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# Some Studies on Design of RCC Silo using Matlab

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***Abstract: The Storage of Structure increased due to development of industrial infrastructure .To store materials like coal, wheat, sugar, cements etc. The height of containers is larger than its diameter it is termed as silo. Reinforced concrete bins are constructed to store such type of material. Hence RCC silos are widely used for storage of granular materials as they are an ideal structural material for the building of permanent bulk-storage facilities for dry granular like fillings. RCC Bin of hopper bottom type. Specified the various parameters such as diameter of bin, height of bin, properties of the material to be stored (angle of repose and density), grade of steel, grade of concrete is considered for design. This study describes a review of design of silos using Matlab. Software and by varying the H/D ratio, volume of silo with different material and density.***
***Keywords: Matlab programming, silos, tension force, storage capacity and economic design.***

## I. INTRODUCTION

Structures for storage of solids those are generally called by bin. The tall structure called as silos and shallow one is bunker. If plane meets the opposite side of structure. The silos storage of bulk solids may be ground supported or elevated. Bulk storage materials are like Iron ore, Coke, gypsum, Sugar and Flour.

Rcc Silos are usually rectangular or circular in Cross section. In older days these bulk materials are stored in bags in warehouse but in now a days due to lack of space availability, loading and unloading problems this Silos are used.

Silos may be of RCC or steel by their requirement of material and cost.

For emptying and self-cleaning a number of columns are constructed through a ring beam. The bottom height is fixed for unloading of trucks. The stored solids exert pressure on the side walls during loading and unloading and position of discharging hole.

So that it is difficult to analyze the pressure. The slip form method of construction and casting of circular rcc silos has resulted in rapid construction of silos.

In the development of industries these silos plays a major role due to economic and time consumption and labour. Normally reinforced silos are 500 to 2000 tons of materials are stored. Concrete structure is progressive hardening, increase in compression strength.

## II. OBJECTIVE OF THE PROJECT

*A.* To study general requirements silos loads and design criteria using IS: 4995-1974.
*B.* To develop a program using Matlab.
*C.* To formulate the H/D ratio in analysis for the horizontal pressure at different height.
*D.* To analyze the most economical size of circular silos for various type of material by considering H/D ratio.
*E.* Programming which gives the complete analysis of wall pressure at different height and for different material of different density.

## III. METHODOLOGY

Conforming to IS: 4995-1974 part I and II code design of silos by using software Matlab.2015 considering H/D ratio and volume for 125m$^3$, 150m$^3$ and 175m$^3$. Funnel flow and Janssen's theory is used.

### *A. Volumes of silos*

 

Table 3.1 various volumes and H/D ratio for silos

| Sl.no | Height of cylinder (m) | Diameter of cylinder (m) | H/D Ratio | Depth of opening (m) | Diameter of opening (m) | volume of cylinder ($m^3$) | volume of frustum cone ($m^3$) | Total volume ($m^3$) |
|---|---|---|---|---|---|---|---|---|
| Volume for 125$m^3$ | | | | | | | | |
| 1 | 23.3 | 2.6 | 9.0 | 1.19 | 0.5 | 123.72 | 2.59 | 126.31 |
| 2 | 21.5 | 2.7 | 8.0 | 1.22 | 0.5 | 123.12 | 2.84 | 125.96 |
| 3 | 19.8 | 2.81 | 7.0 | 1.25 | 0.5 | 122.81 | 3.13 | 125.94 |
| 4 | 17.8 | 2.95 | 6.0 | 1.28 | 0.5 | 121.68 | 3.50 | 125.18 |
| 5 | 15.8 | 3.13 | 5.0 | 1.31 | 0.5 | 121.59 | 3.99 | 125.58 |
| 6 | 13.5 | 3.38 | 4.0 | 1.34 | 0.5 | 121.15 | 4.69 | 125.84 |
| 7 | 11.15 | 3.7 | 3.0 | 1.37 | 0.5 | 119.90 | 5.67 | 125.57 |
| 8 | 8.6 | 4.2 | 2.0 | 1.4 | 0.5 | 119.16 | 7.34 | 126.50 |
| Volume for 150$m^3$ | | | | | | | | |
| 1 | 24.7 | 2.75 | 9.0 | 1.5 | 0.5 | 146.73 | 3.61 | 150.34 |
| 2 | 22.9 | 2.85 | 8.0 | 1.65 | 0.5 | 146.11 | 4.24 | 150.35 |
| 3 | 21 | 3 | 7.0 | 1.8 | 0.5 | 148.46 | 5.07 | 153.53 |
| 4 | 18.7 | 3.14 | 6.0 | 1.95 | 0.5 | 144.83 | 5.97 | 150.80 |
| 5 | 16.5 | 3.33 | 5.0 | 2.1 | 0.5 | 143.72 | 7.16 | 150.88 |
| 6 | 14.15 | 3.58 | 4.0 | 2.15 | 0.5 | 142.45 | 8.37 | 150.83 |
| 7 | 11.75 | 3.9 | 3.0 | 2.3 | 0.5 | 140.38 | 10.50 | 150.88 |
| 8 | 8.75 | 4.45 | 2.0 | 2.45 | 0.5 | 136.11 | 14.31 | 150.41 |
| Volume for 175$m^3$ | | | | | | | | |
| 1 | 26 | 2.88 | 9.0 | 2.6 | 0.5 | 169.40 | 6.81 | 176.20 |
| 2 | 24 | 3 | 8.0 | 2.7 | 0.5 | 169.67 | 7.61 | 177.28 |
| 3 | 21.8 | 3.12 | 7.0 | 2.8 | 0.5 | 166.69 | 8.47 | 175.16 |
| 4 | 19.7 | 3.3 | 6.0 | 2.9 | 0.5 | 168.52 | 9.72 | 178.24 |
| 5 | 17.3 | 3.48 | 5.0 | 3 | 0.5 | 164.57 | 11.09 | 175.66 |
| 6 | 15 | 3.72 | 4.0 | 3.1 | 0.5 | 163.05 | 12.96 | 176.01 |
| 7 | 12.1 | 4.1 | 3.0 | 3.2 | 0.5 | 159.77 | 16.03 | 175.80 |
| 8 | 9.1 | 4.65 | 2.0 | 3.3 | 0.5 | 154.56 | 20.93 | 175.49 |

## IV. ANALYSIS AND RESULTS

### *A. Variation of Horizontal Pressure at Different Height for Various Materials Stored*

Maximum horizontal pressure in obtained for Iron ore and minimum for coke and flour

*A. Iron ore*

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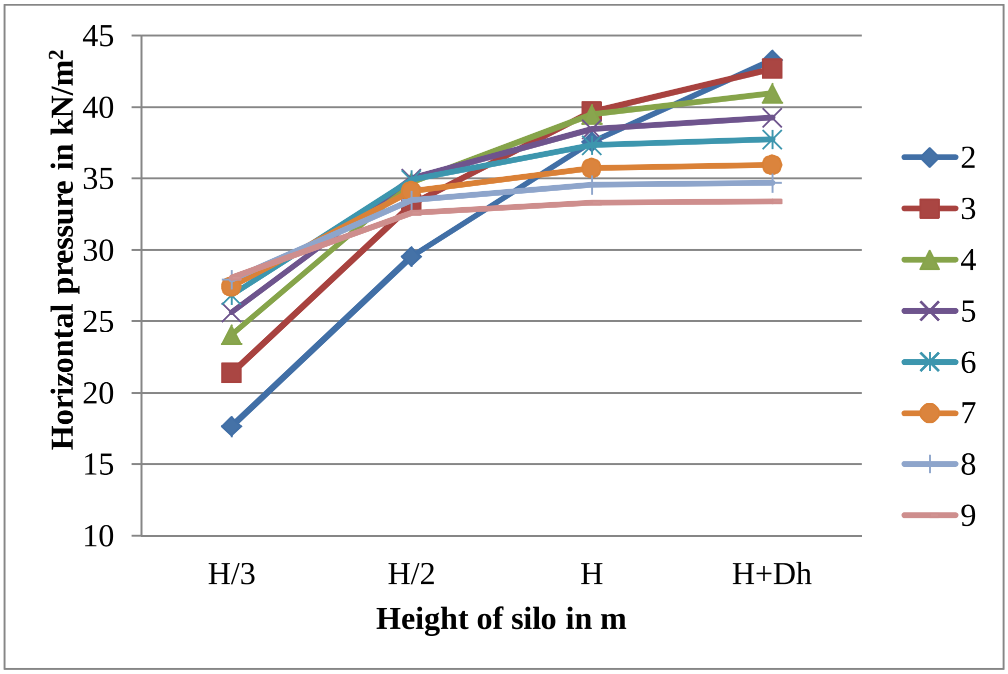


Fig 4.1 Maximum horizontal pressure for iron ore of volume 175m$^3$

The fig 4.1 shows that variation of horizontal pressure for different H/D ratios. Material iron ore having less horizontal pressure at an H/D ratio 9 is 33.38kN/m$^2$ and more horizontal pressure H/D ratio of 2 is 43.3kN/m$^2$.
Coke

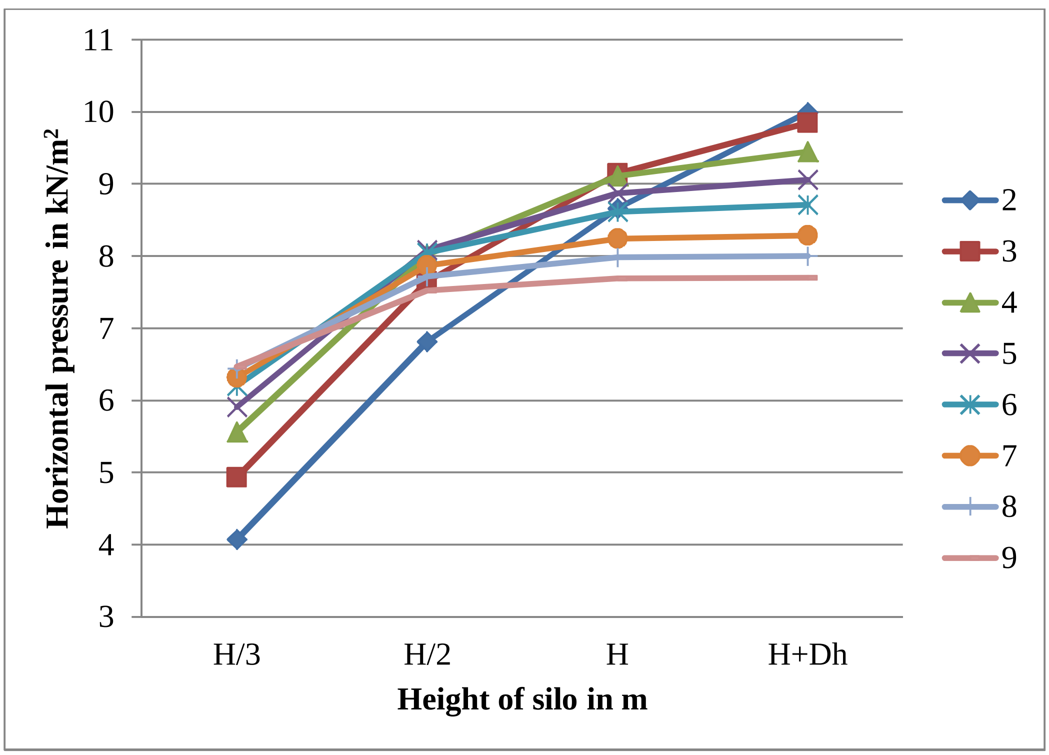


Fig 4.2 Minimum horizontal pressure for coke of volume 175m$^3$

The fig 4.2 shows that variation of horizontal pressure for different H/D ratios. Material coke having less horizontal pressure at an H/D ratio 9 is 7.7kN/m$^2$ and more horizontal pressure H/D ratio of 2 is 9.99kN/m$^2$

*B. Maximum Hoop Tension Force for Different Volume and Materials*

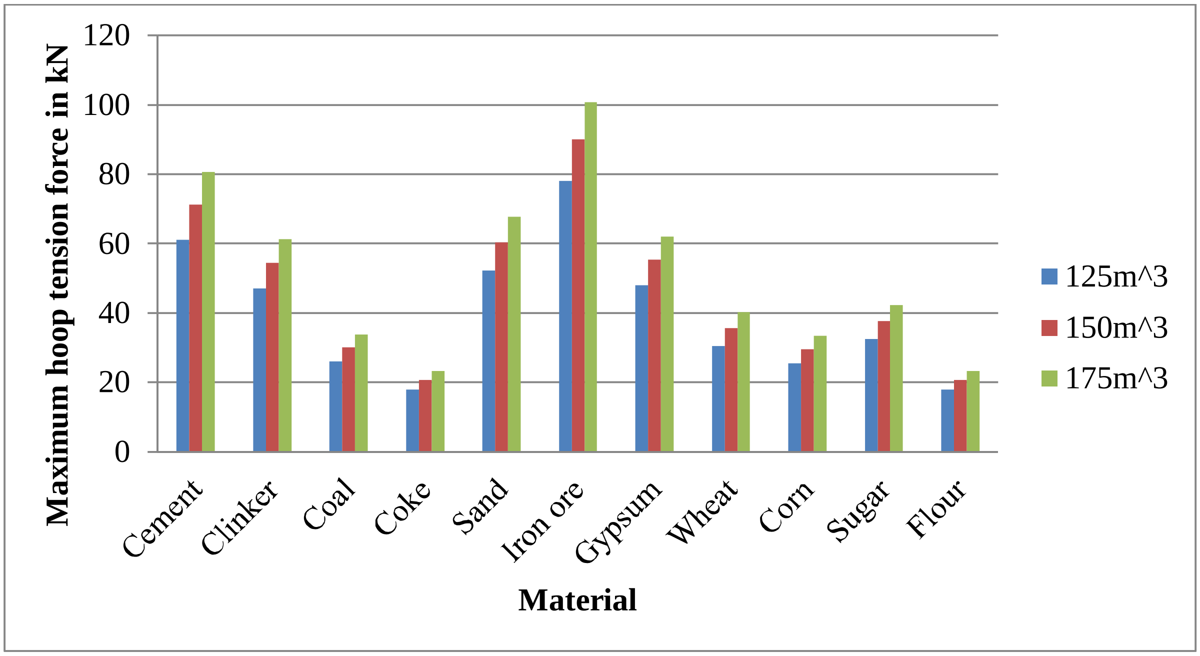


Fig 4.3: Maximum hoop tension force for various material and volume of silo

The fig 4.3 shows it directly the variation of maximum hoop tension force for different material of different density but having same H/D Ratio. The material iron ore having more hoop tension force as compare to other material and coke and flour having less hoop tension force, for different volume is observed.

*C. Storage Capacity of Silos for Different Material Stored*

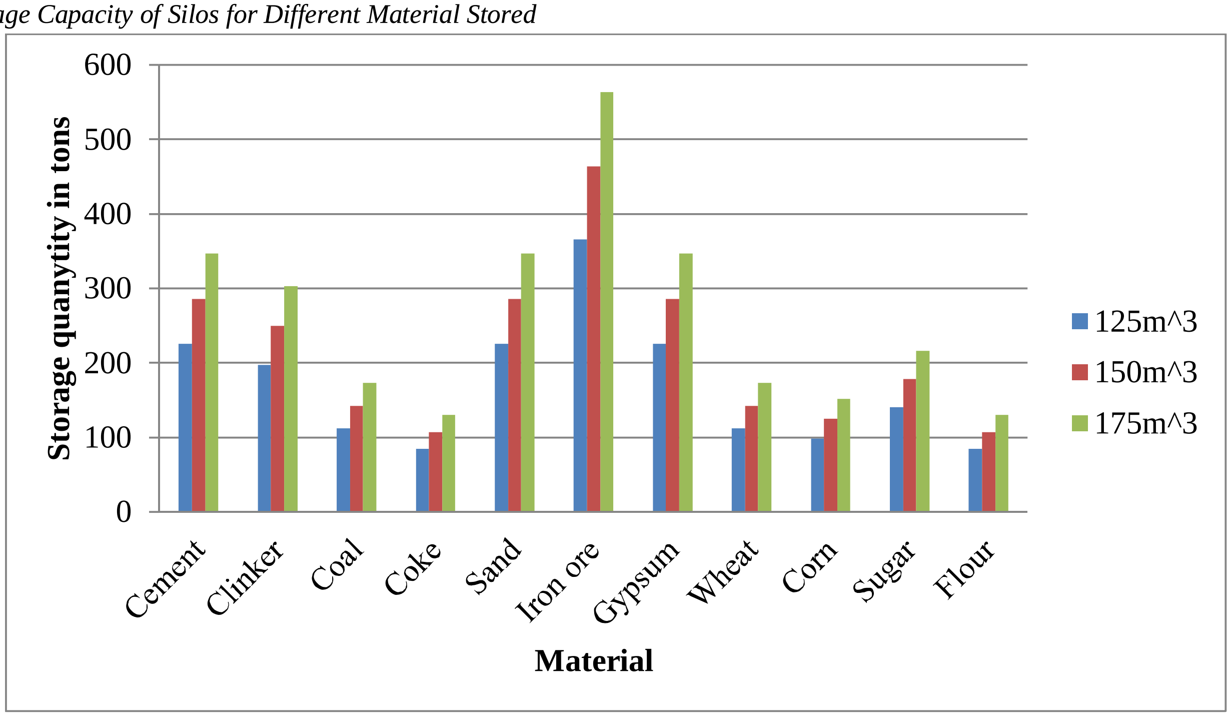


Fig 4.4: Storage quantity of various volumes of silos for different material stored

The fig 4.4 shows it directly the fixed volumes of silos storage capacity for iron ore is maximum storage capacity due to high density and coke and flour having less storage capacity, for different volume is observed

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*D. Cost of construction Materials of Silo*

Table 4.2: Cost of construction materials for different volume of silo

| H/D Ratio | volume of concrete | Concrete rate per $m^3$ | Amount for concrete | weight of steel in kg | Steel rate per kg | Amount for steel | Total cost (lakh) |
|---|---|---|---|---|---|---|---|
| $125m^3$ | | | | | | | |
| 9 | 23.50 | 7692.00 | 180764.52 | 418.83 | 52.00 | 21779.16 | 2.02 |
| 8 | 22.91 | 7692.00 | 176241.81 | 408.72 | 52.00 | 21253.44 | 1.97 |
| 7 | 22.40 | 7692.00 | 172289.51 | 396.56 | 52.00 | 20621.12 | 1.92 |
| 6 | 21.72 | 7692.00 | 167080.00 | 387.85 | 52.00 | 20168.2 | 1.87 |
| 5 | 21.19 | 7692.00 | 162990.14 | 376.73 | 52.00 | 19589.96 | 1.82 |
| 4 | 20.61 | 7692.00 | 158541.31 | 354.97 | 52.00 | 18458.44 | 1.77 |
| 3 | 20.11 | 7692.00 | 154649.57 | 340.44 | 52.00 | 17702.88 | 1.72 |
| 2 | 20.02 | 7692.00 | 154013.59 | 325.88 | 52.00 | 16945.76 | 1.71 |
| $150m^3$ | | | | | | | |
| 9 | 27.11 | 7692.00 | 208567.68 | 471.38 | 52.00 | 24511.76 | 2.33 |
| 8 | 26.85 | 7692.00 | 206562.92 | 460.65 | 52.00 | 23953.8 | 2.30 |
| 7 | 26.95 | 7692.00 | 207299.46 | 448.98 | 52.00 | 23346.96 | 2.30 |
| 6 | 26.40 | 7692.00 | 203047.55 | 438.26 | 52.00 | 22789.52 | 2.25 |
| 5 | 26.31 | 7692.00 | 202411.30 | 422.59 | 52.00 | 21974.68 | 2.24 |
| 4 | 26.08 | 7692.00 | 200594.36 | 404.42 | 52.00 | 21029.84 | 2.21 |
| 3 | 26.56 | 7692.00 | 204277.04 | 391.87 | 52.00 | 20377.24 | 2.24 |
| 2 | 28.01 | 7692.00 | 215418.64 | 374.68 | 52.00 | 19483.36 | 2.34 |
| $175m^3$ | | | | | | | |
| 9 | 32.76 | 7692.00 | 252028.09 | 528.74 | 52.00 | 27494.48 | 2.79 |
| 8 | 32.61 | 7692.00 | 250849.27 | 516.04 | 52.00 | 26834.08 | 2.77 |
| 7 | 32.13 | 7692.00 | 247139.27 | 505.03 | 52.00 | 26261.56 | 2.73 |
| 6 | 32.38 | 7692.00 | 249072.76 | 497.65 | 52.00 | 25877.8 | 2.74 |
| 5 | 32.11 | 7692.00 | 246996.80 | 469.09 | 52.00 | 24392.68 | 2.71 |
| 4 | 32.49 | 7692.00 | 249894.63 | 460.7 | 52.00 | 23956.4 | 2.73 |
| 3 | 33.44 | 7692.00 | 257245.15 | 436.76 | 52.00 | 22711.52 | 2.79 |
| 2 | 35.84 | 7692.00 | 275649.41 | 419.08 | 52.00 | 21792.16 | 2.97 |

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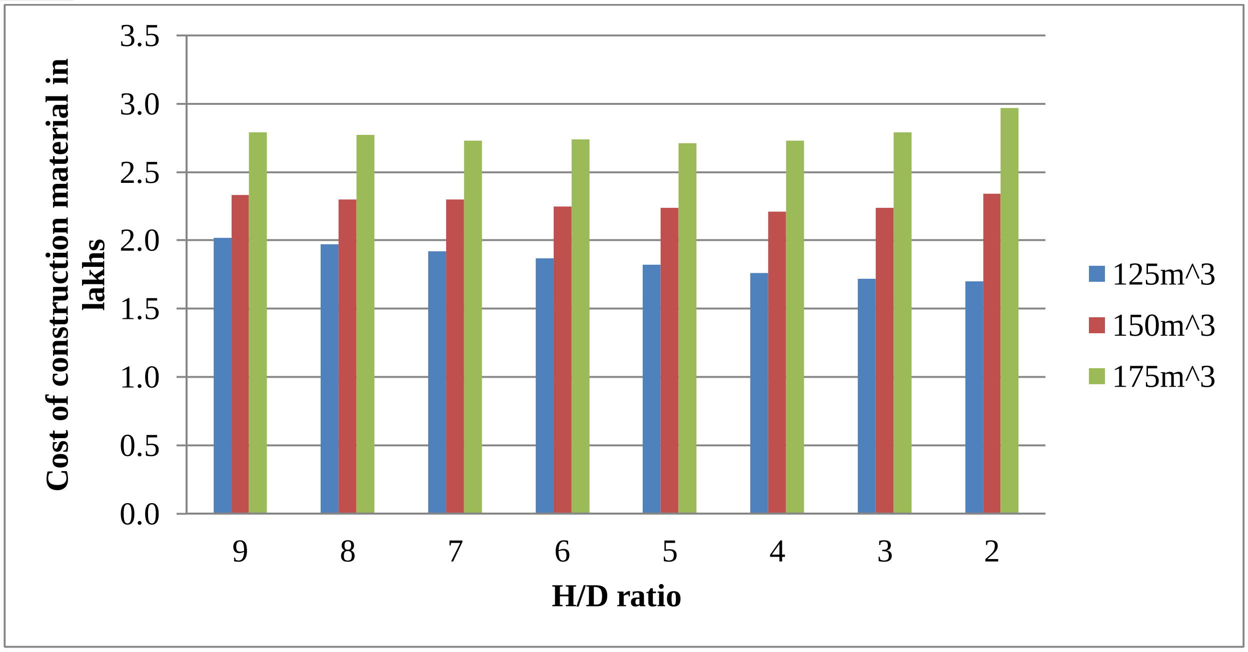


Fig 4.5 Cost comparison of silos with various H/D Ratio and volumes

Fig 4.5 shows the variation of cost of construction materials. Minimum cost of 1.71 lakh is observed for H/D ratio of 2 for $125m^3$. Minimum cost of 2.21 Lakh is observed for H/D ratio of 4 for $150m^3$. Minimum cost of 2.71 Lakh is observed for H/D ratio of 5 for $175m^3$.

*E. Optimum Section*

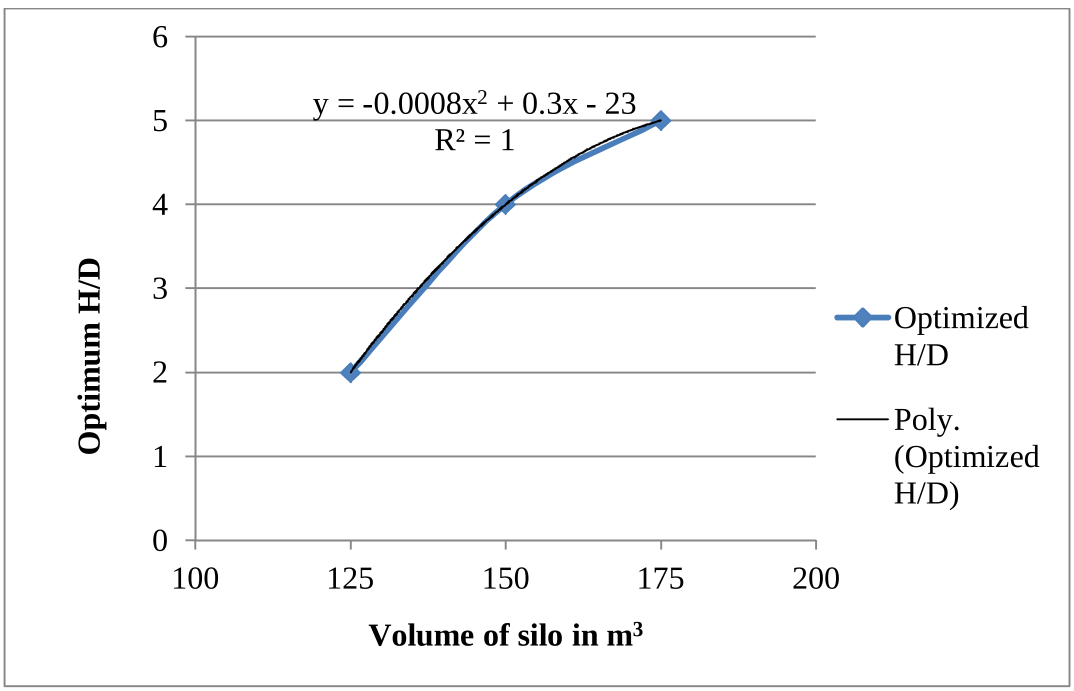


Fig 4.6: Optimum section for different volume

$$H/D_{Opt} = -0.0008V^2+0.3V-23 \qquad \text{………4.1}$$

Table 5.39 shows values of optimum H/D ratios for different volume of silos using equation 4.1, which can be used as ready reference for obtaining optimum H/D value for any volume of silo.

Table 4.3: Optimum H/D ratio for different volume of silo

| Sl.No | Volume in $m^3$ | Optimum H/D Ratio |
|---|---|---|
| 1 | 125 | 2 |
| 2 | 130 | 2.48 |
| 3 | 135 | 2.92 |
| 4 | 140 | 3.32 |
| 5 | 145 | 3.68 |
| 6 | 150 | 4 |
| 7 | 155 | 4.28 |
| 8 | 160 | 4.52 |
| 9 | 165 | 4.72 |
| 10 | 170 | 4.88 |
| 11 | 175 | 5 |

## IV. CONCLUSION

*A.* As the H/D ratio increases, hoop tension at the bottom of silo reduces.
*B.* Horizontal pressure on silo at different heights increases as height of the silo increases.
*C.* Maximum tension force is exerted on silo when the storage material is iron ore and minimum tension force is exerted on silo for storing coke and flour.
*D.* For a fixed volume of silo, storage capacity for iron ore is maximum and that for coke and flour in minimum
*E.* An optimum H/D ratio for $125m^3$ is 2, for $150m^3$ is 4 and for $175m^3$ is 5.
*F.* Equation 4.1 which can be used for obtaining optimum H/D value for any volume of silo.

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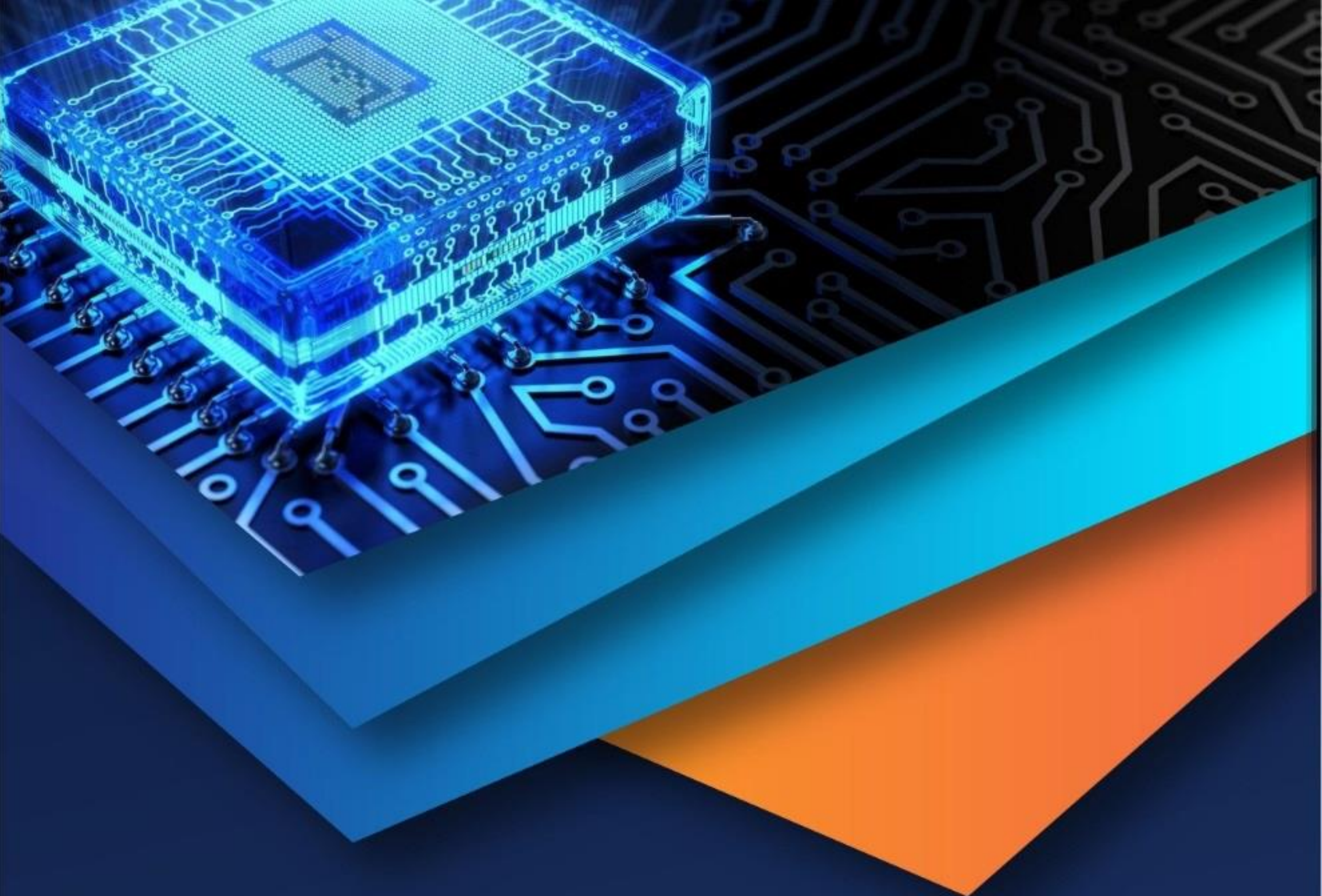


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