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UTILIZATION OF WASTE LIMESTONE DUST (LSD) WITH REPLACEMENT OF FINE AGGREGATES (FA) IN SELF-COMPACTED CONCRETE (S.C.C)

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ABSTRACT

The use of limestone dust in the construction industry has been increasing due to the benefits including good strength, low possibility of Alkali-Lime Stone dust reaction and the decrease in drying shrinkage in concrete.In our work, experiments were conducted on specimen mixtures of SCC of different proportions of fine limestone and FA. In SCC sample specimens there was replacement of fine aggregates and cement with lime stone dust. Various strength tests, workability tests and water absorption tests were performed were performed on sample specimens. These results were compared with the corresponding ordinary grades of concrete (SCC) and was accordingly summarized to what extent we can replace the fine aggregates and cement proportions.

On observing the results, we concluded that there is increase in the compressive and flexural strengths when the limestone proportion is increased up to 15% in replacement with fine aggregates in the mixture. However, the compressive strength and flexure strength decreases if we replace more than 15% of fine and cement content.

On top of that, replacement of fine aggregates and cement upto 15% has great impact on the economy of the project and at the same time, the lime stone dust produced finds its use in self-compacted concrete. There by reducing the demand of fine aggregates and providing alternate to the FA wherever possible..

Keywords: Lime stone Dust, Fine Aggregates, Self-Compacted concrete, Strength, Workability.

1. DEFINITION

The self-compacting concrete with Lime stone Dust (S.C.C) represents one of the most significant advances in concrete technology for decades. Inadequate homogeneity of the cast concrete due to poor compaction or segregation may drastically lower the performance of mature concrete. S.C.C with Lime stone Dust has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas.

S.C.C with lime stone dust is a new innovative material, which shows the property of flow ability under its own weight without segregation, and bleeding, this type of concrete does not require any compaction when placed. The hardened concrete is dense, homogenous and has the same engineering property and durability as traditionally vibrated concrete. With its use more innovative design, more complex shape, thinner sections are possible.

2. LITERATURE

K.H Khayat,et al(2010) The workability requirement for successful placement of S.C.C added wit Lime Stone dust necessitate that the concrete exhibits excellent deformability and proper stability to flow under its own weight through closely spaced reinforcement without segregation and blockage. Insuring high stability is important to limit bleeding, segregation and surface settlement of concrete after placement and secure uniform properties of hardened concrete. In general, S.C.C added with Lime Stone dust exhibits low yield and moderate viscosity. In addition to the slump flow test used to evaluate deformability, the filling test or V-funnel flow test should be used to evaluate the ability to achieve the smooth flow through restricted spacing without blockage.

One approach to enhance viscosity is to lower the water/cement ratio to maintain adequate cohesion friction between the mortar and coarse aggregate and insure uniform flow of S.C.C through restricted sections. Another way is to incorporate a low to moderate dosage of a VMA (Viscosity Modifying Admixture Rheomac-VMA362) without lowering the water/cement.

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Prof. Sudhir Mishra et al, ObtainedS.C.C added with Lime Stone dust, constituents of conventional concrete are either altered and there is significant change in proportion. There is no significant change in proportion of air, water and sand but the proportion of sand volume is increased with a corresponding decrease in proportion of aggregate in order to minimize the friction between solid particles of mixture so that desired deformability of concrete can be achieved

N. Bouzoubaa et al, showed that in terms of mix design cost, the economical self-compacting concrete that achieved 28 day compressive strength of approximately 35MPa was that made with 50% replacement of cement by fly ash, and with water cement ratio of 0.45. The self-compacting concrete can replace the control concrete with similar 28-day compressive strength with no significant extra cost.

Al-Luhybi et al, showed using limestone powder as replacement of cement led to production of S.C.C. Results showed that using LSP as replacement also led to economic advantages due to decrease in plasticizer content, with no noticeable differences in mechanical properties of S.C.C, but causing a fluidity increase of S.C.C when using LSP as an additive.

B.H.V. Pai et al (Reference 10) conducted experimental study on self-compacting concrete containing industrial by products like Lime Stone dustfume and ground blast furnace slag and concluded GGBS based S.C.C has good compressive strength, split tensile strength and flexural strength than SF based S.C.C.
Rahul Dubey et al (reference 14) conducted a study on effect of super plasticizer dosages on compressive strength of self-compacting concrete and concluded with the addition of SP beyond 2% compressive strength decrease with the increase in dosage of SP. However, incorporating SP up to 4%, there was significant increase of compressive strength of S.C.C mix with increase of age. When SP was added beyond 4% and up to 8%, although there was increase in compressive strength at all ages but increase was marginal. Beyond 8% and up to 10% the increase in compressive strength with aging was further reduced. Also with increase in SP dosage setting time was also increased.

General
The constituent materials used for the production of S.C.C with Lime Stone dust are the same as those for conventionally vibrated normal concrete except that S.C.C contains lesser aggregate and greater powder and Lime Stone dust.

Cement is a fundamental ingredient for paste in concrete engineering. Simply increasing cement content to increase powder volume has undesirable effects, indeed other materials like fly ash, blast furnace slag, limestone powder etc. can also add to powder volume and concentration. Increasing the powder content in the paste increases its carrying or holding capacity and also has the effect of increasing the mortar content in concrete mix

i) Super plasticizers help to increase cement or powder content without compromising on workability of mix.
ii) Viscosity modifying admixtures can be used to modify viscosity of paste, i.e, with their use water content in mix can be increased without increasing susceptibility to segregate.

Cement
Cement is the main ingredient of paste; however, increasing cement content to increase powder volume has undesirable effects. Therefore, other materials like fly ash, blast furnace slag, limestone, stone dust need to be added to increase powder volume. Another route available for modification of concrete properties is use of chemical admixtures which include super plasticizers and viscosity modifying agents. Super plasticizers help to increase deformability of concrete that is, cement or powder content increased without compromising on workability of mix. Viscosity modifying agents can be used to modify the viscosity of paste that is, water content can be increased without increasing chances to segregate Selection of the type of cement depends on the overall requirements for concrete, such as strength and durability.

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Lime stone Dust

Research has indicated that finer and better-graded limestone dust significantly increases the deformability of the paste and it also appeared that the addition of filler improved the 28-day compressive strength of concrete mixes besides the required self-compacting properties.

Aggregates

The maximum size and grading of the aggregates depends on the particular application. Maximum size of aggregate is usually limited to 20 mm. The coarse aggregate content in S.C.C is kept either equal to or less than that of the fine aggregate content. The sand ratio (i.e. fine aggregate volume/total aggregate volume) is an important parameter for S.C.C and the properties are improved with an increase in the sand ratio.

Admixtures

Super plasticizer*:* High range water reducers play an important role in the desirable flow at low water contents. Many researches have been conducted in order to know the role of different super plasticizers to achieve S.C.C. In India sulphonated condensates of naphthalene formaldehyde is much preferable because of its low cost as compared to others. Further, the compatibility between cement and super plasticizers is an important issue to be considered as the gypsum present in concrete having low water content and super plasticizer dosage may precipitate out resulting in loss of slump.

The super plasticizer to be selected should have:

- High dispersing effect for low water/powder ratio (less than 1 by volume),
- Maintenance of the dispersing effect for at least two hours after mixing, and
- Less sensitivity to temperature changes *(Okamura and Ouchi, 2003).*

The main purpose of using a super plasticizer is to produce flowing concrete with very high slump that is to be used in heavily reinforced structures and in places where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high-strength concrete at water/cement's ranging from 0.3 to 0.4.

Other types of admixtures may be incorporated as necessary, such as VMA for stability, air-entraining admixture (AEA) to improve freeze-thaw resistance, retarders for control of setting, etc

Introduction

Workability is the ability of a fresh concrete mix to fill the form/mold properly without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration) and can be modified by adding chemical admixtures, like superplasticizer. The concrete ingredients were mixed manually to attain uniform consistency. The self-compatibility of the trial mixes was evaluated using slump flow test, V-funnel test, and U-box test.

Various Tests performed on Trial Mixes of S.C.C to determine workability are:

1. Slump flow test
2. V funnel Test
3. U-Box Test

3. STRENGTH TEST OF TRIAL MIXES

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service conditions. Some of the other engineering properties of hardened concrete includes Elastic Modulus, Tensile Strength, Creep coefficients, density, coefficient of thermal expansion etc.Various Tests performed on Trial Mixes of S.C.C to determine Strength are:

1. Compression Test
2. Flexure Test

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Seven trial mixes were prepared by varying the limestone powder content, fine aggregates, keeping super plasticizer content constant. The seven trial mixes were named Sample Mix A to Sample Mix G. Out of the seven mixes we evaluated the best results of the sample specimens and discussed them accordingly.

4. BASED ON COMPRESSIVE STRENGTH OF TRIAL MIXES

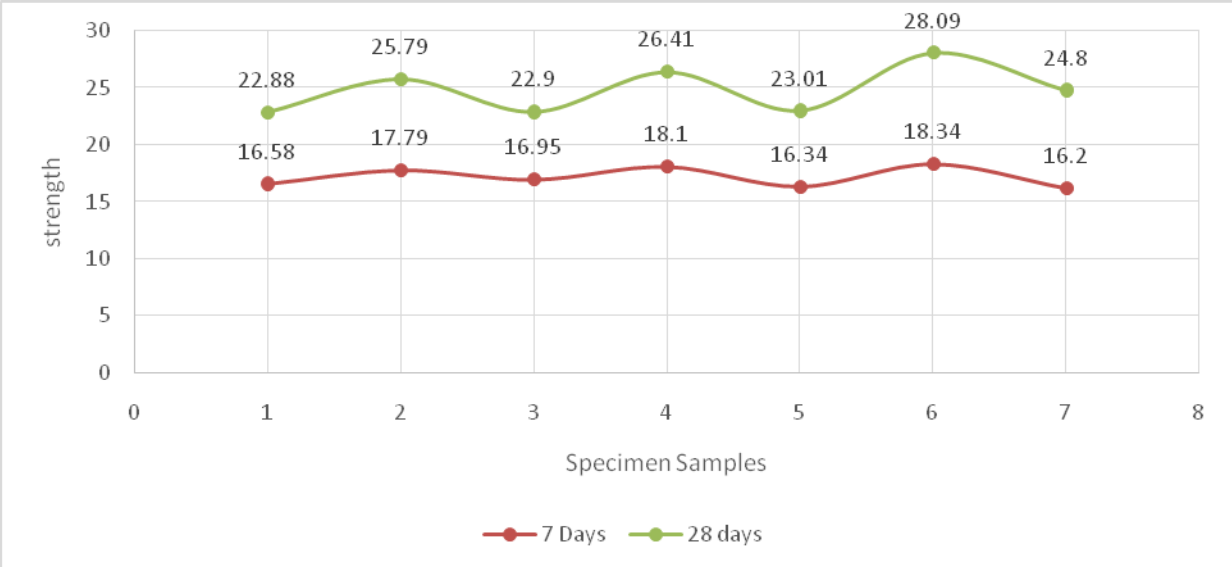
It is evident from the table no .. that compressive strength of the Sample mixes increases when we replace the constituting proportions and it keeps on increasing till replacement of 15% of fine aggregates. There is sudden decrease in the compressive strength if there is replacement of 15% of FA and cement.The Sample Mix A is ordinary S.C.C without any replacement. The Sample Mix B has replacement of 5% of Fine Aggregates. Followed by (5+5)% of FA and cement, 10% of FA, (10+10)% of FA and cement, 15% of FA and finally (15+15)% of FA and cement. It is evident from the experimental investigation that there is incremental increase in sample specimens B,D and F w.r.t A. The increase is 1.21 N/mm^2 1.51 N/mm^2 and 2.14 N/mm^2 .

Average compressive strength of trial mixes after 7 days:

S. No.	Trail Mix	Average Strength (N/mm^2)	
		7 Days	Increase/decrease in av. Strength
1	Sample Mix A	16.58	
2	Sample Mix B	17.79	(+)1.21
3	Sample Mix C	16.4	(-)1.39
4	Sample Mix D	17.91	(+)1.51
5	Sample Mix E	16.2	(-)1.71
6	Sample Mix F	**18.34**	**(+)2.14**
7	Sample Mix G	15.8	(-)2.54

Average compressive strength of trial mixes after 28 days:

Graphical representation of average compressive strengths of 7 days and 28 days



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5. BASED ON FLEXURE STRENGTH OF TRIAL MIXES

Average Flexural Strength of trial mixes after 7 days:

S. No.	Trail Mix	Average Flexural Strength (N/mm2)	
		7 Days	Increase/decrease in av.strength
1	Sample Mix A	2.93	
2	Sample Mix B	2.4	(+)1.21
3	Sample Mix C	3.4	(-)1.39
4	Sample Mix D	3	(+)1.51
5	Sample Mix E	3.4	(-)1.71
6	Sample Mix F	**3**	**(+)2.14**
7	Sample Mix G	2.13	(-)2.54

Table 5.3.2: Average Flexural strength of trial mixes after 28 days:

S. No.	Trail Mix	Average Flexural Strength (N/mm2)	
		28 days	Increase/decrease in av. strength
1	Sample Mix A	5.2	
2	Sample Mix B	4.4	(+)3.91
3	Sample Mix C	4.67	(-)4.43
4	Sample Mix D	5.38	(+)5.05
5	Sample Mix E	4.93	(-)5.55
6	Sample Mix F	**4.8**	**(+)6.23**
7	Sample Mix G	21.33	(-)7.76

6. BASED ON WORKABILITY OF TRIAL MIXES

Various tests were conducted to determine the workability of trial mixes. The tests include Slump flow test, V-funnel test and U-box test. Results of the self-compactibility and strength tests conducted on seven trial mixes are presented in Table 5.4.1.

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Table 5.4.1: Self-compactability of trial mixes.

S. no.	Trial mix	Average Slump flow (mm)	U-Box (mm)	V-funnel (sec)
1	Sample Mix A	670	18.5	7
2	Sample Mix B	670	19	8.5
3	Sample Mix C	695	24	8
4	Sample Mix D	680	20	9.5
5	Sample Mix E	710	25	10
6	Sample Mix F	690	23	**11**
7	Sample Mix G	720	27	12

7. CONCLUSIONS

The primary aim of this project was to design a suitable S.C.C mix with LIME STONE DUST and thereafter determine its structural strength and workability. The main conclusions drawn from the results are summarized below:

- From seven trial mixes, we conclude that increasing the quantity of limestone as a substituent in replacement of fine aggregates increases upto 15% (replacement of fine aggregates) in different spicemens. The compressive strength increases by 25% to 35% against ordinary S.C.C. However there are adverse effect on compressive strength if we replace more than 15% of cement or 15% (fine aggregates and cement) keeping the percentage of super plasticizer and water cement ratio constant.
- We also summarized that there is increase in flexure strength by 3% to 5% against ordinary S.C.C if we replace more than 15% of cement or 15% (fine aggregates and cement) keeping the percentage of super plasticizer and water cement ratio constant.
- The S.C.C specimens with limestone dust displayed better performances with regard to water absorption. The water absorption of specimens exposed to normal laboratory conditions was 1.89% against 5% of conventional concrete.
- The compressive strength of S.C.C specimens increased with the time of curing. Carboxylic acrylic ester showed better strength properties and enhance the passing ability and flow ability of the self-compacted concrete.

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