

Engineering Properties of Concrete by Partial Replacement of Cement with Aluminium Slag and Fine Aggregate with Foundary Sand



G V D Sai Sandeep, Dumpa Venkateswarlu, J Lakshmi Sudha

Abstract: A self-compacting concrete (s.c.c) is a special concrete which settles itself without any vibration due to its own mass and self-weight. This will happen due to use of special admixtures which have tendency to increase the flow of concrete by reducing the viscosity nature. This particular type of concrete was developed by the japan researchers in 1988. Later it was modifies and developed in many parameter's by UK and U.S.A researchers.

This particular thesis is about the improvement of performance of the S.C.C by replacing the fines and cement of the aggregates by the waste products that obtained from the different industries. The fines are replaced partially by crushed sand obtained as quarry waste and the aluminium slag that obtained from many industries as a waste product is partially introduced as binding material

By using this S.C.C the problems that are facing by the construction industries during the placement of the concrete will solve. Now days the structures are designed and made as heavy reinforced structures where the sizes of structural elements are restricted due to architectural and some structural considerations. So the concrete that poured in those elements shows the voids and honey combing it can be prevented by using this S.C.C. not only the improvement of the strength but also the construction time and cost also gets reduced by using this product, because with this material no need of vibration. It reduces the time of construction and cost regarding vibration equipment and labor. But the main problem while preparing s.c.c is to select the proper admixture to prevent the cracking and shrinkage issues. This type of concrete requires 20-25 percent higher matric paste when compared to conventional concrete.

This thesis works on mainly preparing the most feasible mix for s.c.c with the partial replacement of fines and cement by above mentioned materials which makes the matrix still in plastic state without altering the original properties of the concrete. The second task is to prepare the specimens for different strength tests and like compression and tensile and bending parameters check along with the considering the shrinkage issues.

Keywords : Aluminium slag, mechanical sand, self-compaction concrete, Compressive Strength, Split Tensile Strength, Flexural Strength, Curing, shrinkage, cracking, honey combs.

Revised Manuscript Received on August 30, 2019.

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I. INTRODUCTION

A self compaction concrete, simply we can call it as self consolidation concrete. Which have a ability to flow and settle (compacts) on its own due to its self-weight. The air trapped inside the concrete almost gets de aerated in the process of flowing and filling in formwork. With the use of S.C.C we can control and completely eliminate the bleeding and segregation of any shape and size aggregates. All these things makes the concrete more workable and useful in the areas where the concrete placing is difficult like heavily reinforced structural elements.

In this paper the main objectives is to made a comparative study of strengths of the S.C.C like compressive strength test and split tensile test, flexure strength . when the normal concrete with no replacement and the concrete with replacement of fines with foundary sand and cement replaces with aluminium slag on partial replacement basis.

From past 50 years concrete gains much more importance due in increase in urbanization and high rise constructions. But there is little development in the concrete and cement properties still researchers are working to make the concrete more economic friendly and to improve the durability , strength , impermeability, resistance to fire and toughness properties.

A. Benefits and Advantages of SCC

Modern, presently day self-compacting concrete (SCC) can be classified as an advanced construction material. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. This offers many benefits and advantages over conventional concrete.

- Improved quality of concrete and reduction of onsite repairs.
- Faster construction times.
- Lower overall costs.
- Facilitation of introduction of automation into concrete construction.
- Improvement of health and safety is also achieved through elimination of handling of vibrators.
- Substantial reduction of environmental noise loading in and around a site.
- Possibilities for utilization of “dusts”, which are currently waste products demanding with no practical application and which are costly to dispose off.
- Better surface finishes.



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- Easier placing.
- Thinner concrete sections.
- Greater freedom in Design.
- Improved durability, reliability of Concrete structures.
- Ease of placement, results in cost savings through reduced equipment and labor requirement.
- SCC makes the level of durability and reliability of the structures independent from the existing on-site conditions related to the quality of labor, casting and compacting systems available.
- The high resistance to external segregation and the mixtures of self-compacting ability allow the elimination of macro-defects, air bubbles, and honeycombs responsible for penalizing mechanical performance and structure durability.

B. Limitations of SCC:

- Apparent lack of reliable test standards that can qualify the physical properties of SCC. It is important to note that none of the test methods for SCC has yet been standardized, and the tests described are not yet perfected or definitive. There is no clear relation between test results and performance on site.
- Higher material cost not only for admixtures but also for increased quality control and testing needed for concrete and aggregates.
- Mixing time and finishing times will likely be longer.
- Because of SCCs high fluidity, grout leakage could be a problem in forms that do not completely seal.
- Since SCC is inherently self-leveling, filling a form that is not level, could conceivably cause problems.

II. MIX DESIGN

A. Requirements of Concrete Mixdesign

The requirements which form the basis of selection and proportioning of mix ingredients are:

- The minimum compressive strength required from structural consideration.
- The adequate workability necessary for full compaction with the compacting equipment available.
- Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions.
- Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

Table 2.1: Material required for M40 grade concrete per cubic meter quantity of concrete as per the mix design calculation

Material	Water	Cement	Fine aggregate	Coarse aggregate
Kgs/cum	192	399	715	1155
Ratio	0.48	1	1.79	2.89

III. EXPERIMENTAL PROCEDURES



Fig:3.1 Split tensile strength testing



Fig:3.2 flexure strength testing

IV. RESULTS

A. Compressive Strength of Cubes

Cubes of size 150 mm x 150 mm x 150 mm were casted by partial replacement of cement with fly ash. The strength variation was monitored at the ages of 7, 28 and 90 days by conducting compressive strength test using compression testing machine. Cement was replaced with aluminium slag at different percentages for obtaining the optimum value of aluminium slag and the test details are given below

Table : 4.1 variation of compressive strength on partial replacement of cement with aluminium slag at 7 days, 28 days and 90 days

SL.N O	% OF ALUMINIUM SLAG	% OF CEMENT	7 DAYS STRENGTH (MPA)	28 DAYS STRENGTH (MPA)	90 DAYS STRENGTH (MPA)
1	0	100	32.5	46.0	46.3
2	10	90	32.8	46.3	46.5
3	15	85	33.1	46.7	46.7
4	20	80	33.4	47.01	47.02
5	25	75	33.6	47.6	47.8
6	30	70	33.2	46.9	47.0

The optimum value of aluminium slag was found to be 25%

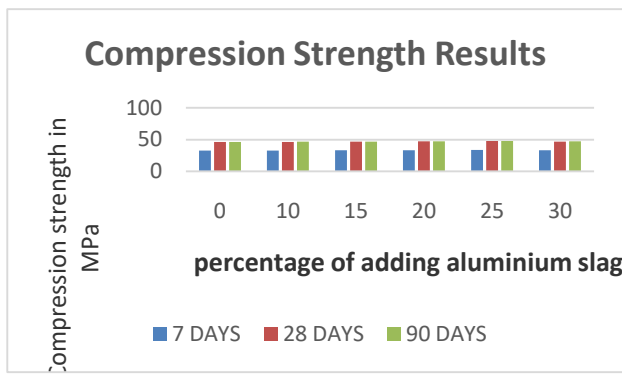


Fig4.1: variation of compressive strength on partial replacement of cement with aluminium slag at 7 days, 28 days and 90 days .

B. Split tensile strength

Table:4.2 Split tensile strength of Conventional concrete and the cement partially replaced with aluminium slag at 7, 28 and 90 days

SL. NO	ALUMINIUM SLAG %	CEMENT %	7DAYS SPLIT TENSILE STRENGTH (MPA)	28 DAYS SPLIT TENSILE STRENGTH (MPA)	90 DAYS SPLIT TENSILE STRENGTH (MPA)
1	0	100	3.0	4.0	4.02
2	10	90	3.05	4.06	4.08
3	15	85	3.1	4.14	4.16
4	20	80	3.18	4.19	4.21
5	25	75	3.22	4.24	4.25
6	30	70	3.01	4.10	4.12

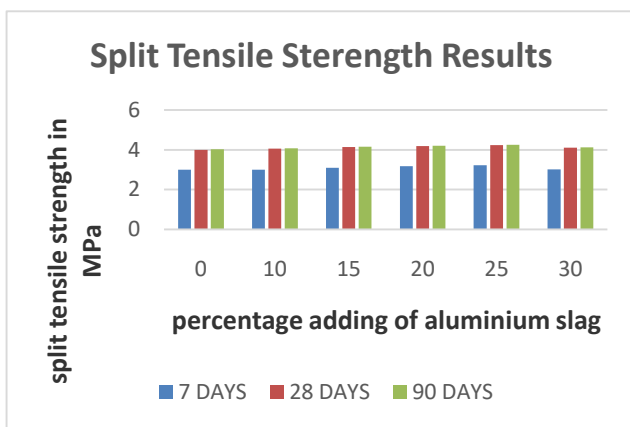


Fig 4.2: variation of split tensile strength on partial replacement of cement with aluminium slag at 7 days, 28 days and 90 days

C. Flexural Strength

Table 4.3: Flexural strength of Conventional concrete and the cement partially replaced with aluminium slag at 7, 28 and 90 days.

SL.NO	ALUMINIUM SLAG %	CEMENT %	7DAYS FLEXURAL STRENGTH (MPA)	28DAYS FLEXURAL STRENGTH (MPA)	90DAYS FLEXURAL STRENGTH (MPA)
1	0	100	3.5	4.7	4.72
2	10	90	3.58	4.72	4.74
3	15	85	3.62	4.77	4.78
4	20	80	3.66	4.80	4.81
5	25	75	3.69	4.84	4.86
6	30	70	3.62	4.78	4.82

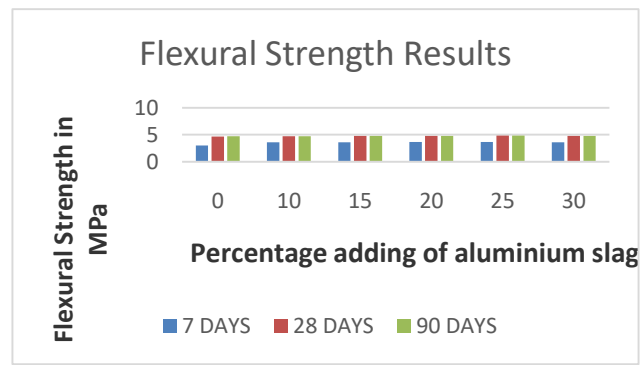


Fig 4.3: variation of flexural strength on partial replacement of cement with aluminium slag at 7 days, 28 days and 90 days

By taking the optimum value of the fly ash (i.e. 25% was obtained from the test results) the fine aggregate was replaced with different percentages of foundry sand. Again various tests were conducted by preparing the samples in the laboratory by keeping 75% cement + 25% aluminium slag as constant and by replacing the fine aggregate with different percentages of foundry sand and the test results are furnished below.

Table 4.4: Compressive strength of concrete with aluminium slag and the fine aggregate partially replaced with foundry sand cubes at 7, 28 and 90 days. (Mpa)

S L . N O	CEMENT % + ALUMINIUM SLAG%	FOUNDRY SAND %	7 DAYS COMPRESSIVE STRENGTH (MPA)	28 DAYS COMPRESSIVE STRENGTH (MPA)	90 DAYS COMPRESSIVE STRENGTH (MPA)
1	75+25	0	32.5	46.0	46.3
2	75+25	10	32.52	46.2	46.31
3	75+25	20	32.56	46.4	46.42
4	75+25	30	32.58	46.62	46.64
5	75+25	40	33.2	46.84	46.89
6	75+25	50	33.0	46.2	46.3
7	75+25	60	32.8	45.8	46



Fig 4.4: variation of compressive strength of aluminium slag (25%) added concrete on partial replacement of fine aggregate with foundry sand at 7 days, 28 days and 90 days

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Table 4.5: Split tensile strength of concrete with aluminium slag and the fine aggregate partially replaced with foundary sand at 7, 28 and 90 days. (Mpa)

SL.NO	CEMENT %+ ALUMINIUM SLAG %	FOUNDARY SAND %	DAYS SPLIT TENSILE STRENGTH (MPA)	28 DAYS SPLIT TENSILE STRENGTH (MPA)	90 DAYS SPLIT TENSILE STRENGTH (MPA)
1	75+25	0	3.0	4.0	4.02
2	75+25	10	3.06	4.06	4.07
3	75+25	20	3.1	4.09	4.1
4	75+25	30	3.14	4.12	4.14
5	75+25	40	3.18	4.14	4.16
6	75+25	50	3.12	4.10	4.12
7	75+25	60	3.06	4.06	4.08

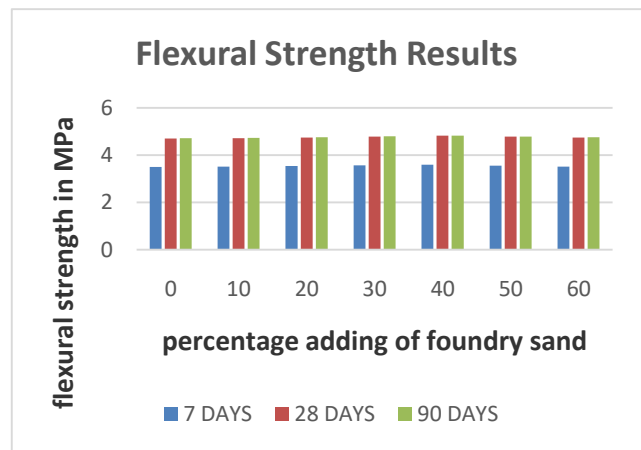


Fig 4.6: variation of flexural strength of (25%) aluminium slag added concrete on partial replacement of fine aggregate with foundary sand at 7 days, 28 days and 90 days

V. CONCLUSION

- Self-compacting concrete can be obtained in such a way, by adding chemical and mineral admixtures, so that its split tensile and compressive strengths are higher than those of normal vibrated concrete.
- By use of chemical and mineral admixtures, self-compacting concrete has shown smaller interface micro cracks than normal concrete, in-fact which lead to a better bonding between aggregate and cement paste and to an increase in split tensile and compressive strengths.
- In addition, self-compacting concrete has two big advantages. One relates to the construction time, which in most of the cases is shorter than the time when normal concrete is used, due to the fact that no time is wasted with the compaction through vibration. The second advantage is related to the placing. As long as SCC does not require compaction, it can be considered environmentally friendly, because if no vibration is applied no noise is made.
- The percentage increase in compressive strength at 7, 28 and 90 days of cement partially replaced with 25% aluminium slag were found to be 3%, 3.4% and 3.2%.
- The percentage increase in split tensile strength at 7, 28 and 90 days of cement partially replaced with 25% aluminium slag were found to be 7%, 6% and 5%.
- The percentage increase in flexural strength at 7, 28 and 90 days of cement partially replaced with 25% aluminium slag were found to be 5%, 3% and 3%.
- Further the strength parameters were slightly enhanced when the fine aggregate was replaced with different percentages of foundary sand. The optimum percentage of foundary sand to replace the fine aggregate was found to be 40%.
- The percentage increase in compressive strength at 7, 28 and 90 days of fine aggregate partially replaced with 40% foundary sand were found to be 2%, 1.8% and 1.2%.

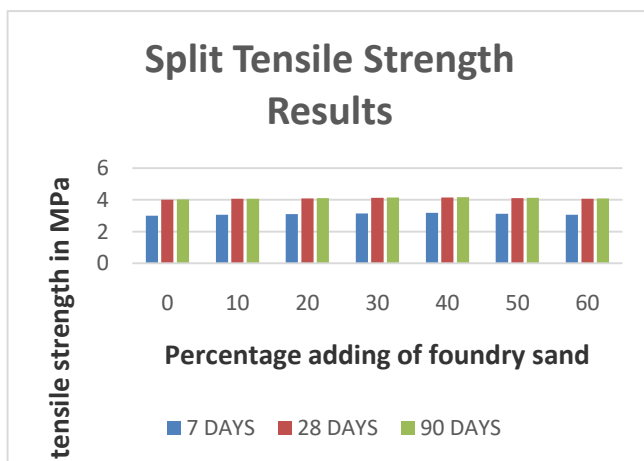


Fig 4.5: variation of split tensile strength of aluminium slag (25%) added concrete on partial replacement of fine aggregate with foundary sand at 7 days, 28 days and 90 days

Table 4.6: Flexural strength of concrete with aluminium slag and the fine aggregate partially replaced with foundary sand at 7, 28 and 90 days. (Mpa)

SL. NO	CEMENT % + ALUMINIUM SLAG %	FOUNDARY SAND %	DAYS FLEXURAL STRENGTH (MPA)	28 DAYS FLEXURAL STRENGTH (MPA)	90 DAYS FLEXURAL STRENGTH (MPA)
1	75+25	0	3.5	4.7	4.72
2	75+25	10	3.52	4.72	4.73
3	75+25	20	3.54	4.75	4.76
4	75+25	30	3.57	4.79	4.8
5	75+25	40	3.6	4.82	4.83
6	75+25	50	3.56	4.78	4.79
7	75+25	60	3.51	4.74	4.76

- The percentage increase in split tensile strength at 7, 28 and 90 days of fine aggregate partially replaced with 40% foundry sand were found to be 6%, 3.5% and 3.4%.
- The percentage increase in flexural strength at 7, 28 and 90 days of fine aggregate partially replaced with 40% foundry sand were found to be 2.8%, 2.5% and 2.3%.
- The values of compressive strength, split tensile strength and flexural strength of both cement and coarse aggregate treated concrete to its optimum values at 28 days were found to be 46.84Mpa, 4.14Mpa and 4.82Mpa respectively.
- The % improvement of compressive strength, split tensile strength and flexural strength of both cement and coarse aggregate treated concrete to its optimum values at 28 days were found to be 2 %, 4% and 3% respectively.

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