Study On Self – Compacting Concrete Incorporating Cement Kiln Dust

C NAVEEN[1], PROF. S. MAKESH KUMAR[2]

[1] *PG student Department of Civil Engineering, GCT Coimbatore.*

[2] *Assistant Professor Department of Civil Engineering, GCT Coimbatore.*

Abstract— ***Concrete has become widely used in various construction projects, ranging from small-scale residential buildings to high-power nuclear plants. Despite its versatility, conventional concrete has limitations, prompting the emergence of innovative types like Self Compacting Concrete (SCC), which exhibits fluid behavior and eliminates the need for external vibration during compaction. However, the widespread use of concrete as a building material contributes significantly to carbon dioxide emissions, posing a threat to atmospheric balance. In response, research endeavors to address this issue by developing a self-compacting concrete mix that offers both workability and durability. This is achieved by strategically substituting conventional cement with industrial waste materials such as cement kiln dust and fly ash. The study replaces a constant 30% of cement with fly ash and explores different percentages (5%, 10%, and 15%) of cement kiln dust replacement. After testing, it was found that a 10% replacement of cement kiln dust yielded the optimum performance in terms of compressive strength. Specimens were subjected to tests for compressive strength, split tensile strength, and flexure at 7 and 28 days, respectively. Comparison with conventional concrete revealed that the specimen containing 10% cement kiln dust replacement achieved the highest strength. Thus, the partial replacement of fly ash and cement kiln dust for cement proves to be a promising and sustainable alternative. This research contributes to reducing the carbon footprint associated with cement production, thereby fostering environmental sustainability.***

Index Terms- Self-Compacting Concrete, Fly Ash, Cement Kiln Dust.

I. INTRODUCTION

A. Self-compacting concrete (SCC) is an innovative solution that revolutionizes traditional concrete placement and compaction methods. Over the years, durability concerns have plagued concrete structures, often attributed to inadequate compaction. Conventional concrete relies on vibration for compaction, but this method can lead to issues such as segregation and difficulty ensuring uniform material quality, especially in heavily reinforced areas. Insufficient concrete cover around steel reinforcement further exacerbates durability problems.

B. SCC addresses these challenges by effectively filling every nook and cranny of formwork and surrounding steel solely through its own weight, without the need for external compaction. This engineered material comprises cement, aggregates, water, and admixtures, with additional components like colloidal silica, pozzolanic materials, pulverized fly ash (PFA), Ground Granulated Blast Furnace Slag (GGBS), micro silica, and metakaolin. These constituents are carefully selected to meet specific performance requirements, including high-flowability, compressive strength, workability, resistance to chemical or mechanical stresses, reduced permeability, and enhanced durability.SCC's unique properties, such as fluidity and high resistance to segregation, enable effortless concrete placement without the need for vibration, resulting in reduced labor, noise, and equipment wear and tear.

C. MATERIAL CONSTITUENTS

1) The material constituents utilized in proportioning the SCC comprise the subsequent items. In this project work, OPC 53 grade cement is used for experimental study. The maximum size of coarse aggregate is generally limited to 12.5mm. Manufactured sands, rich in rock dust fines, deviate from natural sands with their high fines content. ASTM C 33 permits 7% fines passing 75 µm for M sand, while Indian standards propose 20% passing 150 µm. Fly ash, also recognized as pulverized fuel ash, is a light grey powdery

substance with a glassy appearance, resembling cement.

2. Derived from the combustion of pulverized coal or lignite, it's rich in these constituents and classified as class F. Cement kiln dust is a fine-grained material extracted from the cement manufacturing process. It's typically separated from cement kiln exhaust gases using air pollution control devices This dust is typically formed during cement production operations when the kiln temperature reaches approximately 1000°C.The investigation utilizes Master Glenium SKY 8233, a next-generation superplasticizer based on modified carboxylic ether. Developed primarily for high-performance concrete applications, it boasts exceptional durability and performance.

Table 1.1 Test Results of materials

NAME OF THE TEST	Table Column Head		
	Cement	*Fly ash*	*CKD*
Specific Gravity	3.15	2.53	2.7
Fineness	7%	10%	4%
Consistency	32%	31%	-
Initial setting time	32min	60min	-

Table 1.2 Test Results for materials

NAME OF THE TEST	*Fine Aggregate*	*Coarse Aggregate*
Specific Gravity	2.53	2.83
Water absorption	1.9%	0.25%
Fineness Modulus	2.66	6.55
Sieve analysis	Zone II	

D. MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible. Various methods are available from different codes and literatures. The most popular method was the Okamura method. This method was used to design our mix. Mix design often uses volume as a key parameter because of the need to overfill the voids between the aggregate particles.

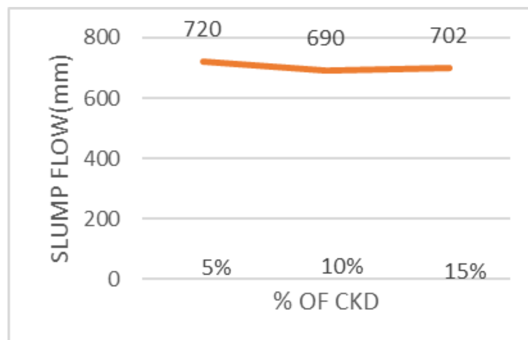
E. EXPERIMENTAL INVESTIGATION

Self-compacting concrete which is made up of cement, fine aggregate, coarse aggregate, water, fly ash and super plasticizer. In this project cement kiln dust of 5%,10%,15% replacements of cement.

F. FRESH CONCRETE PROPERTIES

The performance of self-compacting concrete with cement kiln dust in fresh state is compared and the following important points given in table 1.3 are taken for discussion. The slump flow variation and T50 cm slump flow value for various mixes of SCC with cement kiln dust are presented in Figure 1.1 and 1.2

II. FIGURE 1.1 VARIATION OF SLUMP FLOW VALUE



In this study, all the mixtures exhibited good workability with flow value at least 660mm. Slump flow of 650 mm to 800 mm are typically required for SCC and all the mixtures under investigation fall into this category. For 10% ckd replacement the slump flow is more compare to other proportion

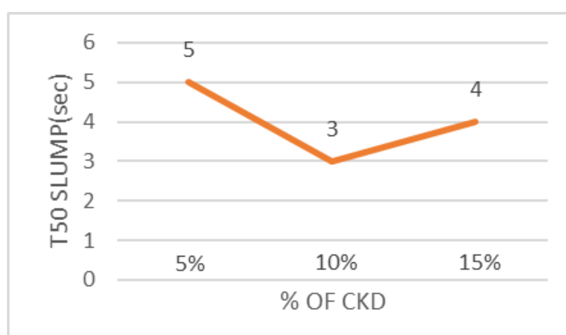


Figure 1.2 Variation of T50 cm slump flow value

In this study, all the mixtures exhibited good filling ability. The T50 time is a secondary indication of flow.

The T50 time was in the range of 5 sec in all mixes. Hence the values are fall under guidelines.

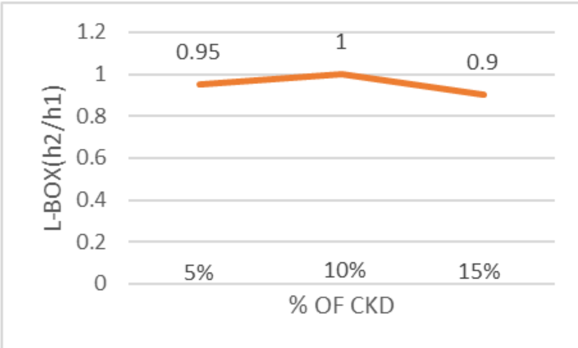


Figure 1.3 Variation of L box test result

The L box ratio characterizes the filling and passing ability of SCC. There is generally a blocking risk of the mixture when the L-box blocking ratio is below 0.8. The blocking ratio (h2/h1) should be between 0.8 to 1.0. From Figure 1.3 all the mixtures of SCC are within the target values. When cement kiln dust percentage has increased it has not negatively affected the blocking ratio.

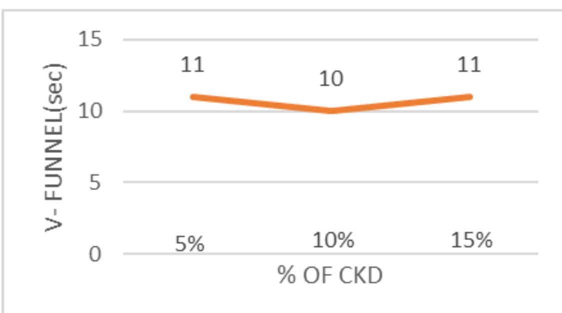


Figure 1.4 Variation of V funnel test result

The flow time of V funnel. Figure 1.4 show filling ability of concrete increased with increasing ckd content upto 15% of fine aggregate re. All the flow time of V funnel test is under the maximum limiting value 10.

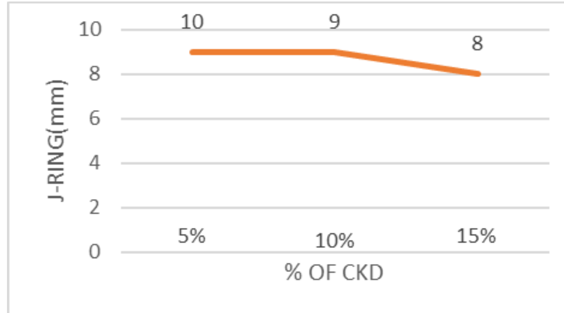


Figure 1.5 Variation of J ring test result

The J ring characterizes passing ability of SCC. From Figure 1.5 all the mixtures of SCC are within the maximum values of 10mm.

A. HARDENED CONCRETE PROPERTIES

Performance of self-compacting concrete in hardened state is compared and the following important points given.

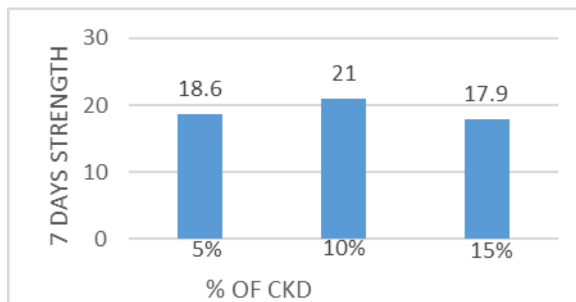


Figure 2.1 7 Days Compressive Strength test result

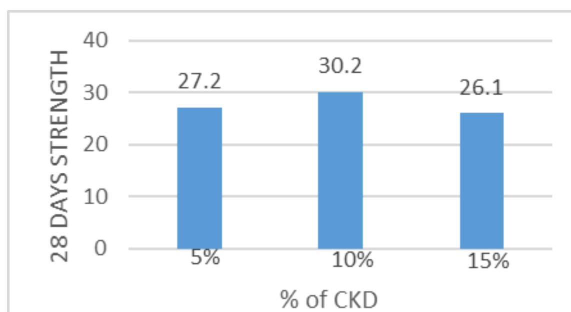


Figure 2.1 28 Days Compressive Strength test result

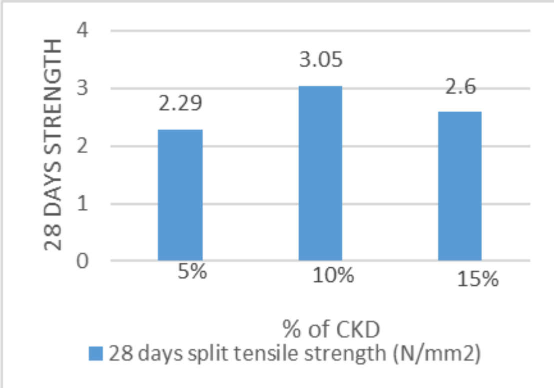


Figure 2.2 28 Days Split tensile strength test result

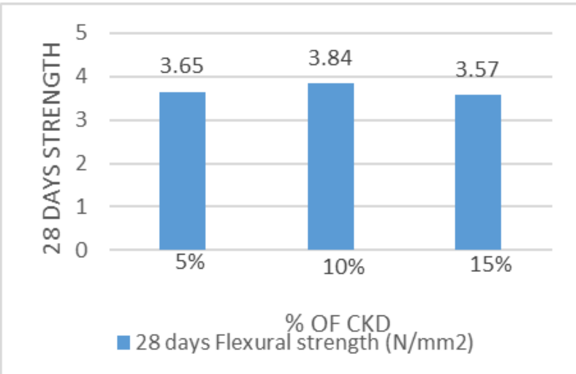


Figure 2.3 28 Days flexural strength test result

Figure 2.1 shows the variation of 7 days and 28 days compressive strength. It is observed that there is slight increase in compressive strength for replacement of cement kiln by 10% cement kiln dust and decreases in compressive strength for further increases in cement kiln dust of 10-15% with the increment of 5%. So the 10% replaced cement kiln dust is obtained as the optimum percentage for further granite powder replacement in M-sand. Similar results for the following split tensile and flexural strength test.

CONCLUSION

In this project, the mix design was arrived at using the Japanese method of mix design. The following conclusions were obtained from this experimental study with the replacement of cement-by-cement kiln dust and fine aggregate by granite powder

- M-Sand can be effectively used as fine aggregate to produce self-compacting concrete.
- The flow ability of self-compacting concrete keeps increasing with the addition of cement kiln dust.
- Passing ability and other fresh properties are good for addition of 10% of cement kiln dust and they are within the limits of EFNARC guidelines.
- Cement is replaced by 5%,10%,15% cement kiln dust the strength is increasing up to 10% replacement after adding 5% more to that the strength is decreasing

REFERENCES

[1] Hajime Okamura, Masahiro Ouchi (2003), "Self-Compacting Concrete", Advanced Concrete Technology.

[2] Brouwers, radix, "Self-Compacting Concrete: Theoretical and experimental study", cement and concrete research, vol 35, November 2005

[3] Caijun Shi," A review on mixture design methods for self-compacting concrete," Construction and building materials, vol 20, December 2015

[4] N. Bouzoubaa and M. Lachemi (2000)," Self-compacting concrete incorporating high volumes of class F fly ash Preliminary results", cement and concrete research, vol 22 may 2000

[5] Burak Felokog Lu (2006), "Effect of water/cement ratio on the fresh and hardened properties of self-compacting concrete" Building and Environment 42 (2007) 1795–1802

[6] Kalirajan Sivagnana (2014), "Development of Self Compacting Concrete Using Manufactured Sand" article published in International Journal of Earth Science and Engineering

[7] Praveen kumar and Radhakrishnan (2016) "Characteristics of SCC with fly ash and M sand" cited in IOP Conference Ser: Material.Sci.Eng.149.

[8] M.Maslehuddin, O.S.B. Al-Amoudi, M.K. Ali, M.S. Barry, "Properties of cement kiln dust concrete", Construction and Building Materials Volume 23, Issue 6, June 2009, Pages 2357-2361

[9] H Shriram, Mahure, Mayur B. Vanjare "Experimental Investigation on Self Compacting Concrete Using Cement Kiln Dust", IJERT, Volume2, Issue 1, January 2013, pp1-6

[10] Mostafa Abd El-Mohsen Abd El-Hameed, Ahmed M. Anwar, Ihab Adam, "Mechanical properties of Self-Consolidating Concrete

incorporating Cement Kiln Dust",vol 20,March 2014

[11] Ahmed S. Kadhim, Alaa A. Atiyah, Shakir A. Salih (2014) "Properties of self-compacting mortar containing nano cement kiln dust ", Materials Today: Proceedings, Volume 3, Issue 5, Sept 2020, pp1-9.

[12] Musab A. Abdulhamed , Zaid Al-Azzawet al (2022), Strength of Self-Compacting Concrete Produced With Cement Kiln Dust Exposed to Elevated Temperature ", IEC 2022, Volume 3, Issue 5, Feb 2022, pp1-9

[13] Suma paralada, "Experimental studies on composite bricks using black cotton soil, fly ash and granite waste," Volume 39, Part 1, 2021, Pages 868-874 september 2013

[14] Elyas Asadi Shamsabadi, Mansour Ghalehnovi (2018)," Performance of Concrete with waste granite powder: the effect of superplasticizers", alpplied Science, vol 5, sept 2018.

[15] Adrian Chajec (2023), "The use of granite powder waste in cementitious composition ", Jurnal of Material research and Technology, Vol.25, pp. 284-291, 2023.

[16] Hoischemacher and Manu Santhanam (2002) "Fresh and hardened properties of self-compacting concrete produced with manufactured sand" (Construction and Building Materials)

[17] IS 4031-11-1988, "Method of physical test for hydraulic cement".

[18] IS 4031-4 -1988, "Method of standard consistency of cement".

[19] IS 4031-5-1988, "Method of Initial and Final Setting time for hydraulic cement".

[20] IS383 – 2016, "Specification for coarse and fine aggregates from natural sources for concrete".

[21] IS2386 (part III) – 1963, "Methods of test for aggregates for concrete".

[22] IS10262 – 2019, "Recommended guidelines for concrete mix design".

[23] IS 456:2000 ANNEXURE J "Self-Compacting Concrete