Study on Economical Design of Bunker

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Abstract- In order to study the most economical material used for construction of bunkers to store a given volume of a material. Two bunkers have been designed by the same ratio of height to lateral dimensions for storing a given material like coal. In this investigation for capacity 300KN, the length to breadth ratio is taken same for reinforced concrete bunker and steel bunker are designed.

Design of bunkers have been based on the recommendations of IS 4995-1974 part 1 & part 2 for "RCC Bunker" and IS 9178-1979 part 1 & part 2 for "Steel Bunker". After designed comparison between RCC Bunker and Steel Bunker is done. Finally, the most economical bunker is found out, which material (RCC or Steel) for construction of bunker will lead to economical, to store a given amount of material have been found out. These findings will be useful for the designers for the designers of bunkers.

Indexed Terms- Angle of Repose, Bending Moment, Bins Loads and Pressure, Plane of Rupture, Unit Weight.

I. INTRODUCTION

Bins are used by a wide range of industries to store bulk material (like grain, coal, cement etc.) in quantities ranging from a few tonnes to over one hundred thousand tonnes. A bin is an upright container for the storage of bulk granular materials.

Shallow bins are usually called as bunkers and deep bins are usually called as silos. If the depth and breadth of a bin are such that the plane of rupture meets the surface of the material before it strikes the opposite side of the bin. It is called a shallow bin or a "bunker". Hopper of bins is four sloping slabs. Bunkers are made from many different structural materials. They can be constructed of reinforced concrete or steel and may discharge by gravity flow or by mechanical means.

Steel Bunkers range from heavily stiffened flat plate structure to efficient unstiffened shell structures. They can be supported on columns, loads bearings skirts. Bins with flat bottom are supported directly on foundations.

Reinforced concrete is an ideal structural material for the building of permanent bulk storage facilities for dry granular material. The total load of material is supported by the floor of the bunker. Rankine's theory is used in design of bunker.

II. OBJECTIVE OF THE STUDY

The main objective of the investigation reported here is:-

i) To identify the most economical material for design of bunker.
ii) To construct on site for storage of given volume of material

III. BUNKER

Bins are used by a wide range of industries to store material like coal, grains, cement and also for food, shelter etc. The main two characteristics that make a bin to act as a bunker is based on the Depth and Angle of Rupture.

Bunkers are shallow structures. Plane of Rupture meets the top horizontal surface.

The total load of material is supported by the floor of bunker.

The intensity of horizontal pressure on the side wall is determined by Rankine's Theory.

IV. TYPES OF BUNKER TO BE DESIGN

4.1 RCC BUNKER- Reinforced Concrete is an ideal structural material for the building of permanent bulk storage facilities for dry granular material.

Concrete Storage units can be designed and built in any shape and size to fit the site or the process for which they are required. They can be poured monolithically by the use of sliding forms when the walls are high in single lifts, when they are low, and in rapidly following lifts of fixed forms. When they are moderate heights.

4.2 STEEL BUNKER- Steel Bunker range from heavily stiffened flat plate structure to efficient unstiffened shell structure. They can be supported on columns.

They can be supported by columns, local bearing skirts, steel bunkers with flat bottom are usually supported directly on foundation.

V. DESIGN OF BUNKER

5.1 DESIGN CONSIDERATION

The Design process is of two types-

Functional- Functional Design must provide for adequate volume proper protection of the stored material, satisafactory methods for filling and discharge.

Structural-Structural design must provide for stability, strength and control of cracks, width and deflection.

Load to be considered include the following -
Dead Load of the structure itself and items supported by the structure.
Live load forces are taken based on the type of material stored.

5.2 DESIGN PARAMETERS

Design Parameters of stored materials include bulk density, angle of internal friction, and angle of wall friction and pressure ratio which are the governing factors for the computation of bin loads. Storage and flow characteristics of granular material differ widely from those of powdery materials.
Shape - Rectangular
Size - 3m* 3m
Storage capacity - 300KN
Unit weight of coal - 8KN/m^3
Angle of repose - 25^0

VI. DESIGN OF BUNKERS

6.1 DESIGN OF RCC BUNKER

Volume of Bunker = 37.5 m^3
Height of Bunker = 5.7 m

Check for Bunker portion
3* tan {(90+25) / 2} = 4.7m > 3.5m.
Total Storage Capacity = 300 kN

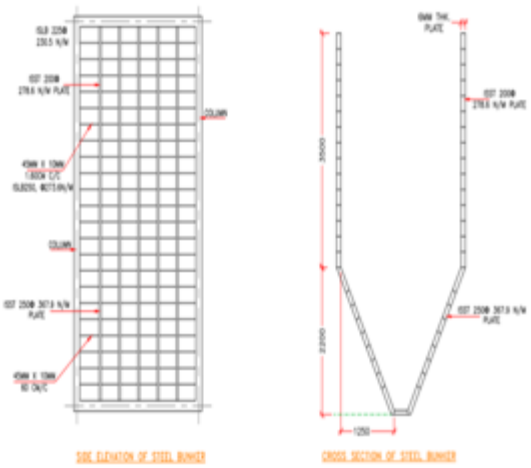
- Design of Side Walls

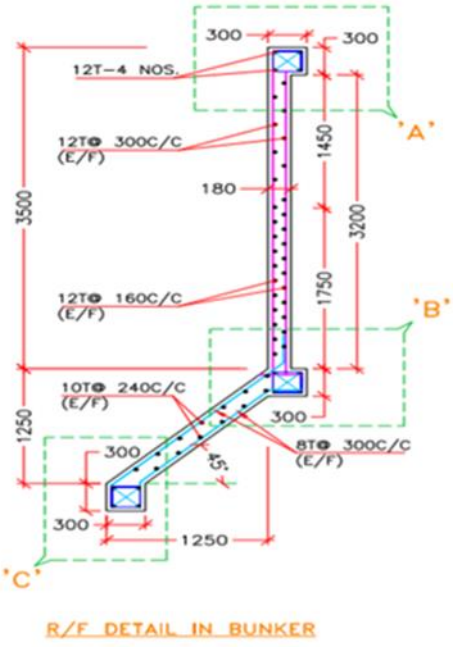
Corner –ve moment = 19.38 kN.m
Tensile force = 36.57 KN
Bending moment tension about centre line of the section
M = 17.19 kN.m
Bending Moment at centre of span due to horizontal pressure
=Ph*L^2 / 8 – Corner Moment
= 9.69kN.m
Moment at centre of span = 7.5 kN.m
Effective Wall Thickness = 150mm
Mu lim = 62.1 kN.m
Mu = 25.785 kN.m

Steel required for corner moment Ast = 512 mm^2
Area of Steel required to resist direct tension= 152 mm^2
Total area of steel required = 512 + 152 = 664 mm^2
Provide 12 mm bars at 160 mm c/c.

- Design of Hopper Bottom –

Area of concrete
Ac = 182808 mm^2
Total normal Pressure, P_n = 35.785 kN/m^2
Effective Span- Provide 10 mm bars at 240 mm c/c.





R/F DETAIL IN BUNKER

6.2 Design of steel bunker

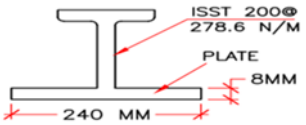
Capacity - 300 kN
Material – Coal
Unit Weight of Coal – 8 kN/m³
Height of Vertical portion = 3.5 m
Height of Hopper Bottom = 2.2 m
Angle of Repose - 25°

For filling, $\phi'f = 18.75°$ and For emptying, $\phi'c = 15°$
Bursting forces on the bunker-
PH1 = P_{h1} * ⅓ = 74.57 * ⅓ = 24.86 kN/m
PH2 = -16.024 kN/m
PH3 = P_{h1} * ⅔ = 74.57 * ⅔ = 49.71 kN/m
PH4 = 56.182 kN/m

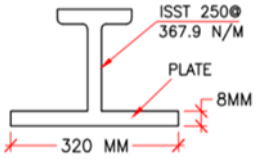
Pressure on Trough Walls -
Pv = 25.2192 kN/m²
Pw = 8 * 2.2 = 17.6 kN/m²
Design of Plate in Trough Portion-
Bending Stress = 6.059 N/mm² < 165 N/mm²
Design of Stiffners in Trough portions-
600mm spacing of stiffners

Provide 10 mm * 45 mm plate.
Vertical Wall Plate-
thickness of wall plate be 6mm.

Vertical Stiffners -
Bending Stress = 66.58 N/mm² < 165 N/mm²
Design of Horizontal Beams -
At A, ISLB 225 @ 230.5 N/m
At B, ISLB 250 @ 273.6 N/m



TEE SECTION
ISST 200



TEE SECTION
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VII. COMPARISON B/W RCC AND STEEL BUNKER ON THE BASIS OF COST

For RCC bunker
Grade of Concrete M20 (1:1.5:3) and Steel Fe 415
Cost os RCC Bunker = 1, 58,356 /-
For Steel bunker Fe 410
Cost of Steel Bunker = 3, 85,284 /-

CONCLUSION

From the above investigation it is concluded that for storing Coal material construction of RCC bunker is more economical than Steel Bunker. The most

economical material used for construction of Bunkers to store given volume of material is RCC because on the basis of cost calcuation after designing of both bunkers RCC is more economical than Steel. These two bunkers have been designed by the same ratio of height to lateral dimension for storing a material like Coal.

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