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# Cost Optimization of Foundation on Low SBC Soil.

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**ABSTRACT:**

This study investigates foundation design cost optimization techniques in regions with poor soil bearing capacity (SBC). The study highlights how crucial it is to choose the right foundation types and building methods to maximize stability and reduce expenses. The study finds important elements impacting each option's cost-effectiveness by thoroughly examining several foundation systems, including as shallow and deep foundations. The performance of various foundations under various soil conditions is assessed using empirical data and sophisticated modelling approaches. The results offer practical advice on how to choose materials, alter designs, and build methods that can drastically lower foundation costs without sacrificing structural soundness or safety. This study advances the subject of geotechnical engineering by providing recommendations for professionals dealing with low sbc of soil on foundation.

**Keywords:** Low SBC soil, cost optimization, rectangular footing

## 1.Introduction:

The Soil bearing Capacity is the main fundamental in the project conduction our project includes a calculation of loads acting on foundation and foundation design with required size and strengths

Basically the soil bearing capacity refers to the maximum load per unit area without undergoing any shear failure or excessive settlement.

In areas with low SBC Soil the ground is less capable of sustaining with the load. In this type of soil following methods used to construct the buildings

1. Soil Stabilization
2. Pile Foundation
3. Combined footing
4. Rectangular footings
5. Square Footings

The Projects based on the variations of foundation size, which deals with the cost optimization of the foundation with various size and various types of characteristics Compressive Strength (Fck) and yield strength (Fy) also the project deals with following characteristics of soil;

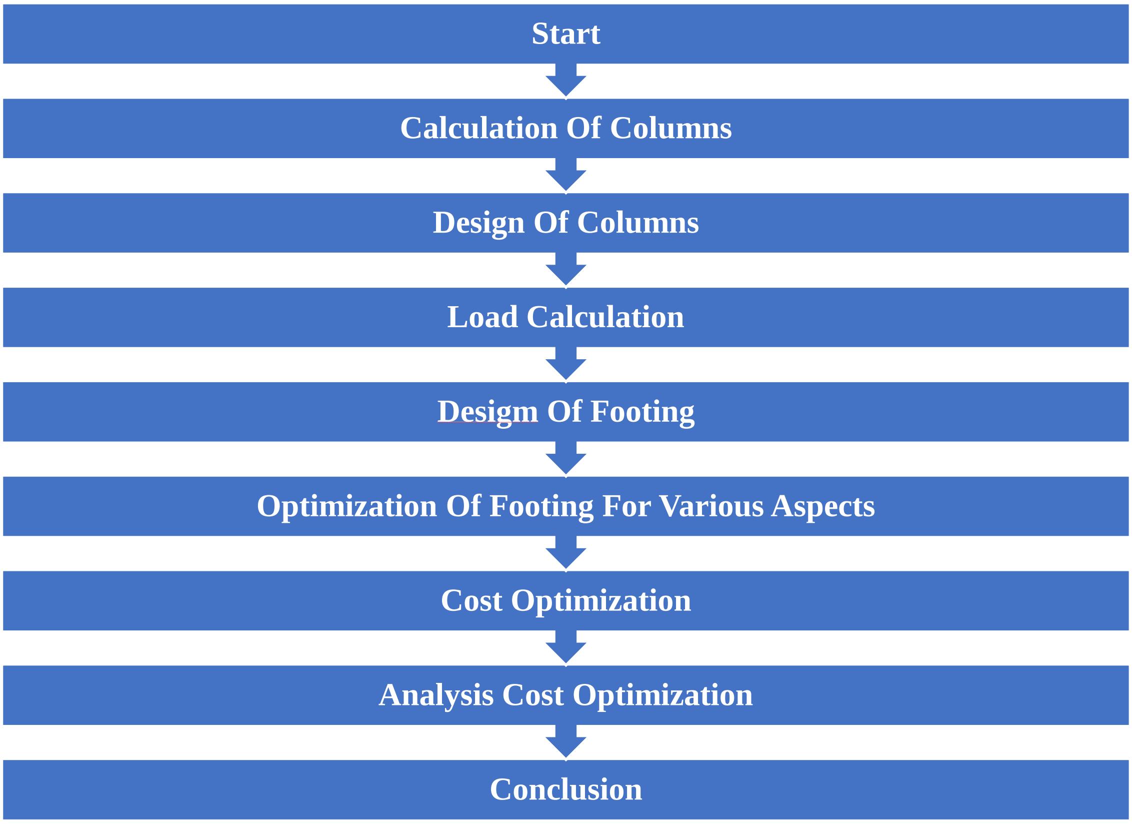
1. High compressibility
2. Low shear strength
3. Variable moisture content
4. Instability

## 2.Objectives of the study:

1. **Minimize foundation costs:** Reduce the cost of foundation construction while ensuring the structural integrity and safety of the building.
2. **Maximize foundation efficiency:** Optimize foundation design to achieve the required bearing capacity while minimizing material usage and excavation.
3. **Improve foundation stability:** Ensure the foundation can withstand various loads and stresses, including those imposed by low SBC soil.

4. **Reduce settlement and movement:** Minimize foundation settlement and movement to prevent damage to the structure and adjacent buildings.
5. **Enhance durability and lifespan**: Optimize foundation design and materials to extend its lifespan and reduce maintenance costs.
6. **Comply with regulatory requirements:** Ensure the foundation design meets local building codes, regulations, and standards.
7. structural system to reduce loads on the foundation and minimize material usage.
8. **Foundation type selection**: Choose the most suitable foundation type (e.g., shallow, deep, or pile foundation) for the specific site conditions.

## 3. Methodology:



## 4. Experimental results:

| | | | | | |
|---|---|---|---|---|---|
| | **Size Of Column LXB** | | 400 | 400 | Sq.MM |
| | **Axial Service Load** | P= | | 2000 | kN |
| | **Safe Bearing Capacity** | = | | 100 | kn/m2 |
| | **Fck** | = | | 30 | N/mm2 |
| | **Fe** | | | 500 | HYSD BARS |
| | | | | | |
| **STEP 1** | **LOAD CALCULATION** | | | | |
| | Axial Load on Column | P= | | 2000 | Kn |
| | Ultimate Load | | | 3000 | Kn |
| | Self Weight Of footing And Backfill | | | 200 | Kn |
| | total load | | | 5200 | Kn |
| | | | | | |
| **STEP 2** | **SIZE OF FOOTING** | | | | |
| | TOTAL LOAD ON FOOTING | | | 5200 | KN |
| | CONSIDER SQUARE | | | | |
| | FOOTING | L=B | | | |
| | AREA OF FOOTING B*B | | TOTAL LOAD | 52 | M2 |
| | | | SBC | | |
| | SIZE OF FOOTING | L=B | | 4.900 | |
| | ADOPT SIZE= | L= | | 10.61 | |
| | | B= | | 4.90 | |
| | Area Provided | | | 51.99 | Sq.mt |

| | | | | | | |
|---|---|---|---|---|---|---|
| **STEP 3** | **NET UPWORD SOIL PRESSURE OF ULTIMATE LOAD** | | | | | |
| | ULTIMATE LOAD | | 3000 | | | |
| | AREA PROVIDED | A= | 51.99 | | | |
| | SOIL PRESSURE | qu | 100.02 | Kn/M2 | | |
| | $Soil\ Pressure = \frac{total\ factored\ load}{area\ provided}$ | | 0.1000 | N/MM2 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **STEP 4** | **CHECK FOR ONE WAY SHEAR** | | | | | | |
| | TO DETERMINE THE DEPTH | | | | | | |
| | qu= | | | 0.100 | N/MM2 | | |
| | SIZE OF FOOTING | | B= | 10.61 | M | | |
| | | | L= | 4.90 | M | | |
| | | | | | | | |
| | SIZE OF COLUMN | | 4.90 | 10.61 | | | |
| | | | | | | | 490.2 |
| | FACTORED SHEAR FORCE (Vul)= | | | 245 | | | |
| | $factored\ shear\ (VuL) = \frac{qu * B}{2} * (B - C1 - 2d)$ | | = | 2600000 | 98020.73516 | = | 4309.8 |
| | | | | | | | |
| | Soil Pressure | qu= | | 0.100 | N/M2 | | |
| | | FROM IS 456:2000 TABLE 19 | | | | | |
| | | DESIGN SHEAR STRENGHT (Ꞇc)= | | 0.36 | N/MM2 | | |
| | | ONE WAY RESISTENCE= | | 3819.6 | | | |
| | | | | 4310 | | | |
| | | | | 2501979 | | | |
| | | d= | | 581 | MM | | |
| | | d'= | | 50 | MM | | |
| | | D= | | 631 | MM | | |

| STEP 5 | PUNCHING SHEAR | (TWO WAY SHEAR CHECKING) | | | |
|---|---|---|---|---|---|
| | $Factored\ Shear\ Force = qu(B*B-(c1+d*d))$ | | | 9040901 | N |
| | | | | 9040.900894 | KN |
| | $PUNCHING\ TWO\ WAY\ SHEAR\ RESISTENCE = KsTc(b0*d)$ | | | | |
| | WHERE CRITICAL PERIMETER (Bo)= | | 3923 | | |
| | K1 | = | 1 | | |
| | T | = | 1.118 | N/MM2 | |
| | VC2 | | 2545679 | N | |
| | | | 2546 | KN | |
| | VC2>VU2 | DEPTH IS SAFE | | | |

| STEP 6 | DESIGN OF REINFORCEMENT | | | | |
|---|---|---|---|---|---|
| | ULTIMATE MOMENT @ COLUMN | | $ultimate\ moment\ (mu) = \frac{qu}{8} * B * (B - C1) * 2$ | | |
| | | Mu= | 1240574.929 | | |
| | | Mu= | 1240.574929 | Kn-M | |
| | $ultimate\ moment\ (mu) = 0.87 * fy * ast * d(1 - \frac{fy * ast}{b * d * fck})$ | | | 411479602.21 | |
| | Ast Req | | 20285 | mm2 | |

| STEP 7 | DEPTH CALCULATION | $ultimate\ moment\ (mu) = 0.87 * fy * ast * d(1 - \frac{fy * ast}{b * d * fck})$ | | | |
|---|---|---|---|---|---|
| | | | 483.6469546 | | |
| | | | 484 | mm | |
| | | therefore dreq = | 0.484 | m | |

| STEP 8 | DESIGN PARAMETERS | | | | |
|---|---|---|---|---|---|
| | # | ASSUMING | 14 | MM DIA BARS | |
| | # | AREA OF SINGLE BARS=A= | 154 | MM2 | |
| | # | NUMBER OF BARS | 132 | | |
| | | = | | | |
| | # | ACTUAL AST= | 1697.85 | MM2 | |
| | # | SPACING= | 75.84914962 | | |
| | | | 76 | C/C | |

| STEP 9 | BAR CALCULATION | | |
|---|---|---|---|
| | **ONE LENGTH OF BAR** | 10.636 | M |
| | WEIGHT OF BAR | 12.86824691 | Kg |
| | TOTAL WEIGTHT OF BAR | 1698.608593 | Kg |

| STEP 10 | BAR CALCULATION | | |
|---|---|---|---|
| | **ONE LENGTH OF BAR** | 4.926 | M |
| | WEIGHT OF BAR | 5.959851852 | Kg |
| | TOTAL WEIGTHT OF BAR | 452.0496948 | Kg |

| SL.NO | PARTICULAR | LENGTH | BREADTH | DEPTH | VOLUME | UNIT | RATE/ UNIT | TOTAL AMOUNT | REMARKS | FOR 4 COLUMNS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | EXCAVATION | 4.90 | 4.90 | 0.48 | 11.62084 | CUBIC METER | 500 | 5,810.42 | | TOTAL PRICE | |
| 2 | CONCRETE AND FOUNDATION WORK | 10.61 | 4.90 | 0.48 | 25.162676 | CUBIC METER | 3000 | 75,488.03 | | | |
| 3 | STEEL | 2151 | | | | KG | 80 | 1,72,080.00 | | | |
| | **TOTAL AMOUNT** | | | | | | | 2,53,378.45 | | 10,13,513.79 | Rs |

| SBC | 200 | | | |
|---|---|---|---|---|
| Fck | 20 | | | |
| fy | 415 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 13sqm | 19.5sqmt | 26sqm | 32.5sqm |
| Depth | 620mm | 778mm | 486mm | 964mm |
| Steel | 560kg | 943kg | 1331kg | 1740kg |
| Amount | 65,693.00 | 1,12,317.25 | 1,60,427.14 | 2,10,790.76 |

| SBC | 150 | | | |
|---|---|---|---|---|
| Fck | 20 | | | |
| fy | 415 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 17.33sqm | 26sqm | 34.66sqm | 43.33sqm |
| Depth | 626mm | 737mm | 805mm | 851mm |
| Steel | 1043kg | 1048kg | 1800kg | 2192kg |
| Amount | 1,09,825.72 | 1,56,770.38 | 2,06,372.49 | 2,56,273.21 |

| SBC | 100 | | | |
|---|---|---|---|---|
| Fck | 20 | | | |
| fy | 415 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 26sqm | 39sqmt | 52sqm | 65sqm |
| Depth | 556mm | 610mm | 640mm | 660mm |
| Steel | 1259kg | 1640kg | 2054kg | 2452kg |
| Amount | 1,32,962.20 | 1,82,161.72 | 2,34,028.38 | 2,84,787.67 |

| SBC | 50 | | | |
|---|---|---|---|---|
| Fck | 20 | | | |
| fy | 415 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 52.02sqm | 78.0sqm | 104.05Sqm | 130.02 |
| Depth | 413mm | 529mm | 640mm | 704mm |
| Steel | 790.56kg | 583.63kg | 464.73kg | 418.91kg |
| Amount | 1,78,152.60 | 2,60,580.00 | 3,76,896.00 | 4,93,897.00 |

| SBC | 200 | | | |
|---|---|---|---|---|
| Fck | 25 | | | |
| fy | 250 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 13sqm | 19.5sqmt | 26sqm | 32.5sqm |
| Depth | 620mm | 778mm | 886mm | 964mm |
| Steel | 888kg | 1121kg | 1398kg | 1698kg |
| Amount | 74,018.00 | 96,096.50 | 1,21,206.45 | 1,48,319.12 |

| SBC | 150 | | | |
|---|---|---|---|---|
| Fck | 25 | | | |
| fy | 250 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 17.33sqm | 26sqmt | 34.66sqm | 43.33sqm |
| Depth | 626mm | 737mm | 805mm | 851mm |
| Steel | 1017kg | 1282kg | 1576kg | 1884kg |
| Amount | 85,907.05 | 1,10,215.27 | 1,36,861.00 | 1,64,773.35 |

| SBC | 100 | | | |
|---|---|---|---|---|
| Fck | 25 | | | |
| fy | 250 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 26sqm | 39sqmt | 52sqm | 65sqm |
| Depth | 556mm | 610mm | 640mm | 659mm |
| Steel | 1250kg | 1535kg | 1849kg | 2158kg |
| Amount | 1,05,583.84 | 1,31,573.16 | 1,60,013.98 | 1,87,963.48 |

| SBC | 50 | | | |
|---|---|---|---|---|
| Fck | 25 | | | |
| fy | 250 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 52.025Sqm | 78.03sqm | 104.045Sqm | 129.965Sqm |
| Depth | 496mm | 571mm | 595mm | 610mm |
| Steel | 778.31kg | 674.15kg | 659.47kg | 650.23kg |
| Amount | 1,41,672.00 | 1,99,930.00 | 2,52,006.00 | 3,03,634.44 |

| SBC | 200 | | | |
|---|---|---|---|---|
| Fck | 30 | | | |
| fy | 500 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 13sqm | 19.5sqmt | 26sqm | 32.5sqm |
| Depth | 620mm | 778mm | 886mm | 964mm |
| Steel | 922kg | 1299kg | 1714kg | 2140kg |
| Amount | 98,118.88 | 1,46,931.71 | 2,00,073.34 | 2,54,722.56 |

| SBC | 150 | | | |
|---|---|---|---|---|
| Fck | 30 | | | |
| fy | 500 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 17.33sqm | 26sqmt | 34.66sqm | 43.33sqm |
| Depth | 628mm | 737mm | 805mm | 851mm |
| Steel | 1066kg | 1471kg | 1905kg | 2334kg |
| Amount | 1,16,020.64 | 1,69,105.40 | 2,25,090.62 | 2,81,776.79 |

| SBC | 100 | | | |
|---|---|---|---|---|
| Fck | 30 | | | |
| fy | 500 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 26qm | 39sqmt | 52sqm | 65sqm |
| Depth | 556mm | 610mm | 640mm | 659mm |
| Steel | 1282kg | 1711kg | 2151kg | 2601kg |
| Amount | 1,40,115.85 | 1,96,227.82 | 2,53,378.45 | 3,11,409.93 |

| SBC | 50 | | | |
|---|---|---|---|---|
| Fck | 30 | | | |
| fy | 500 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 52.025Sqm | 78.035Sqm | 104.4sqm | 129.96sqm |
| Depth | 529mm | 571mm | 595mm | 610mm |
| Steel | 497.98kg | 477.05kg | 466.63kg | 460.10kg |
| Amount | 2,06,173.52 | 2,96,037.83 | 3,88,329.76 | 4,79,826.90 |

| SBC | 200 | | | |
|---|---|---|---|---|
| Fck | 35 | | | |
| fy | 550 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 17.33sqm | 26sqmt | 34.66sqm | 43.33sqm |
| Depth | 626mm | 737mm | 805mm | 851mm |
| Steel | 1066kg | 1471kg | 1905kg | 2334kg |
| Amount | 1,16,020.64 | 1,69,105.40 | 2,25,090.62 | 2,81,776.79 |

| SBC | 150 | | | |
|---|---|---|---|---|
| Fck | 35 | | | |
| fy | 550 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 17.33sqm | 26sqmt | 34.66sqm | 43.33sqm |
| Depth | 626mm | 737mm | 805mm | 851mm |
| Steel | 1066kg | 1471kg | 1905kg | 2334kg |
| Amount | 1,16,020.64 | 1,69,105.40 | 2,25,090.62 | 2,81,776.79 |

| SBC | 100 | | | |
|---|---|---|---|---|
| Fck | 35 | | | |
| fy | 550 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 26qm | 39sqmt | 52sqm | 65sqm |
| Depth | 556mm | 610mm | 640mm | 659mm |
| Steel | 1282kg | 1711kg | 2151kg | 2601kg |
| Amount | 1,40,115.85 | 1,96,227.82 | 2,53,378.45 | 3,11,409.93 |

| SBC | 50 | | | |
|---|---|---|---|---|
| Fck | 35 | | | |
| fy | 550 | | | |
| LOAD | 1000 | 1500 | 2000 | 2500 |
| Size | 52.025Sqm | 78.03sqmt | 104.04sqm | 129.96sqm |
| Depth | 529mm | 571mm | 595mm | 610mm |
| Steel | 474.75kg | 454.80kg | 444.87kg | 438.64kg |
| Amount | 2,16,586.88 | 3,13,419.30 | 4,11,311.46 | 5,09,000.80 |

## 5. Conclusion

- Cost optimization of foundations on soils with low Safe Bearing Capacity (SBC) requires a strategic approach that balances safety, performance, and budget.
- The most effective solutions include employing soil improvement techniques, such as stabilization or compaction, which can enhance the SBC and allow for more economical foundation designs.
- Additionally, opting for deep foundations, like piles, can bypass weak surface soils and transfer loads to more stable strata,reducing the need for extensive soil modifications.

- Optimized foundation designs, such as mat or raft foundations, help distribute loads over a larger area, minimizing stress on the soil while controlling material costs.
- Thorough geotechnical investigations are essential to determine the most appropriate approach, preventing over-engineering and unnecessary expenses.
- By combining these methods, substantial cost savings can be achieved without compromising the structural integrity or safety of the foundation.