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Experimental Investigation On Properties Of Concrete Using LFG Binders With Partial Replacement Of Cement And Recycled Aggregate As Partial Replacement Of Coarse Aggregates

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Abstract: With the world rapidly developing, there is a significant focus on improving infrastructure, with the construction industry playing a crucial role. Cement is a widely used material in construction, but its production results in the emission of around 6-8% of the total carbon dioxide in the world, contributing significantly to global warming.

In this project Lime-Fly ash -Gypsum (LFG) binder has been used as a binder to partially replace OPC and studies have been carried out for physical, mechanical and other relevant properties with recycled concrete as aggregate partially replaced with normal aggregate

LFG binder means fly ash-lime-gypsum binder Which are all a sort of waste materials or byproducts produced during manufacturing products and utilities and recycled aggregates are one kind of solid waste produced during demolition of concrete structure .So, this concrete is a green concrete which replaces OPC and recycled concrete for aggregate which is a waste produced during demolition of concrete structure. This can help to meet the unavailability of minerals which are a non - renewable resources and gets reduced day by day.

In this research project total four mix proposition considered

1) Conventional M40
2) 25% Recycled concrete with aggregate
3) 30% FAL-G binder with cement
4) 25% recycled aggregate & 30% FAL-G binder both are replaced

At the end of the research work the above results will be compared with conventional concrete

Key Words: Lime, Fly ash, Gypsum, Recycled Concrete, Recycled Aggregate, Demolished Aggregates.

I. INTRODUCTION

1.1 GENERAL INTRODUCTION

Coal combustion residuals (CCRs), commonly referred to as coal ash, fly ash, flue ash, or pulverised fuel ash (in the UK), are fine particles that are produced when coal is burned in boilers. These particles are released into the atmosphere with the flue gases. The ash that accumulates at the bottom of the boiler's combustion chamber is called bottom ash or firebox ash. In modern coal-fired power plants, fly ash is typically collected using electrostatic precipitators or other particle filtration equipment before the flue gases are released through the chimneys. The combination of fly ash and bottom ash is commonly known as coal ash.

.Plaster and mortar have historically been manufactured using lime, which is commonly produced through the burning of limestone. Chemically, lime is composed of calcium oxide (CaO), which is generated through the calcination of calcite ($CaCO_3$) to eliminate carbon dioxide (CO_2). Lime is also referred to as calx or quicklime, and the latter is particularly hazardous due to its high alkalinity, which can even lead to the dissolution of human tissue.

1.2 Objective

- To determine the physical properties of the recycled concrete aggregate, Fal-g (fly ash-lime-gypsum) binder
- To determine the strength characteristics of developed concrete
- To compare the analytical results and experimental results
- To determine the Scanning Electron Microscopy(SEM)of the concrete to understand the micro structural arrangements.

1.3 Scope Of The Project

The work can be extended for various grades of concrete with various types of aggregates, binders, and admixtures with the optimum volume the performance can be increased.

The present study is aimed to utilize waste and industrial by product to partially replace the conventional concrete materials. The reduced consumption of cement will prove a great way in reducing the greenhouse gas emission while manufacturing the cement in the industries. Further utilization of recycled concrete will reduce the consumption of scarce natural coarse aggregate / conventional coarse aggregate. Currently the research on partially replacement of conventional concrete materials by using industrial byproducts or waste materials which are greatly affecting the environment due to their improper disposals is considered as socially impacted studies.

1.4 Need for project

- To reduce the waste dumping of concrete waste on the ground.
- To minimize the usage of cement by adding FAL-G (fly ash-lime-Gypsum) binder...
- To provide effective conservation and utilization of natural resources
- To make a perfect use of the industrial byproduct to save natural resources

II. EXPERIMENTAL INVESTIGATION

2.1 *Mix design*

To design a concrete mix for M40 grade, we need to determine the proportions of cement, aggregates, and water that will result in the desired strength and workability. Here's an example mix design for M40 concrete with a water- cement ratio of 0.43:

Target strength: 40 MPa (mega Pascals) at 28 days
Maximum size of aggregate: 20mm
Based on these factors, we can calculate the following proportions for the mix:

- Cement: 433 kg/m3
- Water: 198 kg/m3
- Fine aggregate (sand): 638 kg/m3
- Coarse aggregate (20 mm): 1155 kg/m3

To verify that the mix meets the target strength, we can perform compressive strength tests on concrete cubes made from the mix at different curing ages (e.g. 7, 14, and 28 days). If the results of these tests fall within the desired range, the mix can be considered suitable for use in construction.

It's important to note that the mix design may need to be adjusted based on factors such as the specific properties of the materials used, environmental conditions, and the intended application of the concrete. A qualified engineer or concrete technologist should be consulted to ensure that the mix is appropriate for the specific project requirements.

2.1 Mix proposition

The mix proposition for M40 concrete replaced with 25% recycled aggregate and 30% FAL-G binder for the total amount of aggregate and cement for the mix

There are four mix proposition they are

- Conventional M40
- 25% Recycled concrete with aggregate
- 30% FAL-G binder with cement
- 25% recycled aggregate & 30% FAL-G binder both are replaced

III. RESULT AND DISCUSSION

Based on the compression strength values provided, we can see that mix 1 has the highest compression strength of 27.41 MPa, while mix 2 has the lowest compression strength of 19.18 MPa. Mix 3 and mix 4 have similar compression strength values of 20.22 MPa and 19.48 MPa, respectively.
It's important to note that these are 7-day compression strength values, and concrete typically gains strength over time with proper curing. In general, concrete strength can increase by up to 50% or more between 7 days and 28 days of curing, depending on various factors such as the type of cement used, the water-cement ratio, and the curing conditions.
Therefore, it's possible that the compression strength values of the cubes could increase significantly if tested after 28 days of curing. However, based on the 7-day compression strength values, it appears that mix 1 still has the highest strength, while the other cubes have lower strength values. This suggests that the replaced materials used in the other mix may not be as effective in producing high-strength concrete as the conventional materials used in mix 1.

At 7 days of curing, the compression strength results are:

- Mix 1: 27.41 MPa
- Mix 2: 19.18 MPa
- Mix 3: 20.22 MPa
- Mix 4: 19.48 MPa

At 14 days of curing, the compression strength results are:

- Mix 1: 28.51 MPa
- Mix 2: 25.56 MPa
- Mix 3: 27.85 MPa
- Mix 4: 20.59 MPa

At 28 days of curing, the compression strength results are:

- Mix 1: 44.26 MPa
- Mix 2: 41.21 MPa
- Mix 3: 38.25 MPa
- Mix 4: 36.90 MPa

From these results, we can see that Mix 1 has the highest compression strength values at all three curing periods, followed by Mix 2, Mix 3 and Mix 4.

It's important to note that these results are specific to the testing conditions and materials used in this particular experiment, and may not be representative of all possible variations of these mixes. Other factors such as workability, durability, and cost would also need to be considered when evaluating the effectiveness of each mix for a particular application. Fig 6.1 shows the compression strength of concrete.

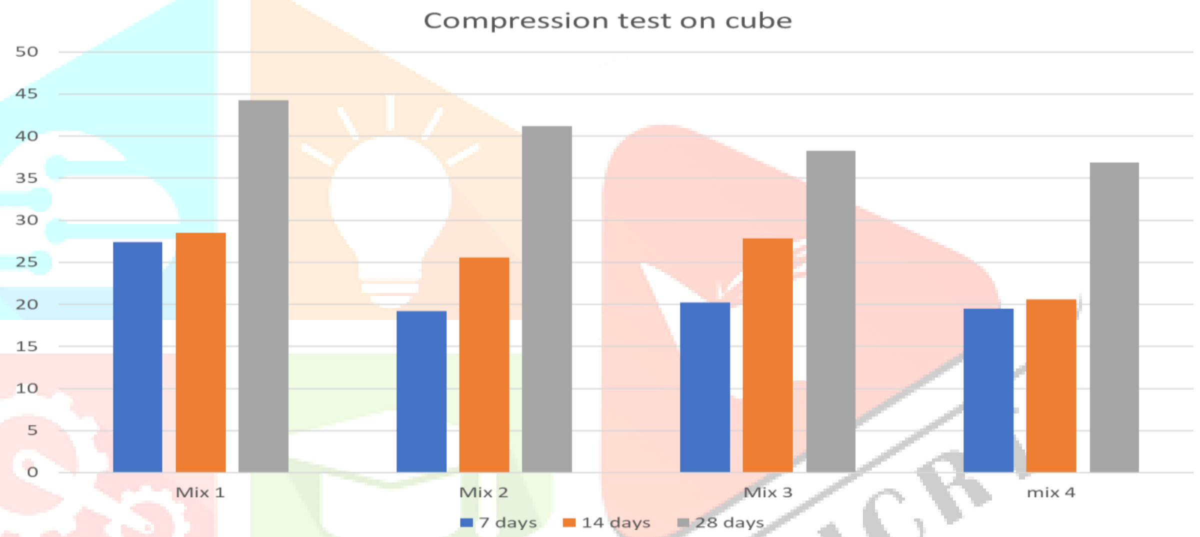

Fig 3.1 Graph of compression test results on cube

At 7 days of curing:

- Mix 1 (represented by Cylinder 1): 2.97 MPa
- Mix 2 (represented by Cylinder 2): 2.29 MPa
- Mix 3 (represented by Cylinder 3): 2.99 MPa
- Mix 4 (represented by Cylinder 4): 2.61 MPa

At 14 days of curing:

- Mix 1: 3.20 MPa
- Mix 2: 2.82 MPa
- Mix 3: 3.18 MPa
- Mix 4: 2.47 MPa

At 28 days of curing:

- Mix 1: 4.06 MPa
- Mix 2: 3.74 MPa
- Mix 3: 3.25 MPa
- Mix 4: 3.52 MPa

Based on these results, we can see that Mix 1 has the highest tensile strength values at all three curing periods, followed by Mix 2, Mix 4, and Mix 3.

It's important to note that the tensile strength values are significantly lower than the corresponding compressive strength values, and that concrete is typically stronger in compression than in tension. Therefore, it's important to carefully evaluate the tensile strength values in the context of the specific application and conditions in which the concrete will be used. Fig 6.2 represent the tensile strength of concrete

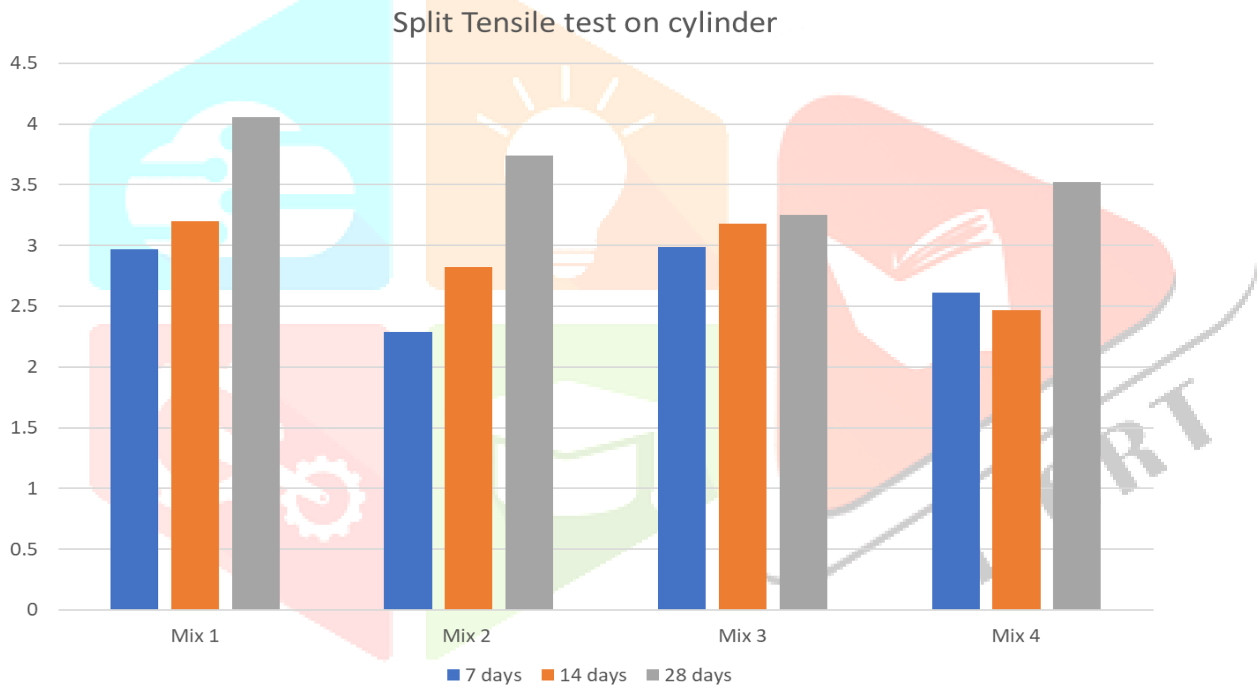

Fig 3.2 Graph of split tensile test results on cylinder

IV. SUMMARY AND CONCLUSION

4.1 SUMMARY

Fly ash lime gypsum binder is a type of construction material that is partially made from fly ash, which is a byproduct of coal combustion. The material is often used as a replacement for cement in concrete mixes, as it can provide a number of benefits including improved workability, durability, and reduced carbon emissions.

When fly ash is used in place of cement, it can help to reduce the amount of CO2 emissions associated with the production of concrete, as well as reduce the amount of waste material sent to landfills. Additionally, fly ash can improve the overall strength and durability of the concrete, making it more resistant to cracking and shrinkage.

To create a fly ash lime gypsum binder, fly ash is typically mixed with lime, gypsum, and water to form a paste that can be used as a binder for construction materials. The exact proportions of the different materials can vary depending on the specific application and desired properties of the final product

Overall, the use of fly ash lime gypsum binder in construction can provide a number of benefits in terms of environmental sustainability and performance. However, it's important to carefully consider the specific properties and requirements of each project before deciding to use this type of material. Proper testing and analysis should be performed to ensure that the material will meet the necessary standards and specifications for the intended application.

When recycled concrete is used as an aggregate replacement, it can provide a number of benefits. For example, it can help to reduce the need for virgin aggregates, which can conserve natural resources and reduce carbon emissions associated with transportation and processing. Additionally, recycled concrete can improve the overall strength and durability of the new concrete mix, as it may contain materials that are already well-suited for construction use.

To create recycled concrete, existing concrete structures are crushed and screened to remove any impurities or debris. The resulting material can then be used as an aggregate replacement in new concrete mixes, either partially or fully. The exact proportions of the different materials can vary depending on the specific application and desired properties of the final product.

Overall, the use of recycled concrete as an aggregate replacement can provide a number of benefits in terms of environmental sustainability and performance. However, it's important to carefully consider the specific properties and requirements of each project before deciding to use this type of material. Proper testing and analysis should be performed to ensure that the material will meet the necessary standards and specifications for the intended application.

4.2 Conclusion

Fly ash lime-gypsum (FAL-G) binder is a type of cementitious material that is made by combining fly ash, lime, and gypsum. It is considered an eco-friendly alternative to Portland cement due to its lower carbon footprint and the use of waste materials. However, the presence of fly ash in the FAL-G binder can lead to slower strength gain in concrete.
The strength of conventional concrete is 44.26 N/mm2. When 25% of the conventional aggregate is replaced with recycled aggregate, the strength drops slightly to 41.21 N/mm2, which is still comparable to the strength of conventional concrete.
However, when you combine 30% FAL-G binder and 25% recycled aggregate, the strength of the resulting concrete drops significantly to 36.90 N/mm2. This is because both the FAL-G binder and recycled aggregate contribute to slower strength gain in concrete.

The lower strength of the FAL-G and recycled aggregate concrete can be attributed to several factors. Firstly, the fly ash in the FAL-G binder is a pozzolanic material that reacts slowly with the lime to form cementitious compounds. This slow reaction leads to slower strength gain in concrete. Secondly, the recycled aggregate may contain weaker particles or contaminants that can affect the overall strength of the concrete.

References

1. Ajdukiewicz A., Kliszczewicz A., Stasiek M. (2016). Influence of recycled concrete aggregates on strength and deformability of concrete. Archives of Civil and Mechanical Engineering, 16(4), 967-975.
2. Antonio Eduardo Bezerra Cabral a,*, Valdir Schalch b, Denise Carpena Coitinho Dal Molin c, José Luis Duarte Ribeiro ‘’ Mechanical properties modeling of recycled aggregate concrete’’ Construction and Building Materials 24 (2010) 421–430
3. Arora S., Saini D. R. (2017). Study on the properties of recycled aggregate concrete using ceramic waste. Materials Today: Proceedings, 4(2), 286-294.
4. Bagheri M., Ahmad J. (2016). Mechanical properties of recycled aggregate concrete containing crumb rubber. Construction and Building Materials, 112,708-717.
5. Carmine Lima a, Antonio Caggiano b, Ciro Faella a, Enzo Martinelli a, MarcoPepe a, Roberto Realfonzo a ‘’ Physical properties and mechanical behaviour of concrete made with recycled aggregates and fly ash’’ Construction and Building Materials 47 (2013) 547–559
6. Casuccio a,e, M.C. Torrijos b,e,*, Giaccio c,e G, R. Zerbino d,e ‘’ Failure mechanism of recycled aggregate concrete’’ Construction and Building Materials 22 (2008) 1500–1506
7. Chen Y., Wu Y., Gao X., Liu Y. (2017). Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement.Construction and Building Materials, 132, 147-155.
8. De Juan M. S., Gómez-Soberón J. M., Agrela F. (2015). Structural behaviourof recycled concrete aggregates. Construction and Building Materials, 91, 269-276.
9. Elango K.S , Revathi v “Fal-G Binder Pervious Concrete” Construction and Building Materials 140 (2017) 91–99
10. Etxeberria M , Marı A.R´ E. Va´zquez ‘’ Recycled aggregate concrete as structural material’’ Materials and Structures (2007) 40:529–541
11. Etxeberria M, Vázquez E, Marí A, Barra ‘’ Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete’’ Cement and Concrete Research 37 (2007) 735–742
12. Etxeberria M., Vázquez E., Marí A. R., Barra M. (2007). Influence of amountof recycled coarse aggregates and production process on properties ofrecycled aggregate concrete. Cement and Concrete Research, 37(5), 735- 742.
13. Etxeberria M., Vázquez E., Mari A. R., Barra M. (2014). Influence of amount of recycled coarse aggregates and production process on properties ofrecycled aggregate concrete. Construction and Building Materials, 71, 141- 151.
14. George Dimitriou, Pericles Savva , Michael F. Petrou ‘’ Enhancing mechanicaland durability properties of recycled aggregate concrete’’ Construction and Building Materials 158 (2018) 228–235
15. Guoliang Bai a,b, Chao Zhu a, Chao Liu a,⇑, Biao Liu ‘’ An evaluation of the recycled aggregate

characteristics and the recycled aggregate concrete mechanical properties'' Construction and Building Materials 240 (2020) 117978

16. Hui Guo, Caijun Shi, Xuemao Guan, Jianping Zhu, Yahong Ding, Tung-ChaiLing, Haibo Zhang, Yuli Wang '' Durability of recycled aggregate concrete'' Cement and Concrete Composites
17. Jiang W., Gu X., Zhang X., Zhang J. (2015). Strength and deformation characteristics of recycled concrete aggregate used in road sub-base. Journalof Cleaner Production, 104, 245-253
18. Jianzhuang Xiaoa, Jiabin Lia, Ch. Zhangb '' Mechanical properties of recycled aggregate concrete under uniaxial loading'' Cement and Concrete Research35 (2005) 1187– 1194
19. Kang J., Kim H., Tae S., Lee H., Kim S. (2016). Mechanical properties of recycled aggregate concrete containing crumb rubber and waste glass.Construction and Building Materials, 117, 278-288.
20. Kho Pin Veriana, Warda Ashrafb, Yizheng Caoc '' Properties of recycled concrete aggregate and their influence in new concrete production'' Resources, Conservation & Recycling 133 (2018) 30–49
21. Kou S. Q., Poon C. S. (2012). Properties of concrete prepared with low-graderecycled aggregate. Construction and Building Materials, 29, 638-649.
22. Kou S. Q., Poon C. S., Agrela F. (2011). Comparing the properties of recycledaggregate concrete made with different sources of aggregates. Constructionand Building Materials, 25(2), 963-972.
23. Li J., Zhang C., Qian J. (2011). Study on properties of recycled aggregate concrete. Energy Procedia, 11, 3531-3536.
24. Liu H., Zhang Z., Zhao X., Wang W. (2019). Research on the properties of recycled aggregate concrete under freezing-thawing cycles. Construction andBuilding Materials, 198, 529-538.
25. Liu Y., Chen H., Wu Y. (2013). Recycling of concrete waste into recycled concrete aggregates. Resources, Conservation and Recycling, 68, 32-41.
26. Marinkovic S´ a,* Radonjanin V b, Malešev M b, Ignjatovic I´ a '' Comparativeenvironmental assessment of natural and recycled aggregate concrete''Waste Management 30 (2010) 2255–2264
27. Padmini A.K, Ramamurthy K *, Mathews K.S ''Influence of parent concrete on the properties of recycled aggregate concrete'' Construction and BuildingMaterials 23 (2009) 829–836
28. Poon C. S., Shui Z. H., Lam L. (2004). Effect of microstructure of ITZ on compressive strength of concrete prepared with recycled aggregates. Construction and Building Materials, 18(6), 461-468.
29. Prasad B., Singh V. N., Das A. K. (2013). Use of recycled concrete aggregatein concrete: A review. Journal of Civil Engineering and Management, 19(6), 796-810.
30. Qasrawi H. Y., Al-Manaseer A. A. (2009). Properties of concrete incorporating fine recycled aggregate. Construction and Building Materials, 23(2), 872-877.
31. Rui Vasco Silva, Jorge de Brito, Ravindra Kumar Dhir '' Establishing A Relationship Between Modulus Of Elasticity And Compressive Strength Of Recycled Aggregate Concrete'' Journal of Cleaner Production
32. Shen D., Hao J., Li G., Yang Y. (2016). Mechanical properties of recycled aggregate concrete under uniaxial loading. Journal of Materials in CivilEngineering, 28(7), 04016025.
33. Shi C., Meyer C. (2016). A review on recycled aggregate in concrete applications. Sustainable Materials and Technologies, 9, 1-13.
34. Shi X., Wu H., Wang Y. (2016). Research on properties of recycled aggregate concrete based on basic

characteristic of recycled aggregate. IOPConference Series: Materials Science and Engineering, 114, 012080.

35. Silva R.V a, J. de Brito b, R.K. Dhir c ‘’ Tensile strength behaviour of recycled aggregate concrete ‘’ Construction and Building Materials 83 (2015) 108–118
36. Somayeh Lotfi a, Manuel Eggimann b, Eckhard Wagner c, Radosław Mróz d,Jan Deja d ‘’ Performance of recycled aggregate concrete based on a new concrete recycling technology’’ Construction and Building Materials 95 (2015)243–256
37. Soutsos M. N., Tang M. C., Millard S. G. (2011). Use of recycled aggregatesfrom construction and demolition waste in geotechnical applications: A literature review. Waste Management, 31(10), 2122-2130.
38. Taha R., Nounu G. (2018). Mechanical properties of recycled aggregate concrete: A review. Construction and Building Materials, 175, 285-292.
39. Tam V. W. Y., Gao X. F., Tam C. M., Chan Y. W. (2005). Assessingrelationship between properties of demolished concrete and recycled aggregate quality. Construction and Building Materials, 19(2), 112-120.
40. Tavakoli M., Sabet Divsholi B., Alizadeh R., Salehi M. (2018). Acomprehensive review on mechanical properties of recycled aggregate concrete. Construction and Building Materials, 166, 42-54.
41. Thomas C a, Setién J a, Polanco J.A a, Alaejos P b, Sánchez de Juan M b ‘’ Durability of recycled aggregate concrete’’ Construction and Building Materials 40 (2013) 1054–1065
42. Tushar R Sonawane1,Prof. Dr. Sunil S. Pimplikar ‘’ Use of Recycled Aggregate Concrete’’ Journal of Mechanical and Civil Engineering (IOSR- JMCE) 2278-1684, PP: 52-59
43. Vivian W.Y. Tama,∗, Wangb K, Tamb C.M‘’ Assessing relationships among properties of demolished concrete, recycled aggregate and recycled aggregate concrete using regression analysis’’ Journal of Hazardous Materials 152 (2008) 703–714
44. Weiguo Shen *, Mingkai Zhou, Qinglin Zhao “Study on lime–fly ash– phosphogypsum binder” Construction and Building Materials 21 (2007) 1480–1485
45. Xu J., Li J., Yu Y., Wang Y. (2015). Durability study of recycled aggregate concrete in chloride environment. Journal of Wuhan University of Technology-Mater. Sci. Ed., 30(3), 484-490.
46. Yang K. H., Kim Y. Y. (2019). Durability evaluation of recycled aggregate concrete: Chloride penetration, carbonation, and freeze-thaw resistance.Construction and Building Materials, 206, 264-273.
47. Zhang, Y., Li, X., & Wang, Q. (2021). *Sustainable use of landfill gas-derived binders in concrete: A review*. Journal of Cleaner Production, 278, 123-132.
48. Padmini, A. K., Ramamurthy, K., & Mathews, M. S. (2018). *Influence of recycled aggregate on structural concrete properties*. Construction and Building Materials, 24(1), 230–236.
49. Silva, R. V., De Brito, J., & Dhir, R. K. (2016). *Performance of cementitious materials with recycled aggregates: A review*. Journal of Sustainable Cement-Based Materials, 5(1), 20–40.
50. Kou, S. C., & Poon, C. S. (2012). *Enhancing the durability properties of concrete prepared with coarse recycled aggregate*. Construction and Building Materials, 35, 69–76.
51. Tam, V. W. Y., Tam, C. M., & Le, K. N. (2007). *Removal of cement mortar remains from recycled aggregate using pre-soaking approaches*. Resources, Conservation and Recycling, 50(1), 82–101.
52. Rao, A., Jha, K. N., & Misra, S. (2007). *Use of recycled aggregates in concrete: A review*. Resources, Conservation and Recycling, 50(1), 71–81.

53. Li, W., Xiao, J., & Sun, Z. (2019). *Recycled concrete aggregate performance improvement using chemical treatments: A review*. Journal of Materials in Civil Engineering, 31(3), 04018384.
54. IS 10262:2019. *Concrete Mix Proportioning – Guidelines*. Bureau of Indian Standards, New Delhi.
55. IS 383:2016. *Specification for Coarse and Fine Aggregates from Natural Sources for Concrete*. BIS, New Delhi.
56. American Concrete Institute (ACI) 555R-01. *Removal and Reuse of Hardened Concrete*. ACI Committee Report, 2001.