ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

Experimental Assessment of in-Situ Compressive Strength of Concrete with Brick Chipsby CapoTest

M Nithin[1], Riyaz Syed[2]
M.Tech Student1, Assistant Professor2
Department of Civil Engineering, Vaagdevi College of Engineering
Warangal, Telangana-506005
nithinmadasu7777@gmail.com

Abstract

This research uses three different water-cement ratios, two different cement volumes, and two different aggregate types to find out how accurate the pullout test is for measuring the in-situ compressive strength of concrete. Cored and cast cylindrical specimens showed a correlation between pullout force and compressive strength, according to statistical analysis. Consistent with other studies conducted all across the world, the statistical analysis yielded the same conclusions. Significant and component-independent linearity was observed between compressive strength and pullout force. The findings also demonstrated that pullout testing accurately measured the compressive strength of concrete.

Mechanical characteristics of concrete mixes including coarse elements such crushed burned brick chips, stone, gravel, and recovered bricks are examined in this research. The concrete is tested for a variety of properties, including compressive strength, fracture toughness, core strength, modulus of elasticity, and splitting strength, among others. The American Concrete Institute suggests using stone aggregate concrete for this specific application. Our goal is to identify inconsistencies and establish causal relationships by studying the effects of various aggregates on the early-stage behavior of concrete. This investigation took compressive strengths between 20 and 45 MPa into account. Here we provide a brief overview of the evaluations made by the parametric studies.

INTRODUCTION

Compressive strength is currently known to be the most essential metric for concrete specifications and quality assurance. You can tell the concrete is of high grade by this. This is so because compressive strength is fundamental to a wide range of concrete properties. When determining the compressive strength of a concrete building, conventional methods may provide inaccurate findings. Pouring, compressing, transporting, and curing concrete is not the same as

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

working with standard laboratory cylinders or cubes. This is the primary rationale for these limitations. It should be remembered that sampling always involves some degree of mistake. On the other side, learning a structure's compressive strength might be dangerous, if not disastrous, due to the gravity of the danger. There has been a lot of focus on finding non-destructive ways to evaluate the usefulness and longevity of concrete in man-made settings. The number of methods for evaluating concrete that do not involve damaging the material has increased dramatically throughout the last few decades. Concerns about the compliance, cracking resistance, and longevity of concrete have been greatly allayed by these tests. Among other things, this test will determine how strong and uniform the in-situ concrete is. Consequently, progress is paramount. Being a Many procedures have been developed to assess the strength, durability, and quality control of concrete in an effort to discover practical and dependable ways to quantify its quality.

These methods assess certain concrete properties in an attempt to provide estimations of the material's elastic properties, strength, and durability. Numerous nondestructive testing methods have been devised based on the inherent features of concrete, such as its hardness, penetration resistance, and the propagation of ultrasonic pulses. One example is the pullout test. Others include the pulse velocity test, binding test, and penetration test. In order to ascertain the strength, characteristics, and homogeneity of already-poured concrete, nondestructive testing methods have become more popular in the last few decades. There is a long history of using concrete testing for quality control and investigating issues with durability, cracking, or standard compliance.

A significant benefit of nondestructive testing is the ability to gather a large amount of test data rapidly and inexpensively. Regardless of how simple the testing is, the results of nondestructive testing on concrete still need interpretation and comprehension by experts in the field. The topic matter is quite complex, which is why this is the case. The in-situ strength of the concrete inside the building has been a topic of research over the last 30 years. The effectiveness of the pullout approach has been verified by several concrete inspectors. The pullout test involves releasing the test bolts from their supporting structure and then measuring the torque needed to perform the test. We then determine the concrete's cylinder compression strength using a technique that has been validated experimentally. The Importance of the Current Issue

Construction companies like concrete as a composite material because of its many desirable qualities, such as its affordability, accessibility, strength, and durability. It may be bent or molded into any shape that architects can imagine because of its pliability. This clarifies the ever-increasing and seemingly endless need for concrete in building projects. When planning the design and calculation of structural components' load bearing capacities, the compressive strength of concrete takes precedence over all other mechanical and physical properties. The compressive strength of concrete may vary with time due to several factors. One such example is starting therapy earlier in life. The ambient or loading conditions also have a role in delaying the onset of internal fracture development till later ages. This is why it is crucial to test the compressive strength of the concrete while it is still in place for several uses. On the occasion of new building, making sure the concrete meets all standards is one of them. • results of contracts that don't match expectations due to problems with reference samples, Finding out how strong the concrete is is a crucial step in assessing the building's structural soundness when there is uncertainty about the concrete's quality or when the building's original purpose changes.

LITERATURE REVIEW

A comprehensive diagnostic is necessary to ensure the proper functioning and safety of a building during its anticipated lifespan. Several variables are tracked during the in-situ evaluation of reinforced concrete buildings. The concrete's homogeneity, steel reinforcement corrosion, crack depth and location, speed of concrete degradation (from things like the environment, chemicals, fire, fatigue, and overloading), surface carbonation depth and location, and mechanical and elastic properties (modulus of elasticity, flexural strength, and compressive strength) are all factors to consider. Based on the intended diagnosis, the specific components of this examination are defined. We are intrigued by the study's emphasis on the assessment of concrete's compressive strength in structural computation and its possible significance. The use of destructive and nondestructive technologies is used to accomplish the purpose. This section covers destructive core tests, ultrasonic pulse velocities, nondestructive rebound hammers, and their widespread practical use. To determine the compressive strength of concrete, it is important to measure its local, mean, variability, and characteristic strengths. Determining the characteristic strength with known mean and concrete variability values is beyond the scope of this investigation, even if it were feasible. Still, we'll limit ourselves to analyzing the top three

features. This chapter offers a comprehensive overview of the methods currently used to measure the in-situ strength of existing structures, including their limitations, standard criteria, and their application. Each section covers a different topic: cores alone in Section 1, nondestructive techniques in Section 2, cores using a single nondestructive technique in Section 3, and cores using a combination of nondestructive methods in Section 4. Various methods for determining in-situ strength are covered in all four sections.
Core sampling is a typical method for evaluating the condition of an existing concrete building or for checking if freshly built concrete satisfies the strength-based acceptance standards (ACI2142010). Core testing may be the most accurate way to find out how strong concrete is when compressed in situ (ACI 214, 2010).

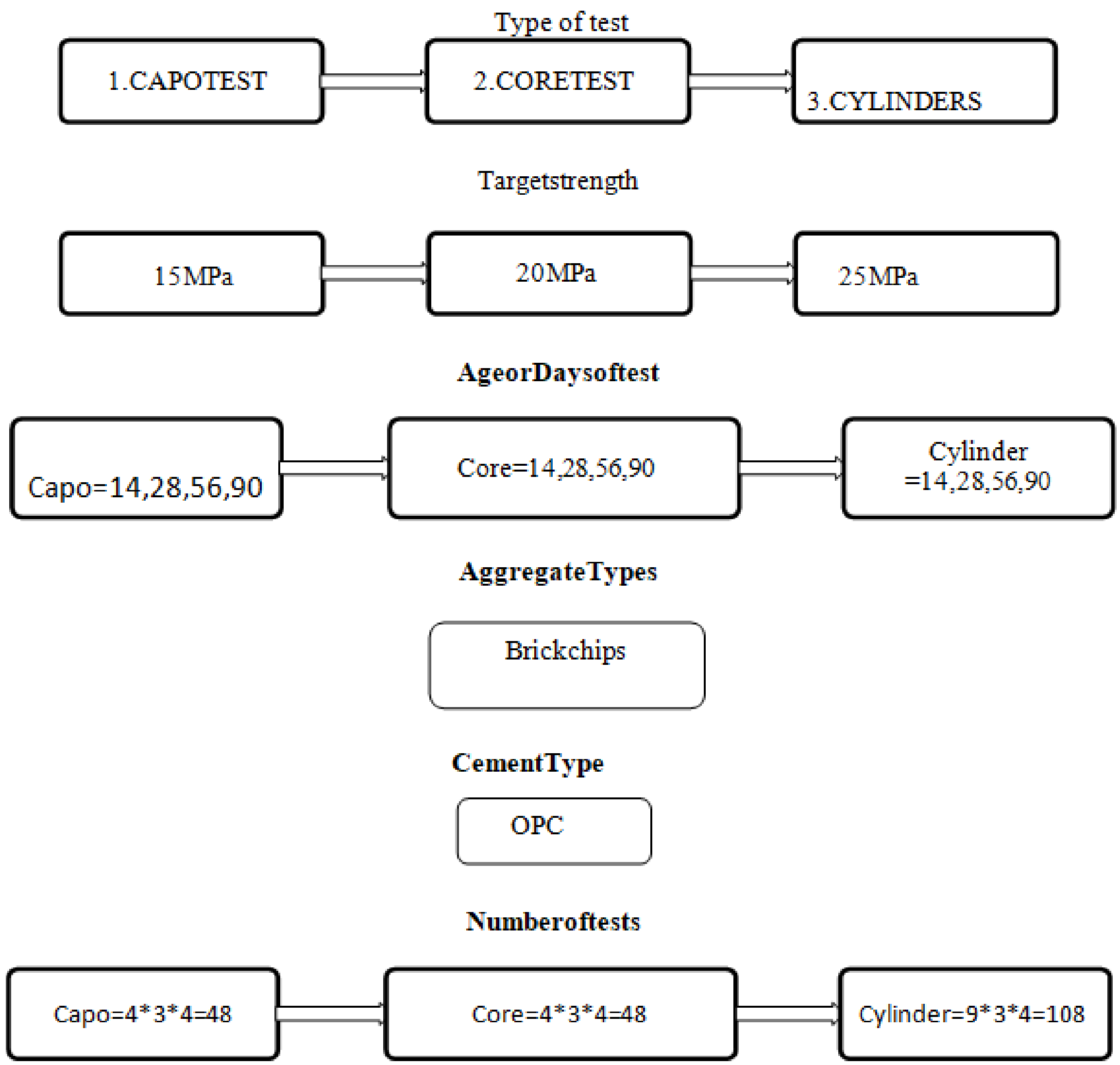
Compressive strength cannot be determined by a single, universal procedure because of the large number of factors that could influence the result. There is a core test that may be done to determine the strength in situ, even though the results of most codes could differ based on the parameters used. One well-known method for determining the extracted core's compressive strength is to divide the ultimate load by the core's cross-sectional area, which is determined from the average diameter. However, the true test will be in converting this discovery into cube or cylinder strength. The findings of core tests should be interpreted with care since there are many variables that affect core strength. Several factors must be taken into account, including the core's diameter, aspect ratio (l/d), moisture condition, drilling direction, aggregate kind and size, concrete strength level, and the presence of reinforcing steel bars.

EXPERIMENTALPROGRAMME

In this study, the CAPO test is used to determine the compressive strength of brick chip-mixed concrete. Numerous factors determine the nature of the test, including the age of the participant, the desired level of strength, and many more. At14,28,56, and 90 days of age, three different concrete compositions were tested, and the results are shown in Table 3.1.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

Table 3.1 Concrete mixes, type of specimens and test number



Gathering test materials is the first step in this chapter's concise explanation of the testing technique. Following that, there is preparation, standard aggregate tests, casting a concrete sample, and lastly, testing the concrete. Acquiring Materials

RESULTS AND ANALYSIS

Compaction strength, core strength, modulus of elasticity, Poisson's ratio, and a non-destructive test using an elastic rebound hammer are all detailed and presented in this chapter. We build correlations among measures and define certain patterns. Cylinder Strength in Concrete

ISSN 2454-9940
www.ijasem.org
INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
Vol 19, Issue 3, 2025

The compressive strength of every combination was determined by averaging the strengths of nine individual cylinders. For a SC concrete cylinder sample, the results of the compressive strength calculation are shown in Table 4.1. There are further results in Appendix A.2.

Table4.1Compressivestrengthofconcretecylinderusingstoneaggregateswith target strength of 35 MPa

Sl.No.	Average Diameter (mm)	Average Area (mm^2)	Length (mm)	Gauge Length (mm)	Max. Load (kN)	Calibrated Load (kN)	Crushing Strength (MPa)
1	102.0	8171	204	204	358	349.0	43.8
2	102.0	8171	204	204	388	378.1	47.5
3	100.0	7854	206	206	354	345.1	45.1
4	100.5	7933	204	204	359	350.0	45.3
5	101.3	8052	204	204	351	342.2	43.6
6	101.0	8012	206	206	340	331.5	42.4
7	101.5	8091	206	206	330	321.8	40.8
8	101.3	8052	206	206	355	346.1	44.1
9	101.0	8012	204	204	319	311.1	39.8

Table 4.2 reveals that when comparing RCB and CBC concrete, the compressive strength of the former is lower, while that of the latter is more than that of SC concrete. Mix design anticipates the strength conservatively for safety reasons. Considerations about the composition of concrete particles and the strength and quality of the cement also arise. Hence, an effort was made to establish a connection between the strengths of the targets and the crushing strengths that were noted.

the fourth, fifth, fourth, and fifth figures. Using the equation, we can get the expected concrete strength for a certain mix design ratio of ingredients.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

Table4.2Averagecompressivestrengthofcylindersat28days

Target Strength (MPa)	Crushing Strength, SC (MPa)	Crushing Strength, CBC (MPa)	Crushing Strength, RCB (MPa)	Crushing Strength, RCS (MPa)
15.0	19.9	19.2	18.2	22.3
20.0	29.2	26.8	28.3	30.5
30.0	37.7	37.2	34.7	35.4
35.0	43.6	47.2	40.1	43.6

The regression coefficients (R2) in all of the previous equations are more than 0.7 and usually fall within the 0.97-1.0 range, indicating a strong relationship between the crushing strength and the target strength. Figure 4.5 shows a wide plot of the specimens' compressive strengths vs their target strengths. A linear regression analysis was carried out in order to determine the compressive strength from the goal strength. According to the findings, stone aggregate concrete had the highest correlation coefficient. This is due to the fact that stone aggregate concrete often makes use of ACI mixes. The bar chart (Fig. 4.6) shows that stone aggregate concrete typically has higher strength than recycled brick concrete and brick aggregate concrete. However, recycled stone concrete fails at higher target strengths while exhibiting reasonable strength at lower ones. Compared to

The high compressive strength of recycled concrete aggregate is probably due to the presence of two types of interfacial transition zones (ITZ) in the matrix. While the ITZ often lacks the strength of the aggregate or wet cement paste, it serves to highlight their connection. Interstitial temperature zone (ITZ) occurs in concrete including recycled concrete, but it also occurs in concrete mixed with SC and CBC between the aggregate and mortar, as well as between the original aggregate and the old and new mortar. The combination of recycled mortar's surface age and its reduced density gives recycled concrete a weaker compressive strength compared to freshly mixed concrete.

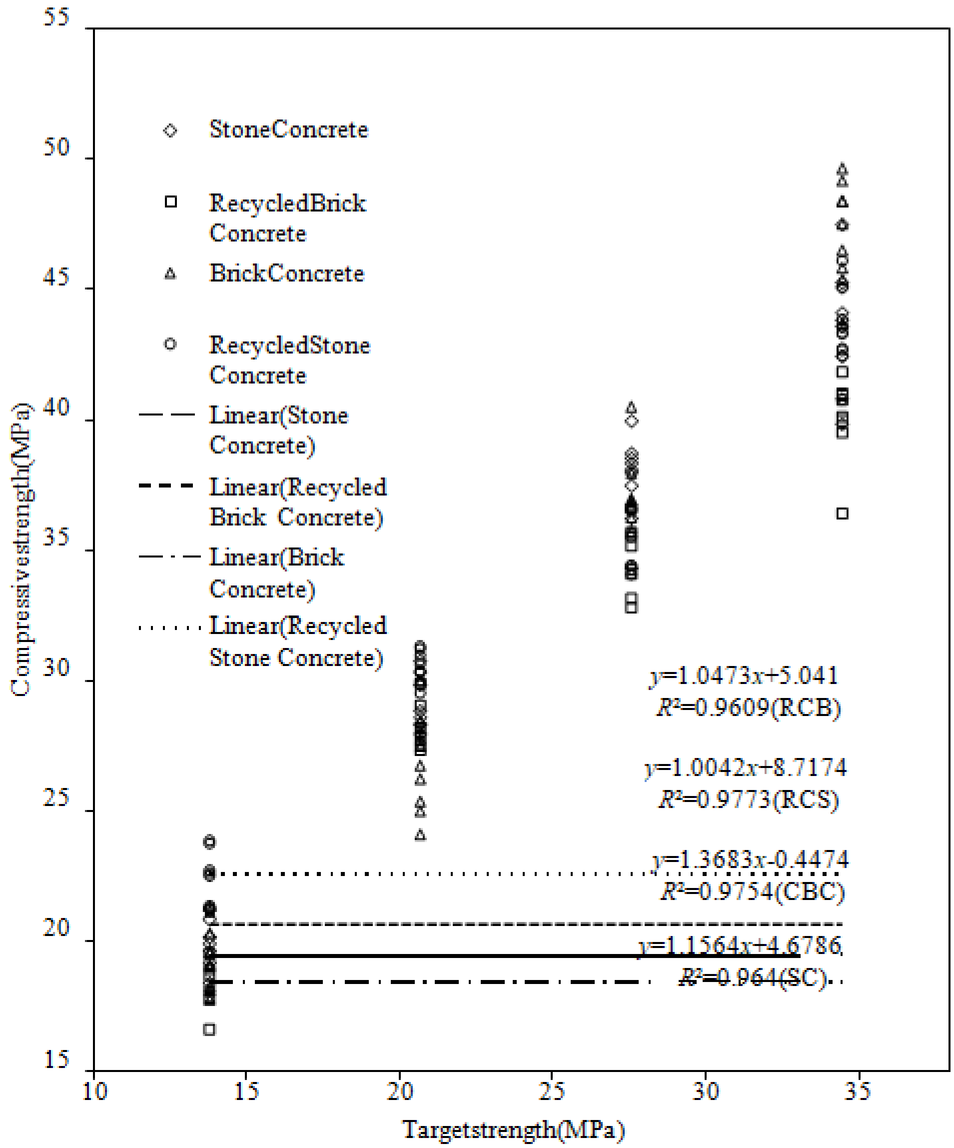


Figure4.5Regressionanalysiscorrelatingcompressivestrengthtotargetstrength

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

InfluenceofCoreDiameteronCoreStrength

Figure 4.9 shows bar charts illustrating the concrete core strengths throughout all three removed diameters, as a function of the average cylinder compressive strength for each mix percent. These numbers make it clear how the dimensions of the core impact the strength of the concrete core. Decreasing core sizes result in weaker concrete of any grade or aggregate mix. While there is a discernible trend for core capabilities obtained by other means, there are significant

There are many obvious problems with the tolerance factor approach. Tolerance factor analysis has shown that 50 mm cores may outperform 75 mm ones in some instances. As said, it does not lend credence to our hypothesis. An further consideration that could affect the relative behavior of small and big cores is the strength of the concrete. For a given core diameter, an increase in objective strength often results in a reduction in relative core strength. Again, there is some difference when this assertion is compared to the TFM approach.

Among the four different stone concrete mixes, the relative core strength (TFM) is highest for a 100 mm core compared to a 75 mm or 50 mm core. Although SC-2 and SC-3mix have 75 mm cores, the actual diameter is 50 mm, which is the core strength. With respect to SC-1, SC-3, and SC-4, the alternate method adheres to the anticipated pattern. You may be able to ignore the little variation in SC-2. Core strength decreases with time for all three SC concrete mix sizes (100 mm, 75 mm, and 50 mm), as shown in Figure 4.9. For 50 mm diameter cores, for example, the relative core strength decreases in the following order: 80-71-58-54 as the target strength rises. Relative core strengths of 70-90%, 50-90%, and 40-90% should be used for 100 mm, 75 mm, and 50 mm SC cores, respectively, within the prescribed compressive strength range, according to Table 4.5. For each of the four varieties of brick concrete, the relative core strength (TFM method) is best achieved with a 100 mm diameter core rather than a 75 mm or 50 mm diameter. Cores with a 75 mm diameter are weaker than those with a 50 mm diameter for

Combination of CBC and -2. With 100 mm core strength being higher than 75 mm and 50 mm core strengths, the other method preserves the proposed trend for all four mixes. All cores except the 50 mm CBC-1 have a declining relative strength with increasing target strength. For example, from 103 to 94 to 77 to 59, the relative strength decreases for 75 mm diameter cores.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

Fromtheplot(Fig.4.10),itcanbeobservedboththemethodsoverestimatecore strength for CBC-1 and CBC-2 mix, giving relative core strength greater than 100%.

Table4.6Relativecorestrengthvariationfordifferentdiametercoresofbrickconcrete

Diameter (mm)	RelativeCoreStrength (%)	Range (%)	RelativeCoreStrength (%)	Range (%)
100	62-110	48	68-116	48
75	49-90	33	59-103	44
50	47-87	40	55-94	39

According to Table 4.6, there is a more significant variation in the core strength of CBC concrete as the targetstrength increases compared to SC concrete. Recycled brick concrete cores with a 100 mm diameter had a greater relative core strength (TFM technique) than 75 and 50 mm cores in all four kinds of mixtures. Nevertheless, the core strength of the combined RCB-1, RCB-2, and RCB-4 is less than 50 mm in diameter. Based on the proposed pattern, the other method takes RCB-2, RCB-3, and RCB-4 mixes with core strengths of 100 mm, 75 mm, and 50 mm, respectively. Relative core strength decreases in TFM and AM as target strength rises. Think about a core with a diameter of 100 mm; its AM is 121-100-91-70 on the relative strength scale. The RCB-1 mix's relative core strength is above 100%, as shown in Figure 4.11, which is an indication of an overestimation of the actual core strength.

Table 4.7 shows that RCB concrete has a much broader range of variation in core strength as a function of increasing target strength compared to SC concrete.

Table4.7RelativecorestrengthvariationfordifferentdiametercoresofRCBconcrete

Diameter (mm)	RelativeCoreStrength Variation,TFM(%)	Range (%)	RelativeCoreStrength Variation,AM(%)	Range (%)
101.6	62-115	50	70-121	51
76.2	54-98	44	64-107	43
50.8	51-99	48	62-110	48

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

Using the TFM and AM methods, we found that 100 mm diameter cores constructed of recycled stone concrete had a higher relative core strength than 75 and 50 mm diameter cores for all four combination types. Just as 50 mm has a stronger core, 75 mm does as well. With the exception of 100 mm cores, the relative strength of the core consistently decreases as the goal strength increases. Figure 4.12 shows that there is no discernible pattern in the 75 mm and 50 mm cores. Table 4.8 shows that 100 mm, 75 mm, and 50 mm cores have relative strengths ranging from 80 to 100%, 65 to 80%, and 75 to 50%, respectively, which may be used to determine the compressive strength of cylinders. Core strength decreases with decreasing diameter. One possible explanation is that the cut surface area to volume ratio is higher, making strength loss from cutting damage more likely. The impact is magnified at greater maximum aggregate sizes due to the fact that aggregate particles increase in ratio to specimen size when core diameter decreases (Ariozetal., 2007a). Furthermore, the internal failure characteristics of the specimen might be impacted by the decrease in material homogeneity that occurs with a smaller specimen diameter (Bungey, 1979). This research found that smaller cores had more variance in their strengths, which made them untrustworthy. We calculated the mean, maximum, standard deviation, and 95% CI for every set of concrete core findings. You may get the values of the standard deviation in Table 4.9.

Table4.8Relativecorestrengthvariationfor differentdiametercoresofRCSconcrete

Diameter (mm)	RelativeCoreStrength Variation,TFM(%)	Range (%)	RelativeCoreStrength Variation,AM(%)	Range (%)
100	81-103	22	86-102	16
75	65-77	12	78-81	3
50	52-65	13	76-66	10

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

Table4.9Standarddeviationofcorestrengthsofallmixes

ConcreteMix	DiameterofCores		
	50mm	75mm	100mm
CBC-1	6.28	2.78	1.99
CBC-2	3.64	3.57	3.24
CBC-3	4.58	4.88	2.92
CBC-4	5.04	4.61	3.55
SC-1	1.93	1.78	1.76
SC-2	2.13	3.31	2.08
SC-3	3.44	3.78	1.34
SC-4	5.41	5.01	3.26
RCB-1	3.34	2.42	1.87
RCB-2	3.80	4.02	2.10
RCB-3	4.76	4.36	2.49
RCB-4	4.07	3.94	3.50
RCS-1	4.25	3.27	1.37
RCS-2	3.59	2.25	1.22
RCS-3	3.70	3.65	2.10
RCS-4	6.61	3.67	3.53

According to Table4.9, the standard deviation of the core strength data drops as the core diameter goes up. Hence, the aggregate strength distribution across the individual strengths of 50 mm cores will be more widely distributed once eight cores with 100 mm and 50 mm diameters are eliminated. Because of this,

skews the results of a compressive strength test when smaller-diameter cores are used. The relationship between each participant's core strength and their total cylinder strength is seen in Figure 4.13. According to the figures, for a certain cylinder strength, the 95% confidence range is wider for 50 mm cores than for 75 mm cores. In terms of 100 mm cores, there is almost no variance. High levels of in-place concrete strength variation within the cored part might explain the considerable amount of variance found in tiny diameter core specimens (Bartlett & MacGregor, 1994). Our findings corroborate the widespread belief among academics that smaller cores exhibit more strength variance compared to larger ones, even when the strengths are very near (Erdogan, 2003). Compressive strength is directly proportional to the width of the 95% confidence band for a particular diameter core, as shown in the figures. For instance, with RCB 100 mm cores, the standard deviation jumps from 1.87 to 3.50 and the confidence bandwidth grows from 2.6 to 4.8 MPa.

CONCLUSION

This study aims to examine the mechanical properties of concrete that contains recycled brick, stone, or chipped bricks. A summary of the evaluations grounded on the parametric study is provided below. Modulus of elasticity and Poisson's ratio in concrete

An overview of the elastic moduli values for different concrete composition designs was the primary objective of this study area. The Poisson's ratio of expanded concrete was also computed.

a) In all four types of aggregate concrete—stone, brick, recycled brick, and recycled stone—the relationship between compressivestrength and the square root of the modulus of elasticity seems to be linear.

(b) The bulk of the current codes tend to employ formulae that exaggerate the modulus of elasticity of concrete, as compared to data from actual tests according to ASTM C469. The Euro code is the most inaccurate, suggesting that MAE readings could range from over 2,000 MPa to over 20,000 MPa. On the other hand, the Type I and Type II correlations suggested in this study (i.e., MAE less than 2000 MPa) significantly improve the accuracy of experimental result prediction.

(c) Whereas the ACI and AIJ technique yields a correct modulus of elasticity for stone aggregate concrete (MAE range from 2292 MPa to 2487 MPa), it produces an exaggerated result when used to brick and recycled aggregate concrete.

(d) The modulus of elasticity of brick concrete may be approximated using the ACI guidelines and the unit weight of concrete; the yielded values are closer to those of stone concrete. Compared to parent concrete, RCS and RCB concrete have a lower modulus of elasticity.

(e) The Poisson's ratio of the concrete was determined, however the results were more inconsistent than anticipated. Based on the data presented here, the average Poisson's ratio for concrete types SC, CBC, RCBC, and RCS are 0.199, 0.185, 0.189, and 0.159, respectively.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 3, 2025

REFERENCES

Abdelfatah,A.S.,&Tabsh,S.W.(2011).ReviewofResearchonandImplementation of Recycled Concrete Aggregate in the GCC.*Advances in CivilEngineering*, *2011*.

AIJ,A.(1985).StandardforStructuralCalculationofReinforcedConcreteStructures. *Chapter2,ArchitecturalInstituteofJapan*,pp.8-11.

Aitcin,P.C.,Miao,B.,Cook,W.D.,&Mitchell,D.(1994).Effectsofsize andcuring on cylinder compressive strength of normal and high-strength concrete. *MaterialsJournal*, *91*(4), 349-355.

Akashi,T.&Amasaki,S.(1984).StudyoftheStressWavesinthePlungerofa Rebound Hammer at the Timeof Impact.*ACI Special Publication*, Volume 82, pp. 17-34

Akcay,B.(2004).Variationofin-placeconcretecorestrengthinstructuresfrom Istanbul area: Statistical analysis of concrete core data. *Journal of materials in civil engineering*, *16*(5), 507-510.

Akhtaruzzaman,A.A.andHasnat,A.(1983).Propertiesofconcreteusingcrushed brick as aggregate. *Concrete International*, 5(2), 58-63.

Al-Gahtani,A.S.(2010).Effectofcuringmethodsonthepropertiesofplainand blended cement concretes. *Construction and Building Materials*, 24(3), 308-314.

Aliabdo, A. A. E., & Elmoaty, A. E. M. A. (2012). Reliability of using nondestructivetests to estimate compressive strength of building stones and bricks. *Alexandria Engineering Journal*, *51*(3), 193-203.

Al-Mufti,R.L.,&Fried,A.N.(2012).Theearlyagenon-destructivetestingof concrete made with recycled concrete aggregate. *Construction and Building Materials*,37, 379-386.

American Concrete Institute. Committee 211. (1991). Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete: (ACI 211.1-91). American Concrete Institute.

American Concrete Institute. Committee 214. (2010). Obtaining Cores and Interpreting Compressive Strength Results: (ACI 214.4R-10). *ACI*, Farmington Hills, MI: American Concrete Institute.

American Concrete Institute. Committee 228. (2003). In-Place Methods to Estimate Concrete Strength: (ACI 228.1 R-3). American Concrete Institute
American Concrete Institute. Committee 318. (2011). Building Code Requirements for Structural Concrete and Commentary: (ACI 318). *ACI*, Farmington Hills, MI: American Concrete Institute.