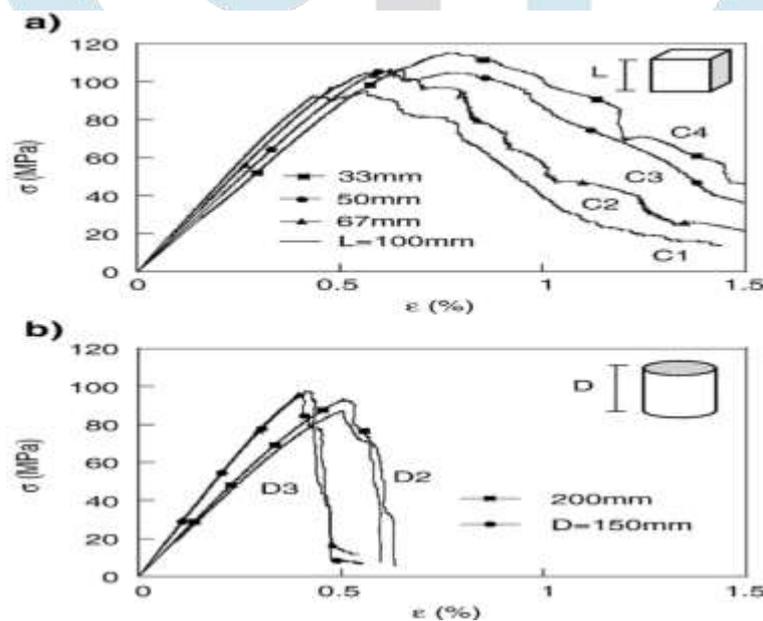


Fig 1.5 : Stress vs strain curves of (a) cubes & (b) cylinders of varying dimensions (del Viso et al 2008 [7]).

The compressive strength of cement ought to be free of length when a frictionless end condition is utilised (Hughes & Bahramian 1965 [13]). The concrete 3D shapes & crystals were tried in the compression under typical conditions and were discovered to possess a huge inconsistency in the quality. At the point when tried with decreased surface friction, the crystals & concrete shapes had fundamentally the same as qualities [Table 1.2]. Under typical compressive tests conditions, blocks are roughly 28 % more grounded compared to crystals. At the point when friction was decreased, 3D squares were just 5% more grounded than crystals.

Table 1.2 : Comparison of cube &amp; prism strength with varying end conditions (Hughes &amp; Bahramian 1965 [13]).

| Aggregate |                | Crushing strength in ( lb/in <sup>2</sup> ) |       |                       |       |
|-----------|----------------|---|-------|-----------------------|-------|
|           |                | Without using M.G.A pads                    |       | with using M.G.A pads |       |
| coarse    | fine           | cube  | prism | cube                  | Prism |
| Gravels   | Ham river sand | 8530  | 5960  | 5420                  | 5360  |
| Aloxite   |                | 14600                                       | 9930  | 9880                  | 9520  |
| Granite   |                | 6020  | 4900  | 5000                  | 4430  |

Hughes & Bahramian (1965) [13] expressed that if grinding at the surface were totally killed, 3D shapes & crystals would have a similar quality. This presumption can be utilised to survey the adequacy of a friction decrease medium (Kotsovos 1983 [18]). Fig 1.6, a case plot of cylinder & concrete shape qualities for a few enemies of friction media, shows that the size impact diminishes as indicated by the viability of the counter contact medium.

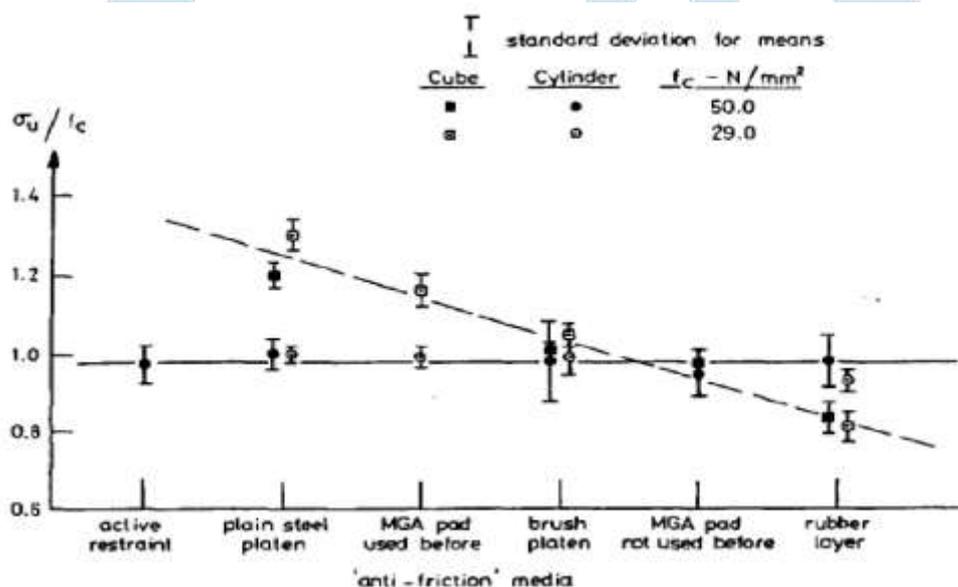


Fig 1.6: Effect of Size &amp; anti-friction media (Kotsovos 1983 [18]).

#### 1.4 CONCLUSION

Water to cement proportion, coarse aggregates substance, & curing procedure has all appeared to affect concrete somehow. Expanded concrete substances have appeared to build the quality of the sample. Concrete quality is majorly subject to volume of the aggregates compared to the kind of aggregates utilised, since the expansion in the coarse aggregate substance expands quantity of ITZ in the sample. By the by, the kind of the aggregates utilised additionally has an impact on the quality of the sample, however not on the resist failure. Relieving has appeared to influence the young's modulus, that subsequently, expands incline of compression strain bend.

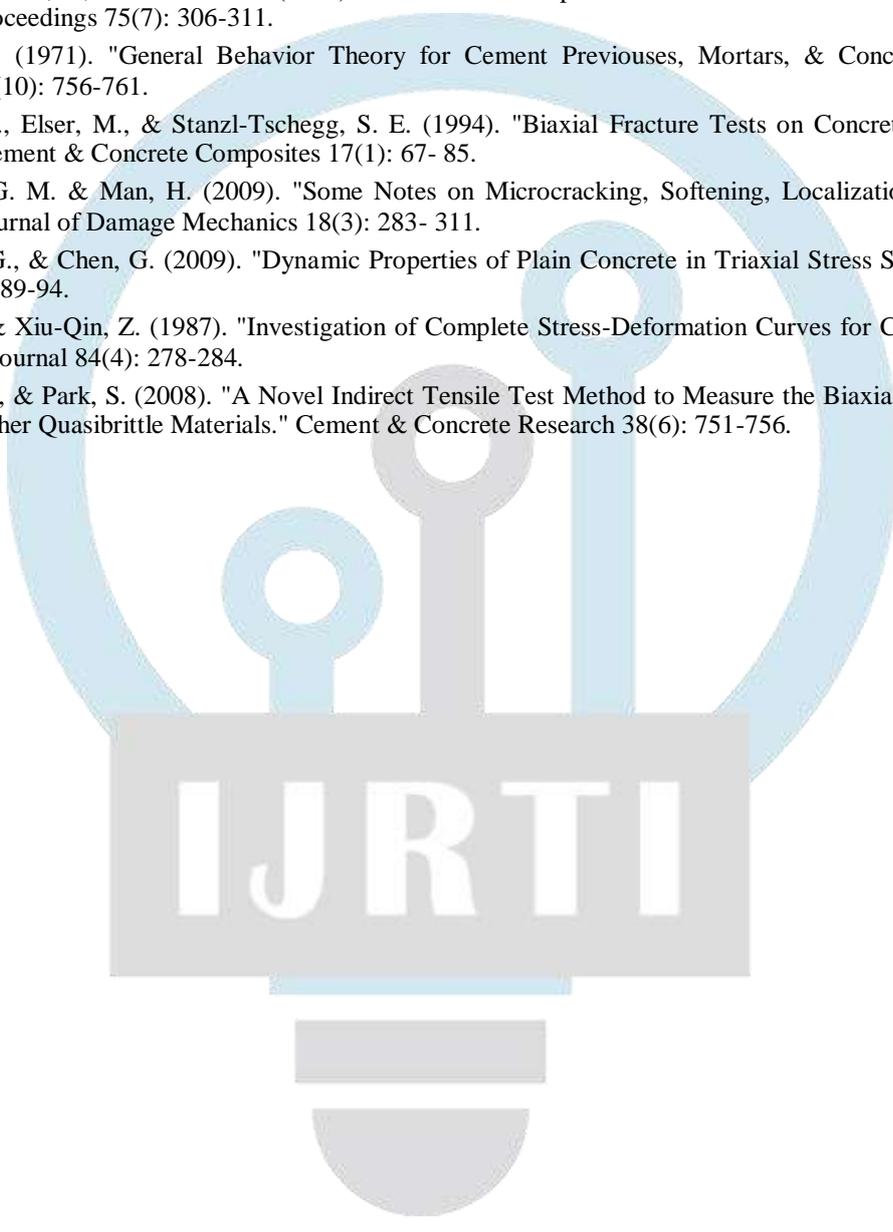
Consequences of different tests carried out offer motivation to accept that the size impact is aftereffect of the state of compression states brought about by the frictional limitation. The way that the size impact diminishes when size & length are expanded backings this end (del Viso et al 2008 [7]). The Long examples are very less influenced by the frictional limitations &, in this way, are more vulnerable than the shorter examples. In actual, lower extreme worry of the samples which is nearer to genuine compressive strength of the concrete, that would be accomplished by decreasing surface grating in the uni-axial compression tests.

Size impact is the wonder fundamentally, or perhaps completely, because of frictional restrictions. The way that the size impact diminishes when size & length are expanded demonstrates this (del Viso et al 2008 [7]). At the point when sample's length is expanded, focal point of sample is further away from surface plates, &, along these lines, encounters less control because of friction. The diminished repression, therefore, makes a lower extreme compression, giving the fantasy of a size impact. The less extreme worry of the more extended sample is in reality nearer to the quality of cement in unadulterated compression.

## REFERENCES

- [1] ASTM-International (2004). Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- [2] Atan, Y. & Slate, F. O. (1973). "Structural Lightweight Concrete Under Biaxial Compression." *ACI Journal Proceedings* 70(3): 182-185.
- [3] Bresler, B. & Pister, K. S. (1958). "Strength of Concrete Under Combined Stresses." *ACI Journal Proceedings* 55(9): 321-244.
- [4] Buyukozturk, O., Nilson, A. H., & Slate, F. O. (1971). "Stress-Strain Response & Fracture of a Concrete Model in Biaxial Loading." *ACI Journal Proceedings* 68(8): 590-598.
- [5] Carino, N. J. & F. O. Slate (1976). "Limiting Tensile Strain Criterion for Failure of Concrete." *ACI Journal Proceedings* 73(3): 160-165.
- [6] Carreira, D. J. & K. Chu (1986). "Stress-Strain Relationship for Reinforced Concrete in Tension." *ACI Journal Proceedings* 83(1): 21-27.
- [7] Del Viso, J. R., Carmona, J. R., & Ruiz, G. (2008). "Shape & Size Effects on the Compressive Strength of High-Strength Concrete." *Cement & Concrete Research* 38(8): 386-394.
- [8] Evans, R. H. (1946). "Extensibility & Modulus of Rupture of Concrete." *Structural Engineer* 24: 636.
- [9] Föppl, A. (1899). Reports from the Laboratory for Engineering Mechanics (Mitteilungen aus dem Mechanisch Technischen Laboratorium der Technischen Hochschule München). München, Technische Hochschule München. 27.
- [10] Gabet, T., Malécot, Y., Daudeville, L. (2008). "Triaxial Behaviour of Concrete Under High Stresses: Influence of the Loading Path on Compaction & Limit States." *Cement & Concrete Research* 38(3): 403-411.
- [11] Gerstle, K. H., Linse, D. L., & Bertacchi, P. (1978). "Strength of Concrete Under Multiaxial Stress States." *ACI Symposium Publications* 55: 103-131.
- [12] Gramberg, J. (1965). "Axial Cleavage Fracture: A Significant Process in Mining & Geology." *Engineering Geology* 1(1): 31-72.
- [13] Hughes, B. P. & Bahramian, B. (1965). "Cube Tests & the Uniaxial Compressive Strength of Concrete." *Magazine of Concrete Research* 17(53): 177-181.
- [14] Iyengar, K. T. S. R., Chandrashekhara, K., & Krishnaswamy, K. T. (1965). "Strength of Concrete Under Biaxial Compression." *ACI Journal Proceedings* 62(2): 239-249.
- [15] Kaplan, M. F. (1961). "Crack Propagation & the Fracture of Concrete." *ACI Journal Proceedings* 58(11): 591-608.
- [16] Kaplan, M. F. (1963). "Strains & Stresses of Concrete at Initiation of Cracking & Near Failure." *Journal of the American Concrete Institute* 60(7): 853-880.
- [17] Kordina, R. (1960). Experiments on the Influence of the Mineralogical Character of Aggregates on the Creep of Concrete. R.I.L.E.M. 6.
- [18] Kotsovos, M. D. (1983). "Effect of Testing Techniques on the Post-Ultimate Behavior of Concrete in Compression." *Materials & Structures* 16(1): 3-11.
- [19] Kupfer, H., Hilsdorf, H. K., Rusch, H. (1969). "Behavior of Concrete Under Biaxial Stresses." *ACI Journal Proceedings* 66(8): 656-665.
- [20] L'Hermite, R. G. (1960). Volume Changes of Concrete. Fourth International Symposium on the Chemistry of Cement, Washington, D.C.
- [21] Lee, S., Song, Y., & Han, S. (2004). "Biaxial Behavior of Plain Concrete of Nuclear Containment Building." *Nuclear Engineering & Design* 227(2): 143-152.
- [22] Lessard, M., Challal, O., & Aticin, P. (1993). "Testing High-Strength Concrete Compressive Strength." *ACI Materials Journal* 90(4): 303-307.
- [23] Li, Q. & Ansari, F. (2000). "High-Strength Concrete in Uniaxial Tension." *ACI Materials Journal* 97(1): 49-57.
- [24] Malvar, L. J. & Ross, C. A. (1998). "Review of Strain Rate Effects for Concrete in Tension." *ACI Materials Journal* 95(6): 735-738.
- [25] Mazzotti, C. & Savoia, M. (2002). "Nonlinear Creep, Poisson's Ratio, & Creep-Damage Interaction of Concrete in Compression." *ACI Materials Journal* 99(5): 450-456.
- [26] McHenry, D. & Karni, J. (1958). "Strength of Concrete under Combined Tensile & Compressive Stress." *ACI Journal Proceedings* 54(4): 829-838.
- [27] Mills, L. L. & Zimmerman, R. M. (1970). "Compressive Strength of Plain Concrete Under Multiaxial Loading Conditions." *ACI Journal Proceedings* 67(10): 802-806.
- [28] Murray, Y. D., Abu-Odeh, A., & Bligh, A. (2007). Evaluation of LS-DYNA Concrete Material Model 159. Washington D.C., U.S. Department of Transportation / Federal Highway Administration: 206.
- [29] Najjar, W. S. & Hover, K. C. (1989). "Neutron Radiography for Microcrack Studies of Concrete Cylinders Subjected to Concentric & Eccentric Compressive Loads." *ACI Materials Journal* 86(4): 354-358.
- [30] Neville, A. M. (1981). *Properties of Concrete*. Essex, England, Longman Publishing.
- [31] Neville, A. M. (1997). "Aggregate Bond & Modulus of Elasticity of Concrete." *ACI Materials Journal* 94(1): 71-73.
- [32] Ortiz, M. (1985). "A Constitutive Theory for the Inelastic Behavior of Concrete." *Mechanics of Materials* 4: 67-93.
- [33] Pistilli, M. F. & Willems, T. (1993). "Evaluation of Cylinder Size & Capping Method in Compression Strength Testing of Concrete." *Journal of Cement, Concrete & Aggregates (CCA)* 15(1): 59-69.

- [33] Raju, N. K. (1970). "Comparative Study of the Fatigue Behavior of concrete, Mortar, & Previouses in Uniaxial Compression." *ACI Journal Proceedings* 67(6): 461-463.
- [34] Richart, F. E., Brandtæg, A., & Brown, R. L. (1928). *A Study of the Failure of Concrete Under Combined Compressive Stresses*. University of Illinois (Urbana-Champaign Campus). Engineering Experiment Station. Bulletin no. 185. Urbana, University of Illinois at Urbana Champaign. University of Illinois bulletin: 104.
- [35] Rosenthal, I. & Glucklich, J. (1970). "Strength of Plain Concrete Under Biaxial Stress." *ACI Journal Proceedings* 67(11): 903-914.
- [36] Shah, S. P. & Chandra, S. (1970). "Fracture of Concrete Subjected to Cyclic & Sustained Loading." *ACI Journal Proceedings* 67(10): 816-824.
- [37] Susantha, K. A. S., Ge, H., & Usami, T. (2001). "Uniaxial Stress–Strain Relationship of Concrete Confined by Various Shaped Steel Tubes." *Engineering Structures* 23(10): 1331-1346.
- [38] Tasuji, M. E., Slate, F., & Nilson A. H. (1978). "Stress-Strain Response & Fracture of Concrete in Biaxial Loading." *ACI Journal Proceedings* 75(7): 306-311.
- [39] Taylor, M. A. (1971). "General Behavior Theory for Cement Previouses, Mortars, & Concretes." *ACI Journal Proceedings* 68(10): 756-761.
- [40] Tschegg, E. K., Elser, M., & Stanzl-Tschegg, S. E. (1994). "Biaxial Fracture Tests on Concrete - Development & Experience." *Cement & Concrete Composites* 17(1): 67- 85.
- [41] Van Mier, J. G. M. & Man, H. (2009). "Some Notes on Microcracking, Softening, Localization, & Size Effects." *International Journal of Damage Mechanics* 18(3): 283- 311.
- [42] Yan, D., Lin, G., & Chen, G. (2009). "Dynamic Properties of Plain Concrete in Triaxial Stress State." *ACI Materials Journal* 106(1): 89-94.
- [43] Zhen-Hai, G. & Xiu-Qin, Z. (1987). "Investigation of Complete Stress-Deformation Curves for Concrete in Tension." *ACI Materials Journal* 84(4): 278-284.
- [44] Zi, G., Ohb, H., & Park, S. (2008). "A Novel Indirect Tensile Test Method to Measure the Biaxial Tensile Strength of Concretes & Other Quasibrittle Materials." *Cement & Concrete Research* 38(6): 751-756.

The logo for IJRTI is a large, light blue watermark centered on the page. It features a stylized lightbulb shape with a circular top and a semi-circular base. Inside the circle, there are three vertical lines of varying heights, each ending in a small circle, resembling a stylized 'I' or a set of test equipment. Below the circle is a grey rectangular box containing the letters 'IJRTI' in a bold, white, sans-serif font. Below the box are two horizontal bars, one solid grey and one white with a grey outline, forming the base of the lightbulb.

IJRTI