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# Soil Stabilization Using Construction and Demolition Waste for Pavement Construction

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***Abstract:*** ***This study evaluated soil properties and the impact of adding construction and demolition waste on pavement performance. Tests included water content, specific gravity, Atterberg's limit, sieve analysis, compaction, and California bearing ratio. Soil samples were mixed with 10%, 20%, 30%, and 40% construction and demolition waste.***

***Results Showed:***
- ***Maximum dry density decreased from 1.88g/cc (0% waste) to 1.767 g/cc (40% waste).***
- ***Optimum moisture content decreased from 11.95% (0% waste) to 11.08% (40% waste).***
- ***California Bearing Ratio (CBR) increased from 3.82% (raw soil) to 14.04% (40% waste).***

***These values meet Indian Standard Codal specifications (IS 2720, 1983) for pavement subgrade and embankment construction. Therefore, construction and demolition waste can be an effective soil additive for pavement and embankment construction, potentially reducing pavement thickness per CBR design.***
***Keywords: Atterberg's limits, soil stabilisation, California bearing ratio, Pavement,embankment, optimum moisture content, maximum dry density, construction and demolition waste***

## I. INTRODUCTION

The explosive growth of population in recent decades, accompanied by the rapid urbanisation and socio-economic development has resulted in the need for more efficient and economical vehicular operations, which is reliant on the quality of road structures. The strength and shear characteristics of the pavement subgrade are essential for the adequate quality and appropriate performance of the road. It reinforces the social, economic, and cultural development of the country.

### *A. Soil Stabilization*

Stabilization is the process of altering specific soil properties by different method in order to obtain an improved material that has all the desired engineering characteristics. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation; and thus creating a soil material or system that will withstand the designed use conditions and life of the project. The main objective of this study is to effectively stabilize the locally available subgrade in a cost-efficient manner.

### *B. Sub-grade*

Sub grade is a lowermost part of road pavement structure, which acts as a stresstransmitting medium and disseminates the acting wheel load such that it aids in the prevention of shear and consolidated deformation. However, several researches have indicated that existing soils often do not fulfil the conventional requisites for the highway material. Even the soils that exhibits satisfactory characteristics for pavements construction can undergo changes in several attributes during construction and consequent operation, in which gradation is considered as most sensitive. It is therefore is essential to stabilize the soil. Recent years have witnessed several countries considering the reutilization of waste materials as a new construction material as a significant sustainable construction activity.

This study concentrates on reuse of recycled concrete aggregate as a partial replacement for soil in order to achieve stabilization. In recent times, with the increased demand for infrastructural development, raw materials and fuel, soil stabilization has gained a significant amount of emphasis.

With the availability of better research, materials and equipment, it has been emerging as a beneficial and cost- effective method for soil improvement.

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### *C. Construction and Demolition Waste*

The waste generated from construction, renovation, repair, and demolition of houses, large building structures, roads, bridges, piers, and dams is categorised under construction and demolition waste. It constitutes of wood, steel, concrete, gypsum, masonry, plaster, metal, asphalt, et\cetera. C&D waste can also contain hazardous materials such as asbestos and lead. Estimates vary, but commonly accepted statistics say that 15% to 20% of generated municipal solid waste originates from construction and demolition projects. Specifically, for India, the Building Materials Promotion Council (BMPC) estimates 1504.444 million tonnes of C&D waste annually, while its capacity is only that of 6,500 tonnes per day (TPD), which is barely 1% of the waste quantity produced.

The aim of this research is to determine the soil improvement capabilities of recycle aggregates obtained from demolition waste. The main cause of using demolition waste in place of other improvisation materials such as lime, bitumen etc is that these materials poseand more significant and direct damage to the environment.

## II. MATERIALS USED AND METHODOLOGY

Construction and Demolition waste was used in powdered form, consisting of the following materials:

1) Broken concrete pieces
2) Sand
3) Bricks
4) Cement
5) Fly ash, etcetera.

Soil sample was collected from the Sitapur district (Banoga village). Initial tests were conducted on raw soil sample, followed by tests that were performed on the soil sample mixed it with construction and demolition waste in varying percentages (10%, 20%, 30%,and 40%).


Fig.1 Location of soil sample collection: Banoga village, Sitapur, Uttar Pradesh (source:GoogleEarth) [Latitude:27.1531501°N, Longitude:80.8626856°E]

| *Serial Number* | *Engineering Property* | *Test used for determination* | *ReferredIS Code* | *Value* |
|---|---|---|---|---|
| 1 | Water Content | Oven Drying | IS 2720:Part II | 8.80% |
| 2 | Specific Gravity | Density Bottle | IS 2720:Part III | 2.639 |
| 3 | Liquid limit | Cassagrande's apparatus | IS 2720:Part V | 26.10% |
| 4 | Plastic limit | 3 mm Thread rolling | IS 2720:Part V | 21.35% |
| 5 | Coefficient of uniformity (Cu) | Dry sieve analysis | IS 2720:Part IV | 9.617 |
| 6 | Coefficient of curvature (Cc) | Dry sieve analysis | IS 2720:Part IV | 1.411 |
| 7 | Maximum Dry Density | IS Heavy compaction | IS 2720:Part VIII | 1.88 g/cc |
| 8 | Optimum Moisture Content | IS heavy compaction | IS 2720:Part VIII | 11.95% |
| 9 | California Bearing Ratio | CBR Test | IS 2720:Part XVI | 3.82% |

Table 1. Engineering properties of soil sample under study, estimated according to the specifications of IS 2720 : 1983

## III. RESULT AND DISCUSSION

### A. *IS Light Compaction Test*

The test was conducted on mixtures of soil with increasing percentages (10%, 20%, 30% and 40%) of construction anddemolition waste as per the specifications of IS 2720 : 1983Part VII, and the following results were obtained :

| *SerialNumber* | *Soil + Percentage of C&D waste added* | *Maximum Dry Density* | *Optimum Moisture Content* |
|---|---|---|---|
| 1 | Soil + 0% C&D waste | 1.88 g/cc | 11.95 % |
| 2 | Soil + 10% C&D waste | 1.853 g/cc | 11.83 % |
| 3 | Soil + 20% C&D waste | 1.814 g/cc | 11.44 % |
| 4 | Soil + 30% C&D waste | 1.791 g/cc | 12.60% |
| 5 | Soil + 40% C&D waste | 1.767 g/cc | 11.08% |

Table 2. Variation of Maximum Dry Density and Optimum Moisture Content with increasing percentages of construction and demolition waste

Since the used construction and demolition waste has a lesser weight than soil sample, when same volume is taken into consideration, and also due to its lower specific gravity than the soil; a decrease in the maximum dry density of soil withaddition of construction and demolition waste in increasing percentage is demonstrated:

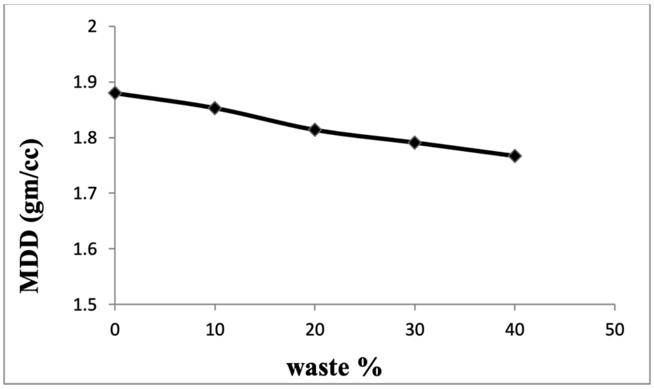


Fig. 2. Graphical representation of the variation of MDD with increasing percentages of C&D waste

Due to the inorganic nature of construction and demolition waste, lesser water was required to each the maximum dry density, hence there was an overall decrease in theoptimum moisture content with increasing percentage of construction and demolitionwaste, as shown in the following illustration:

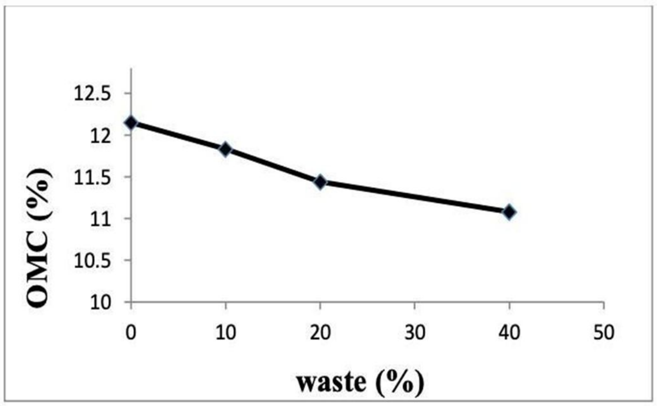


Fig. 3. Graphical representation of the variation of OMC with increasing percentages of C&D waste

### B. *California Bearing Ratio Test*

The test was conducted on mixtures of soil with increasing percentages (10%, 20%, 30%and 40%) of construction anddemolition waste, as per the specifications of IS 2720:1983Part XVI.

| *Serial Number* | *Soil + Percentage of C&D waste added* | *CBR Value* |
|---|---|---|
| *1* | Soil + 0% C&D waste | 3.82 % |
| *2* | Soil + 10% C&D waste | 5.47 % |
| *3* | Soil + 20% C&D waste | 8.13 % |
| *4* | Soil + 30% C&D waste | 11.02 % |
| *5* | Soil + 40% C&D waste | 14.04 % |

Table 3. Variation of California Bearing Ratio with increasing percentages of C&D waste added

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Analysis of the above results shows that addition of construction and demolition waste hasa direct positive impact on thequality of soil as pavement sub-grade material. The CBRvalue of soil shows a continuous increase with the addition of construction and demolitionwaste; increasing it from 3.82% in the raw soil sample to 5.47%, 8.13%, 11.02% and 14.04% in mixtures of soil with 10%, 20%, 30% and 40% of construction and demolition waste. This increase in CBR value is illustrated in the following figure:

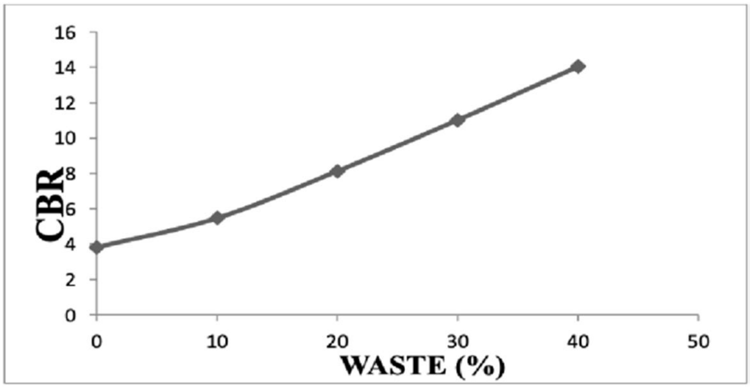


Fig. 4. Graphical representation of variation of CBR value with increasing percentages of C&D waste

### *C. Discussion*

According to the specifications of IS 2720:1983, for embankment and subgrade –

| *Property* | *For embankment* | *For subgrade* | *Relevant code* |
|---|---|---|---|
| Density | > 1.52 g/cc | > 1.60 g/cc | IS 2720 Part 8 |
| Moisture content | 9-18% | 9-18% | IS 2720 Part 2 |
| CBR Value | Minimum 2% | Minimum 6% | IS 2720 Part 16 |

Table 4. Specifications for soil for embankment and subgrade, according to IS 2720 : 1983

Since the addition of construction and demolition waste ensures that the properties of soillie within the acceptable range for embankment as well as pavement subgrade, we can conclude that construction and demolition waste can be elucidated as a satisfactorily economical as well as environment friendly additive to soil.

## IV. CONCLUSION

The study of strength characteristics of stabilization soil using construction and demolition waste show that there is a general decrease in maximum dry density (MDD)as well as optimum moisture content (OMC) of the soil sample.

The California Bearing Ratio of original soil sample is found to be 3.82%, which is sufficient for embankment (as perIS: 2720 Part 16, minimum for embankment 2%) but isnot sufficient for pavement subgrade (as per IS: 2720 Part 16, minimum for subgrade 6%).

Hence, construction and demolition waste is mixed with the soil for the purpose of improving the CBR value. Consequently, an increase in the CBR value is observed; withincreasing percentage of construction and demolition waste content in the soil. The CBRvalues corresponding to 10%, 20%,30% and 40% C&D waste are found to be 5.47%, 8.13%,11.02% and 14.04% respectively; which also satisfy the aforementioned IS code recommendations.

Hence, we can justify the of use soil stabilised using construction and demolition waste for the purpose of pavement subgrade, as well as embankment design and construction. Itcan be adopted as an easily procurable and ecologically as well as fiscally advantageous soil stabiliser.

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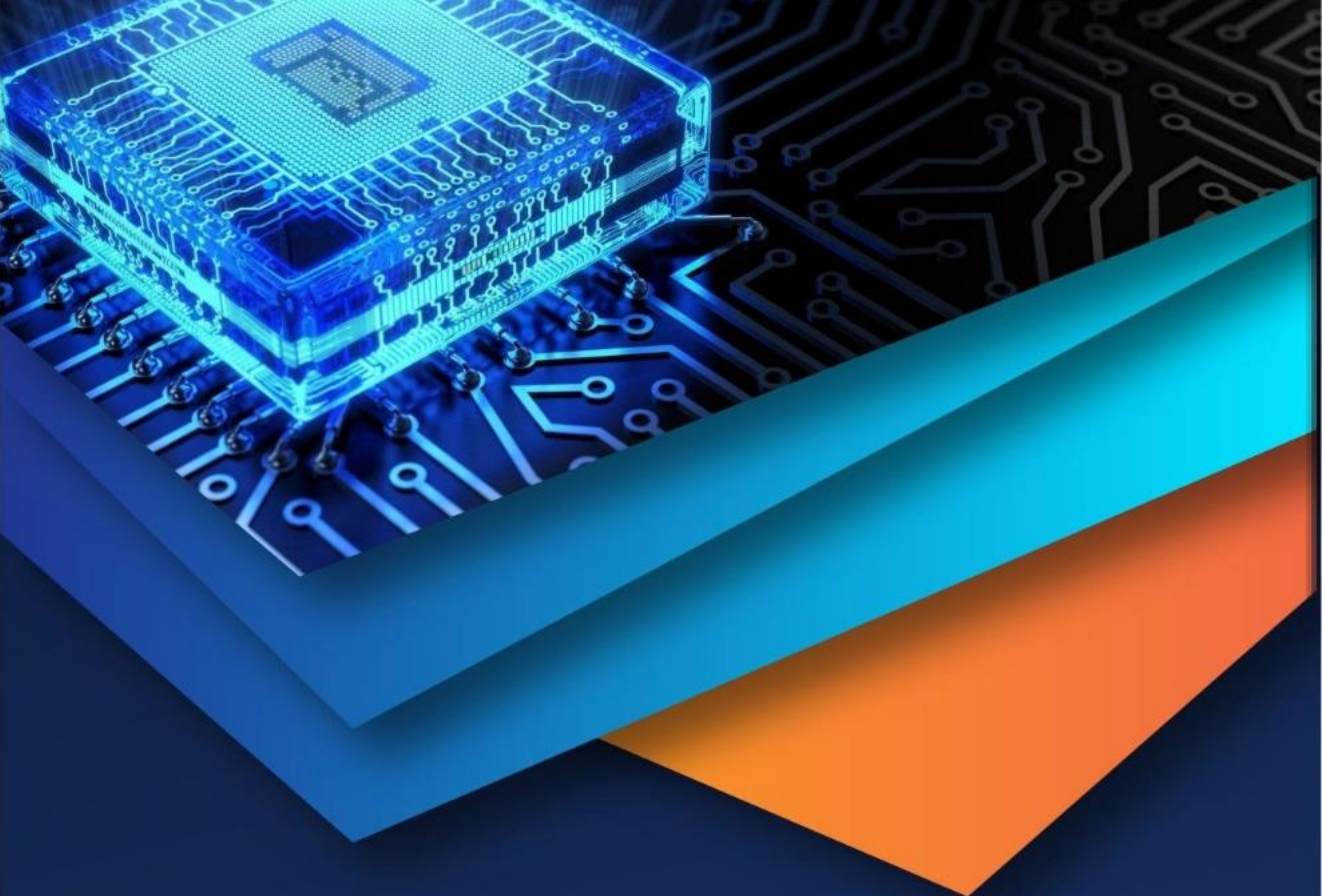

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