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# Production of Dry Lean Concrete by Sustainable Materials to Use in Road Sub-Base Layer for Rigid Pavement

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***Abstract*—In the present scenario, due to the rapid demand on the infrastructure projects and consistent dependency over conventional materials have resulted in scarcity of the conventional construction materials and rise in construction costs. By replacing subbase layer of road with Dry lean concrete produced with sustainable materials, cost on the construction can be reduced by 51.4%.**

***The various soil used in this study are red soil, loamy soil and black cotton soil. These soils are brought from different places of Bangalore. These soils are used to totally replace the fine aggregates. The LD slag obtained from JSW steel manufacturing plant from Bellary. To use the steel slag in concrete making process of Low strength Dry Lean Concrete, initial optimization of materials (steel slag) was done with the 7days strength. The most desirable and equivalent material to that of natural aggregates (i.e. steel slag) was found to be at 50% replacement and 100% replacement of coarse aggregate with LD slag. The each batch of concrete is prepared with soil and combination of 100% slag, 50% natural aggregates + 50% LD slag and 100% natural aggregates. The various soils used are red soil, loamy soil and BC soil. These cubes, cylinder and beams are tested for compressive strength, split tensile strength and flexure strength respectively for 7days and 28 days, and water absorption for each specimen of cube is measured at 28 days.***

***It was observed that, strength of concrete produced using red soil, loamy soil are fulfilling the strength requirements of conventional dry lean concrete used as a sub base in rigid pavements. As per IRC: SP: 49-2014, the minimum strength requirement of cubes at 7 days is 7MPa.***

***Index Terms*— Dry lean concrete, LD Slag, Natural Coarse aggregates (NCA), Sustainable Materials, Wet Compressive Strength.**

## I. INTRODUCTION

his study, alternative materials were used for the production of concrete that is equivalent to the properties of DRY LEAN CONCRETE to be used as a sub base material in the rigid pavements. The main objective of the study is to reduce the cost of sub base layer in the rigid pavements therefore, alternative materials like LD slag and soils were used as coarse aggregate and fine aggregate.

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In this present study three types of soils are being used as fine aggregates in concrete with the full replacement to the sand in the dry lean concrete, the soil used are **red soil, loamy soil, and black cotton soil.** The comparison of the three soils on the basis of its compressive strength is studied and how far the various soils are used according to their strength characteristics is being analyzed.

Detailed study on soil properties are being carried out in this study and it was found that red soil and loamy soil with higher sand content is better in use of producing Dry lean concrete than black cotton soil.

According to the test carried out, it was found that black cotton soil contains higher plasticity index and various studies have been carried out to reduce the plasticity index of the black cotton soil. Treating soil with the lime is one of the best methods. In this study 5% of lime is used for stabilizing the soil. Lime stabilization involves, thorough mixing of lime to the soil and after pulverizing the soil with the slacked lime, soil is packed in bags and kept for 7days for the stabilization to happen, after stabilization the reduction in plasticity index of the stabilized soil is found out to be (4%- 5%). black cotton soil is used in the present study after it is being stabilized.


**Fig (i). Different types of soils used in the study**

To use soil in making of Dry lean concrete, soil is being sieved through 4.75mm sieve. The soil passing through 4.75mm sieve is the sand portion of soil that has to be used in concrete. It was found that about 60% to 50% of sand portion in red and loamy soil respectively but there is only 20% of sand portion was found in black cotton soil.

## II. OBJECTIVE OF THE STUDY

The objective of the study on Dry lean concrete is to use the locally available soil and to use the industrial waste (LD slag), which is alternative material for coarse aggregate, those would be economical and cost effective and effective use of various soil and steel slag include:

- The behaviour of Dry Lean Concrete using different soils as a fine aggregate
- The behaviour of Dry Lean Concrete using different soil and natural sand
- The behaviour of Dry Lean Concrete using different proportion of steel slag as coarse aggregates in different soils
- Strength parameters of Dry Lean Concrete using natural sand v/s different soils
- Strength parameters of Dry Lean Concrete using natural coarse aggregates v/s steel slag
- Optimization of steel slag usage in various soil
- The age effect on the strength parameters of different combination Dry Lean Concrete
- Water absorption characteristic of different combination Dry Lean Concrete
- Rate analysis of Dry Lean Concrete

## III. LITERATURE REVIEW

**[1] Chandrashekhar S Y (2016),** Materials such as steel slag, blast furnace slag are being used as replacement for coarse aggregates. This paper reports the result of different mixes obtained by partial replacement of natural coarse aggregates (CA) and complete replacement of fine aggregates (FA) by alternative material such as LD slag and Natural soil respectively.

**[2] Dr.K.Channaraju, (2013) et al,** attempted to make use of steel slag as a coarse aggregate in concrete and Eco sand which is a byproduct of cement industry as fine aggregate replacement. Possible optimum replacement of steel slag and ecosand in designed mix of M30 grade was found to be 60% and 40% respectively. Test on 7 and 28 days were conducted for compressive strength and split tensile strength and flexural strength. It was concluded that replacement of steel slag and eco sand in concrete will not have any adverse effect to the concrete.

**[3] Praveen Mathew (2013) et al,** studied on Steel Slag ingredients for concrete pavement, as the Steel Slag disposal had become environmental concern so the focus of study is over using steel slag aggregates as a ingredient in concrete pavement, thus using steel slag results in decreasing demand of conventional coarse aggregates. 20%, 40%, 60%, 80% and 100% replacement of steel slag to the conventional coarse aggregates was done and the results obtained for the compressive strength flexure strength and split tensile strength was compared with the conventional concrete.

**[4] Dr. V. P. Singh (2013),** studied on replacement of coarse aggregate to the Blast furnace slag to produce high performance concrete. In recent years High performance concrete is much being used because of its long term durability. In this study, well graded steel slag with 0.1% of water absorption, 19% crushing value and 22% impact value of steel slag was used. The compressive strength obtained using steel slag was found to be 10% to 15% higher than that of conventional concrete, from this study it was concluded that slag can be used as a good alternate material.

## IV. MATERIALS

### *A. CEMENT*

Portland cement of 43 grade confirming to IS 12269:1987 is used in this study. The specific gravity of cement is 3.10.

### *B. FINE AGGREGATES*

The properties of soil vary from place to place depending on the climatic factors and nature of parent rock available at the site. Each of the soil possess different physical properties such as water content, density, specific gravity, shrinkage properties and grain size distribution in the soil etc, basically the soil is formed by the weathering of the rock over a long time and the weathered rock with soil is transported from place to place and that get deposited. This cycle of event make possible to formation of the soil over the top layer of the earth. The chemical weathering to the soil is by the process of oxidation, hydration, carbonation and leaching by organic acids and water. In this present study, three types of soils were chosen which are from different places. The basic idea of choosing soils from different places is to study wide variety of soils and to make possible to use in the production of low strength concrete, which can possibly be used as a sub base material in the rigid pavement or in any other civil engineering application which warrant low strength requirements. Based on the preliminary test, the three soils were categorized (named) as red soil, loamy soil and black cotton soil (clayey soil). The red soil was procured from the site next the college in Bangalore, which has good amount of sand and fine fraction within, (i.e. 57% sand & 42 % fines). The second type of soil, (named 'Loamy') was procured based on the criteria of its abundance availability in local areas (currant geological location) was procured from Jigani, in South Bangalore. The preliminary tests on the second type of the soil classify it as a 'Loamy Soil" consists of the sand fraction of about 47% and fine fraction of about 52%. The third type of soil was procured from a construction site near Dharwad (North Karnataka).The basic criterion considered in choosing the soil from the Dharwad was to evaluate the strength characteristics of highly plastic soil. According to the geological studies carried out, about 70% of the soil in the north Karnataka is Black cotton soil. If this soil can be used (treated and utilised) as sub base material in the 'Dry Lean Concrete', then the major problems related with the pavement construction on similar strata may be solved. This soil was categorized as Black Cotton Soil (Clayey Soil) based on the grain size distribution, colour, texture and Atterberg Limits. In its native form this soil possessed 80% of fines and 20% of sand content.

Table(i): Physical properties of soils used

| Sl. No | Physical Properties | | Results | | |
|---|---|---|---|---|---|
| | | | Red soil | Loamy soil | BC Soil |
| 1 | Grain Size Distribution | Gravel% | 2.55 | 3.45 | 2.66 |
| 2 | | Sand% | **57.94** | **47.16** | **20.86** |
| 3 | | fines% | 42.06 | 52.83 | 79.14 |
| 4 | Specific gravity($G_s$) | | 2.55 | 2.60 | 2.72 |
| 5 | Liquid Limit W1 (%) | | 27.00 | 32.00 | 57.76 |
| 6 | Plastic Limit Wp (%) | | 21.83 | 19.13 | 37.12 |
| 7 | Plasticity Index Ip (%) | | 5.17 | 12.87 | 20.64 |

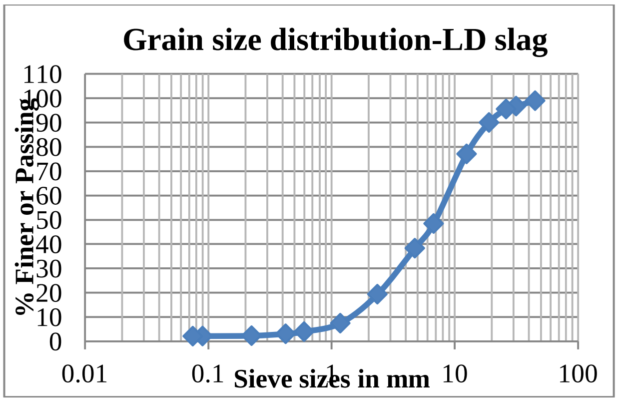
### *C. LD SLAG*

The slag was procured from the JSW steel plant Bellary, LD slag is by product, non-metallic material formed from the reaction of flux and non-metallic component present in the steel scrap. The LD Slag which was procured has good physical properties.

Various tests have been conducted on the slag and it is seen that, the slag possesses better physical characteristics to use for concrete making process and preliminary tests conducted on LD slag is shown in the table.

**Table(ii): Physical properties of LD Slag used**

| Sl No | Physical properties | Results | Permissible limits |
|---|---|---|---|
| 1 | Density, kg/m$^3$ | 1840.00 | - |
| 2 | Specific Gravity | 2.98 | 2.5-3.0 |
| 3 | Water absorption (%) | 1.89 | <2 |
| 4 | Impact value (%) | 17.00 | <30 |
| 5 | Crushing Value (%) | 22.10 | <45 |




Fig(ii): Grain size distribution of LD Slag

| | |
|---|---|
| Gravel | 60.67 % |
| Sand | 36.20 % |
| Fines | 2.09 |

*D. CONVENTIONAL COARSE AGGREGATES*

**Table (iii): Physical properties of convention coarse aggregate**

| Sl. No | Physical properties | Results | Permissible limits |
|---|---|---|---|
| 1 | Density, kg/m$^3$ | 1520 | - |
| 2 | Specific Gravity | 2.78 | 2.5-3.0 |
| 3 | Water absorption(%) | 1.56 | <2 |
| 4 | Impact value (%) | 18.50 | <30 |
| 5 | Crushing Value (%) | 24.40 | <45 |

*E. WATER*

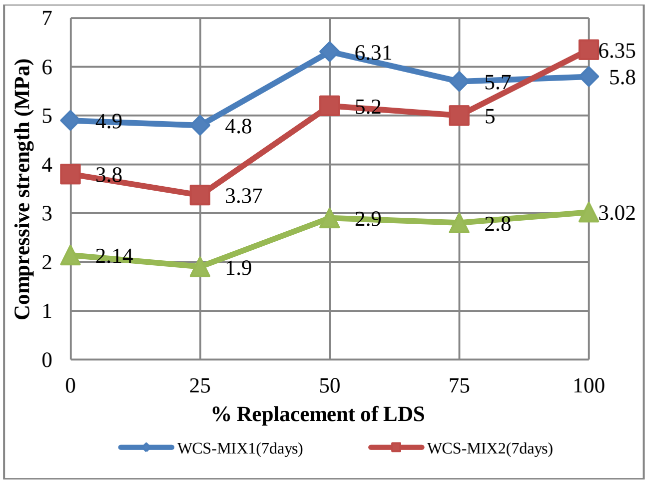
The potable water used for manufacture of Dry Lean Concrete in the study Water content corresponding to each mix was carefully monitored and it was fixed based on required slump values.

## V. EXPERIMENTAL PROGRAM

Trial mix was done to study the behaviour of DLC using soil as a fine aggregates and steel slag as a coarse aggregates and to study how much amount of steel slag has to be used to achieve the required strength of 10MPa. Study on Trial mixes was carried out find the optimum mixes of fine aggregates and coarse aggregate in DLC. Main purpose of this study is to achieve the strength of 10MPa in DLC mix. It was decided to replace the whole portion of sand content by soil. Soil used in this study is red soil, loamy soil and black cotton soil those contain sand portion of 60%, 80% and 35% respectively. Table (iii) Trial mix results

**Table (iii): Different Mixes of concrete under study**

| Sl. No | Type of soil used | Mix proportion Cement :Soil: (LDS+NCA) | Proportion name |
|---|---|---|---|
| 1 | Red soil (type1 soil) **MIX-1** | **1:3:(0+6)** | **RC** |
| | | 1:3:(1.5+4.5) | 25R75 |
| | | **1:3:(3+3)** | **RCS** |
| | | 1:3:(4.5+1.5) | 75R25 |
| | | **1:3:(6+0)** | **RS** |
| 2 | Loamy soil (type2 soil) **MIX-2** | **1:3:(0+6)** | **LC** |
| | | 1:3:(1.5+4.5) | 25L75 |
| | | **1:3:(3+3)** | **LCS** |
| | | 1:3:(4.5+1.5) | 75L25 |
| | | **1:3:(6+0)** | **LS** |
| 3 | Black soil (Type3 soil) **MIX-3** | **1:3:(0+6)** | **BC** |
| | | 1:3:(1.5+4.5) | 25B75 |
| | | **1:3:(3+3)** | **BCS** |
| | | 1:3:(4.5+1.5) | 75B25 |
| | | **1:3:(6+0)** | **BS** |
| 4 | NATURAL RIVER SAND **MIX-4** | **1:3:(0+6)** | **SC** |
| | | 1:3:(1.5+4.5) | 25S75 |
| | | **1:3:(3+3)** | **SCS** |
| | | 1:3:(4.5+1.5) | 75S25 |
| | | **1:3:(6+0)** | **SS** |




Fig(iii): Compressive strength of Trial mixes at 7days

In the figure shown above the DLC prepared with the loamy soil as fine aggregate gives the optimum compressive strength at 100% replacement and there is a increase in strength after 25% replacement can be seen up to 50% Replacement, After that once again there is a decrease in strength of DLC mix, therefore in this DLC mix, therefore the further study was carried out to the DLC mixes of 0%, 50% and 100% replacement. The results shown in the table and figures shown above clearly depicts decrease in strength at 25% and 75% Replacement of coarse aggregate with slag in all the soils.

So the further detailed study was carried out on mix proportions of 1:3:0:6, 1:3:3:3 and 1:3:0:6 (i.e. 0%, 50% & 100%) in all the soils.

The process of casting procedure involves the various steps and those steps are listed in sequential order below:

- Sieving
- Batching
- Mixing
- Compaction
- De moulding
- Curing.

**Fig(iv): Process of casting**

## VI. RESULT AND DISCUSSION

RC, LC, BC and SC proportions were compared with their respective cube compressive strength and it was found that, conventional concrete (SC) achieves the maximum strength (5.61MPa) at 7 days as well as (11.68MPa) 28 days but there no significant difference in the strength achieved by RC and conventional low strength concrete proportion (SC).7 days strength of RC is 44.55% of total strength observed at 28 days for the same mix, similarly 48.72% for LC proportion, 46.35% for BC proportion and 48.03% for SC proportion. The strength observed in conventional low strength concrete at 28 days for SC proportion is only about 5.82% higher than RC where Red soilwas being used as fine aggregate. In mix proportions of RC, LC, BC and SC, consisting FA as different soil and 100% NCA, from the results of comparing these proportion, one can say strength characteristics will vary with soil types in the mix proportion of Low strength concrete.

In proportions RCS, LCS, BCS and SCS, strength achieved in the SCS proportion is higher (10.35MPa) at 7 days which is 68.14% of total strength achieved by same proportion at 28days similarly RCS, LCS and SCS proportions have achieved 67.87%, 77.30%, 79.55% respectively. The strength gain in the proportions RCS, LCS, BCS & SCS at 7 days is comparatively more than strength achieved in the proportions RC, LC, BC and SC respectively. The increase in strength gain may be because of usage of 50% LDS in coarse aggregate portion of low strength concrete. There is no much significant difference in compressive strength RCS proportion and the SCS proportion, only 3.49% increase in the strength was observed for the conventional concrete proportion at 28 days. So instead of using SCS proportion with sand as a fine aggregate red soil may be recommended to use with 50% replacement of LD Slag coarse aggregate portion.

**Table (iv): Wet compressive strength at 7 and 28 days**

| Sl. No | Type of mix proportion | WCS-Cube (MPa) | |
|---|---|---|---|
| | | 7 days | 28 days |
| 1 | RC | 4.90 | 11.00 |
| 2 | LC | 3.80 | 7.80 |
| 3 | BC | 2.41 | 5.20 |
| 4 | SC | 5.61 | 11.68 |
| 5 | RCS | 9.93 | 14.63 |
| 6 | LCS | 9.91 | 12.82 |
| 7 | BCS | 4.20 | 5.28 |
| 8 | SCS | 10.35 | 15.16 |
| 9 | RS | 12.26 | 15.96 |
| 10 | LS | 10.95 | 13.04 |
| 11 | BS | 4.50 | 5.45 |
| 12 | SS | 11.72 | 18.78 |

The compressive strength of BCS is lowest among all the proportions. In the proportions RS, LS, BS, and SS, different soils were being used as FA and only LDS as NCA. These proportions of low strength concrete shows higher wet compressive strength of Cube compared with other proportions used in the study, from the results it is clear that, only 15.01% of higher compressive strength was achieved in the conventional concrete with respect to the RS proportion, similarly 30.56% in LS and 70.97% in BS was observed for 28 days Cube compressive strength. From the study Soil-1 and Soil-2 were observed to be good FA in the production of low strength concrete where 100% NCA was replaced with LDS. 76.81% of strength gain was observed at 7 days of curing for the RS proportion and similarly 83.95%, 82.56% and 62.40% was observed for LS, BS, and SS proportion respectively. Higher cube compressive strength was observed in RS, LS, BS and SS proportions among the different mixes, the reason may be replacement of LDS to NCA had resulted in yielding the good compressive strength.

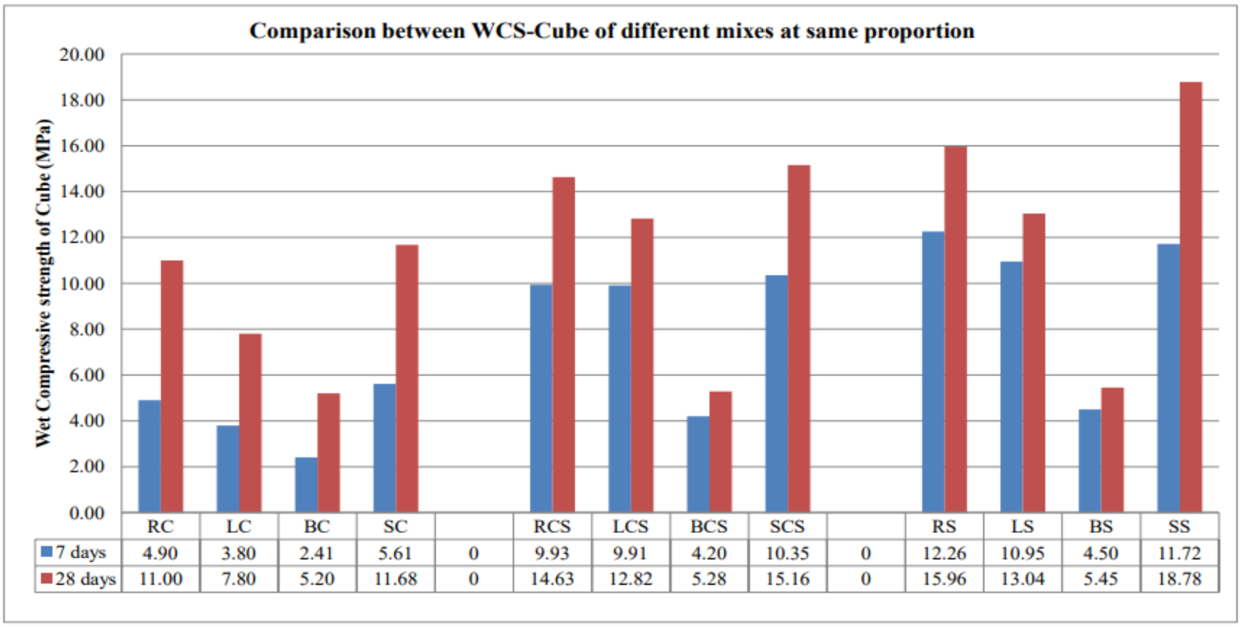
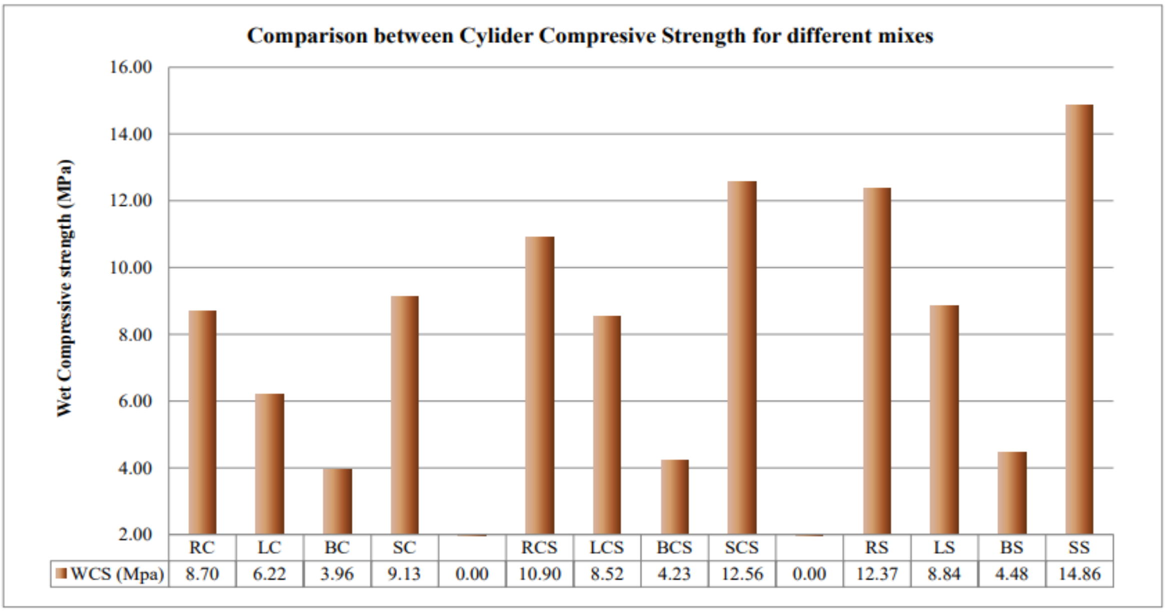



**Fig (v): Comparison of Wet compressive strength of various mixes**

The cylinder compressive strength same proportion of different mixes are compared in the Figure CCS of RC is 4.70 % less than the conventional mix using sand as FA and CCS of LC is 31.87% less than SC similarly BC is less than 56.62%. Since RC proves to be the good proportion among LC & BC. Many journals and code suggests that, cylinder compressive strength should lie between 0.75 – 0.87 of cube compressive strength. CCS values of RC, LC, BC and SC lies in the suggested range. From the study it was observed that, RC has the maximum strength followed by LC and BC in Low strength Dry Lean Concrete when 100% NCA was used. The RCS, LCS, BCS and SCS have comparatively higher CCS value than RC,LC, BC and SC respectively, this means increasing the percentage of LDS in concrete had resulted in increasing CCS. Only 13.21% increase in the CCS was observed in

Conventional concrete than RCS proportion using Soil-1. The higher CCS was observed in RS, LS, BS and SS compared to their respective mixes. RS proportion had resulted in achieving 83.24% of CCS of conventional concrete proportion (i.e. SS). CCS of RS, LS, BS& SS lie in the range of 0.75 – 0.87 of cube compressive strength.

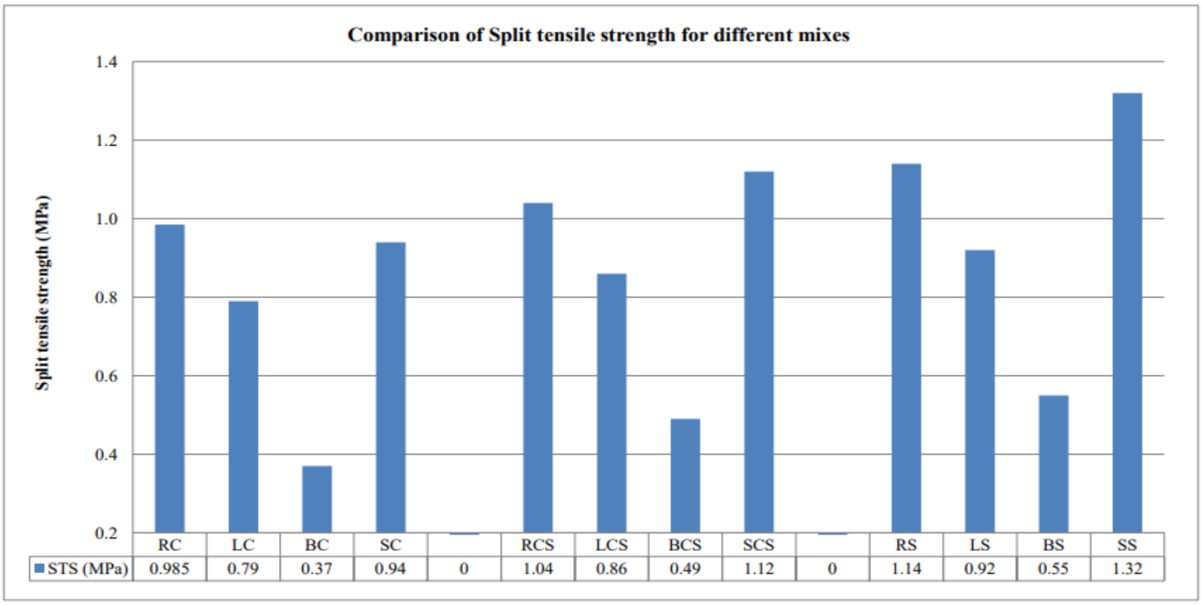



**Fig(vi): Comparison of Cylinder compressive strength of various mixes**

**Table (v): Split tensile strength at 28 days**

| Sl. No | Type of mix proportion | Proportion of coarse aggregates | STS-Cylinder (MPa) |
|---|---|---|---|
| 1 | RC | NCA (100%): LDS (0%) | 0.985 |
| 2 | LC | NCA (100%): LDS (0%) | 0.79 |
| 3 | BC | NCA (100%): LDS (0%) | 0.37 |
| 4 | SC | NCA (100%): LDS (0%) | 0.94 |
| 5 | RCS | NCA (50%): LDS (50%) | 1.04 |
| 6 | LCS | NCA (50%): LDS (50%) | 0.86 |
| 7 | BCS | NCA (50%): LDS (50%) | 0.49 |
| 8 | SCS | NCA (50%): LDS (50%) | 1.12 |
| 9 | RS | NCA (0%): LDS (100%) | 1.14 |
| 10 | LS | NCA (0%): LDS (100%) | 0.92 |
| 11 | BS | NCA (0%): LDS (100%) | 0.55 |
| 12 | SS | NCA (0%): LDS (100%) | 1.32 |

In RC, LC, BC and SC proportions, were tested for its split tensile strength. The STS of RC and SC were similar i.e., 0.985MPa and 0.94MPa respectively. In fact RC has the higher split tensile strength. LC is 15.95% less than the proportion SC. BC possess least value of STS among all in this combination, which is understood because of its clayey property. The STS of RC is about 11.77% of CCS. 12.7% for LC, 9.34% for BC and 10.29% for SC. As per literatures, the STS value of concrete mix is up to 10% of CCS of same mix and proportion. The proportions RCS, LCS, BCS, and SCS consists of soil as FA, 50% NCA and 50% LDS as CA. From results, RCS (1.04MPa) has less split tensile strength compared with SCS (1.12MPa). The value of LCS is 23.21% less than SCS, BCS showed 56.25% less strength compared to SCS. The strengths are compared with cylinder compressive strength to check its consistency and reliability. STS of RCS is about 9.51% of CCS, 10.09% for LCS; 11.58% and 10.03% for BCS and SCS respectively. The value of split tensile strength is slightly less than conventional concrete for proportion containing 50% NCA and 50% LDS. The STS of RS is 1.14MPa and SS is 1.32MPa; STS of LS is 19.21% less than that of RS and 30.30% less than SS. The STS of RS is 9.21% of CCS. SS is 8.88%, for LS it is10.40% and for BS it is 12.27%. The increase in percentage of LDS has resulted in the increase in value of split tensile strength.




**Fig(vi): Comparison of Split tensile strength of various mixes**

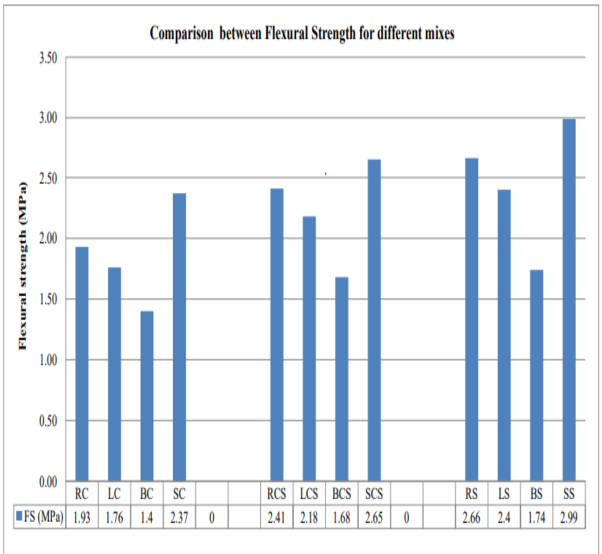
In RC, LC, BC and SC proportions, were tested for its split tensile strength. The STS of RC and SC were similar i.e., 0.985MPa and 0.94MPa respectively. In fact RC has the higher split tensile strength. LC is 15.95% less than the proportion SC. BC posses least value of STS among all in this combination, which is understood because of its clayey property. The STS of RC is about 11.77% of CCS. 12.7% for LC, 9.34% for BC and 10.29% for SC. As per literatures, the STS value of concrete mix is up to 10% of CCS of same mix and proportion. The proportions RCS, LCS, BCS, and SCS consists of soil as FA, 50% NCA and 50% LDS as CA. From results, RCS (1.04MPa) has less split tensile strength compared with SCS (1.12MPa). The value of LCS is 23.21% less than SCS, BCS showed 56.25% less strength compared to SCS. The strengths are compared with cylinder compressive strength to check its consistency and reliability. STS of RCS is about 9.51% of CCS, 10.09% for LCS; 11.58% and 10.03% for BCS and SCS respectively. The value of split tensile strength is slightly less than conventional concrete for proportion containing 50% NCA and 50% LDS. The STS of RS is 1.14MPa and SS is 1.32MPa; STS of LS is 19.21% less than that of RS and 30.30% less than SS. The STS of RS is 9.21% of CCS. SS is 8.88%, for LS it is10.40% and for BS it is 12.27%. The increase in percentage of LDS has resulted in the increase in value of split tensile strength

The Flexural strength of RC was found to be 1.93MPa which is 18.56% more than SC (2.37MPa). The value of SC is 23.73% higher than that LC(1.76MPa) and LC showed 20.45% higher strength than that of BC (1.40MPa). As per code, the flexural strength of concrete mix shall be equal to 0.7√fck where fck = Characteristic strength of concrete cube.

**Table (vi): Flexural strength at 28 days**

| Sl. No | Type of mix proportion | Proportion of coarse aggregates | Flexural strength (MPa) |
|---|---|---|---|
| 1 | RC | NCA (100%): LDS (0%) | 1.93 |
| 2 | LC | NCA (100%): LDS (0%) | 1.76 |
| 3 | BC | NCA (100%): LDS (0%) | 1.40 |
| 4 | SC | NCA (100%): LDS (0%) | 2.37 |
| 5 | RCS | NCA (50%): LDS (50%) | 2.41 |
| 6 | LCS | NCA (50%): LDS (50%) | 2.18 |
| 7 | BCS | NCA (50%): LDS (50%) | 1.68 |
| 8 | SCS | NCA (50%): LDS (50%) | 2.65 |
| 9 | RS | NCA (0%): LDS (100%) | 2.66 |
| 10 | LS | NCA (0%): LDS (100%) | 2.40 |
| 11 | BS | NCA (0%): LDS (100%) | 1.74 |
| 12 | SS | NCA (0%): LDS (100%) | 2.99 |

In RCS, LCS, BCS, and SCS the flexural values of RCS and SCS are similar i.e., 2.41MPa and 2.65MPa respectively. SCS has highest flexural strength (2.65MPa) and BCS has flexural strength of 1.68MPa. Proportions with NCA-50% and LDS-50% have performed well as far as Flexural Strength parameter is concerned and also similar behaviour was observed for other strength parameters. In RS, LS, BS, SS, Flexural strength for RS is good when compared to SS, which indicated that, the strength achieved mix produced with Red soilis reasonably good when compared with conventional concrete (SS). From above results it is observed that the increase in Flexure strength consistently have improved with the increased percentage of LD slag being used. This is true for all types of materials (soils or sand) are being used as Fine Aggregate. This shows use of LD slag definitely improves strength but increase in water absorption values was observed; effect of which must be further explored.




**Fig(vii): Comparison of Flexural strength of various mixes**

## VII. RATE ANALYSIS

**Table (vii): Proportions considered for rate analysis**

| Name | Coarse aggregate proportion | Fine aggregates used | Proportion (cement : soil: LD slag : coarse aggregate) |
|---|---|---|---|
| Proportion 1 | NCA (100%): LDS (0%) | Soil | 1:3:0:6 |
| Proportion 2 | NCA (50%): LDS (50%) | Soil | 1:3:3:3 |
| Proportion 3 | NCA (0%): LDS (100%) | Soil | 1:3:6:0 |
| Proportion 4 | NCA (100%): LDS (0%) | Natural Sand | 1:3:0:6 (Conventional concrete) |
| Proportion 5 | NCA (50%): LDS (50%) | Natural Sand | 1:3:3:3 |
| Proportion 6 | NCA (0%): LDS (100%) | Natural Sand | 1:3:6:0 |

**Table (viii): Cost calculation for 100mm and 150mm thick sub base layer for different concrete proportions**

| Sl. No | Different proportions | Amount (Rs) per Cu.M | Total amount required for 100mm thickness sub base layer/km (Rs) | Total amount required for 150mm thickness sub base layer/km (Rs) | % Reduction in cost |
|---|---|---|---|---|---|
| 1 | Proportion 1 | 2493 | 934875 | 1402313 | 44.60 |
| 2 | Proportion 2 | 2340 | 877500 | 1316250 | 48.00 |
| 3 | Proportion 3 | 2187 | 820125 | 1230188 | 51.40 |
| 4 | Proportion 4 | 3576 | 1341000 | 2011500 | 20.53 |
| 5 | Proportion 5 | 3510 | 1316250 | 1974375 | 22.00 |
| 6 | Proportion 6 | 3270 | 1226250 | 1839375 | 27.33 |
| 7 | RMC, M10 concrete | 4500 | 1687500 | 2531250 | 0.00 |

## VIII. CONCLUSION

1. The Dry Lean Concrete produced using Red soil and LDS showed better results. The strength achieved at 7 days for this mix was 76% of the 28 days strength which is well within permissible limit as per code
2. The mix proportion with Loamy soil with 100% LDS achieved 13.04MPa @ 28 days which is satisfactory as it is higher than designed strength. Along with cube compressive strength even Cylinder Compressive Strength, Flexural Strength and Split Tensile Strength were reasonably good.
3. The mix proportion with Black cotton soil and LDS showed consistent result with respect to all strength parameters (WCS, CCS, STS, and FS) when compared with other proportions of different mixes. The strength achieved at 7 days was around 80% of the 28 days strength when LDS was used as CA. Hence, one can consider lime stabilized Black cotton soil and LDS in concrete mix for further performance studies.
4. Water absorption increases with increase in the percentage of LDS. Water absorption in all the mix proportions is within limits. The increase in the water absorption characteristics with increase in LDS may further be explored
5. As per IRC: SP: 49-2014, the minimum strength requirement of cubes at 7 days is 7MPa. Here, MIX-1 and MIX-2 satisfy the condition. So these mixes may be further studied for their field performance evaluation.
6. Certain places in Indian subcontinent contain Gravelly Soil / Sandy Soils. One can make use of this locally available soil and by products of production like LD Slag in the production of concrete results in sustainability and utilization of natural resources.

7. Use of Naturally available Soil and LD slag in concrete mix cuts down the cost of mix up to 39% when compared with Normal Conventional

Concrete; up to 51.4% when compared with Ready mix concrete of equivalent Grade.

8. Using locally available source (Natural soil) reduces the transportation charges, which may reduce the cost of construction project.

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