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Design & construction of Dyke walls in a petrochemical tank farm

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ABSTRACT

This technical paper shows how a dyke wall is designed and built in a Petrochemical complex. Petrochemical complexes contain tanks which store various combustible and inflammable materials like Benzene, Toluene, Xylene and similar type of petrochemicals. The tank farm contains vertical and horizontal tanks to store the above said materials and are constructed with a plain cement concrete (500 mm thick) dyke wall around these tanks for long life of the structures. Dyke walls of varying heights are constructed. In this study different type of dyke walls constructed based on the locally available materials are shown. The dyke walls are of the various types/size, keeping in view the fire load aspects and distance from critical operations, area of effectiveness, ease of workmanship in construction and cost effectiveness. In this case study, dyke walls have been constructed using the locally available materials/bricks and CC blocks. The extract of photos have been obtained from public domain and have been used within the paper for demonstration.

Keywords: *Storage, Chemicals, Inflammable Selection, Fire Load , Safety ,Durability, Time, Cost.*

1. INTRODUCTION

During the design of any dyke wall the type of materials used in its construction is an important factor. The dyke wall should be temperature resistant to a complete burnt-out and should prevent the spread of rapid fire, smoke and fumes which may otherwise contribute to the loss of lives and property.

According to Oxford Dictionary and Civil Engineers Hand Books, '**Dyke or Dike'** is a partition wall or an earthen embankment built on each side of the river some distances away from its banks to control floods. They are more or less like earthen embankments kept about 1.2 m to 1.8 m above the highest flood level. This enables; the dyke walls are prominently / mainly depend on its own/self-weight .The principle may be same, but functionaries are from technical requirements; the materials being highly inflammable. For comparative study, Table-1 indicates the unit weight of the different engineering/construction materials.

Sl. No	Material	Unit weight (kgs/Cum)	Remarks
1	Brickwork masonry	1800-1950	An alternative
2	Plain Cement Concrete (PCC)	2300	The one used
3	Stone masonry rubble dressed	2500	An alternative
4	Stone random rubble masonry (RRM)	2100-2200	-do-
5	Bricks burnt	1600-2000	-do-
6	Manufactured sand	1840	-do-
7	Stone aggregate	2250	-do-
8	Earth dry/loose	1500	-do-
9	Broken fire clay bricks/spoils	1760-2000	-do-
10	Laterite spoils	2080-2400	-do-

Table1: indicates the unit weight of the different engineering/construction materials.

In the above Table – 1, the alternative materials other than the PCC/RCC more or less equal in weight of PCC. Hence, alternative materials can be suitably used in the construction of dyke walls.

Aromatic solvents such as Benzene, Xylene, Toluene, Heavy solvent naptha and light solvent naphtha have almost no action/effect on RRM/Plastered brickwork masonry/PCC/RCC. The effect of these chemicals on RRM/Plastered brickwork masonry when compared with ordinary PCC/RCC is less. But at higher temperatures, RRM/Plastered brick/block work masonry (1:6) are as susceptible as ordinary PCC; even with respect to heat resistance.

Different varieties of stones are available (other than the granite), Eg: Kondolites Falls under Garnetiferrous silimanite schists etc..Generally schistore rocks/materials are suitable for **dyke/bund wall** works where structural stability is given slightly less importance.

The Kondolites/RRM/Plastered brick/block masonry effectively resists high temperature.

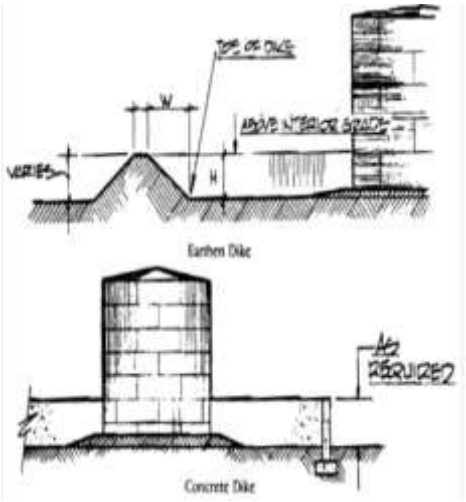

Fig.1, An extract from domain; Typical cross sectional view

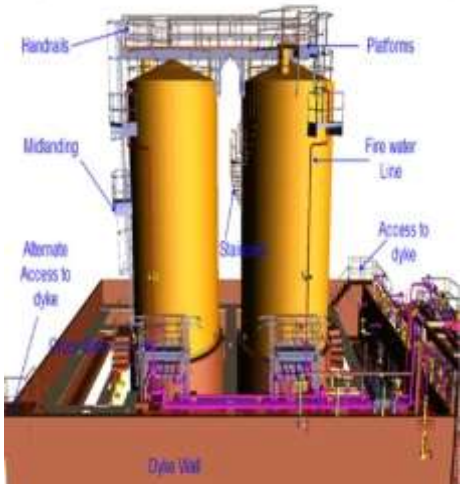

Fig. 2, Dyke wall; A view

Fig. 3, Dyke wall; A part view

A. Purpose:

The chemical stored in the respective tanks are highly inflammable. Considering this the designer while planning has to carefully choose a proper slope on the floor. This slope is designed by providing drains on the floor with intermittent collection pits; which inturn discharge to the existing plant drains. In very large capacity units, the **dyke** walls built around the unit; will not suffice. The selective area partition shall be properly planned by constructing further suitable '**dyke'** walls to obtain required chambers. This is to take care of unexpected fire accidents and to control further fire spreading. During and till the fire is brought under complete control; the **dyke** walls to resist against extent of heat to withstand.

B. Procedure:

The **Dyke** walls of various types be planned considering the use of locally available materials of various cross sectional/ profiles. Table-2 indicating details of different cross sectional profiles of the '**Dyke wall'**.

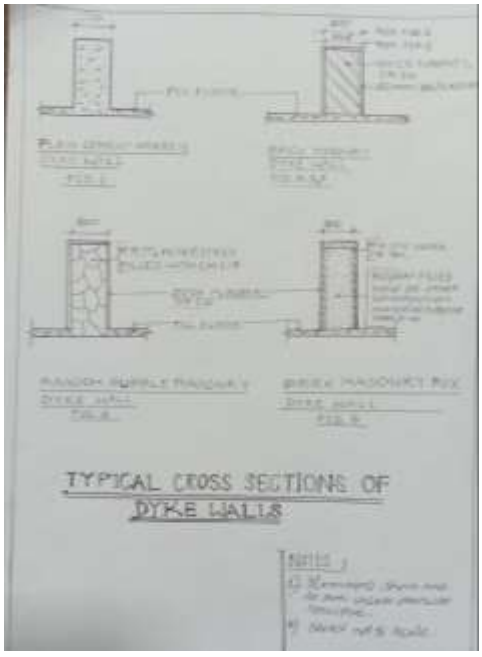

Fig. 4, Typical cross sections of Dyke wall.

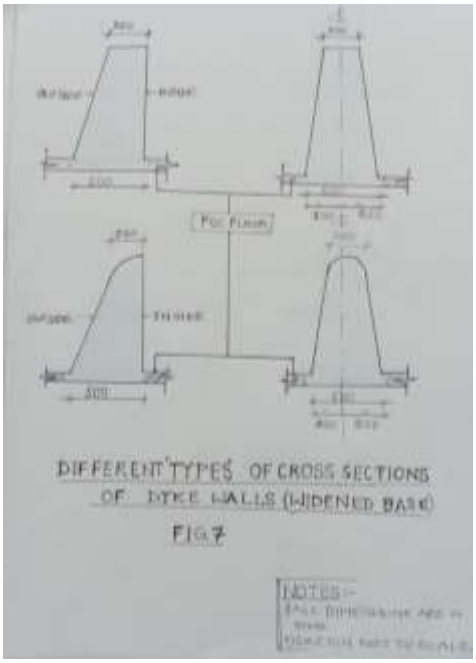

Fig. 5, Different types of cross sections of Dyke walls

Sl.No	Brief description	Remarks
1	PCC ,M10 grade.	Refer Figure-1 Use of heat resisting concrete (HRC) adopting Basalt, Black granite aggregates instead of Granite aggregates; if locally available.
2	Brickwork, 1st class in CM 1:6, 20 MM thick.	Refer Fig-2 and Fig-3
3	RRM (Random Rubble Masonry) & cavities filled with CM 1:8.	Refer Fig:4
4	Brick masonry, 115 mm thick in CM 1:6, box section filled with M-Sand/River Sand/Sea Sand/plastering 20 mm thick, in CM 1:6 alround.	Refer Fig-5 Use of: Broken half burnt bricks/BF slag/ Surplus good earth including spoils/ broken refractory bricks.

Table 2 : Refer photo 4 for typical cross sections of dyke wall

Note: For a large size projects the area exceeding 500 m^2 , RCC **Dyke** wall be Preferred.

C. Protection Measures: towards 'Fire' Drains Provision :

Depending on design and requirement a base floor of RCC/PCC, minimum of 150 mm thick shall be constructed, Within the chambers catering for the entire tank zone. This is to properly ensure the required adequate number of chambers.
The intermittent collection pits so designed would able to receive the product spillage; thus finally connected to main collection/sump pits to nullify the burning fire any. The collection pits are different for different products. The type and design of main collection pit with water seal arrangement to 'ground the fire' at very first instant. This is a technical art/expertise. The so collected product shall undergo the process of recoup based on the tank capacity to extract the original products & to minimize the wastage. The drainage network system to be well planned with 'adequate slope' both in floor & drains. In the event of fire, the drainage system effectively reduce the effect & impact of fire on **Dyke** walls including the floor.

2. FIRE LOAD CALCULATIONS

An example of fire load calculations

Refer Photo 6:Consider one of the **dyke** chambers. Tank position as per Technical requirement . The tank position indicatively shown in the sketch.

By constructing **dyke** wall of lesser thickness, the increase in effective area is shown in hatched line (See Photo 6). Therefore, consider the area binding the co-ordinater.

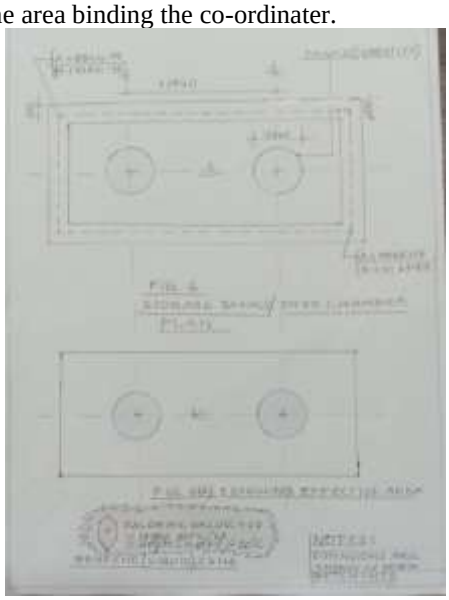

Fig. 6, Plan of Dyke chamber

A+8844.75 / b+3186.75 and A+8865.225 / B+3227.925

Floor Area = 20.475 M X 41.175 M = 843.05 m^2

Deduct for two tanks = 2 x 3.14 x $(11.84)^2$ / 4

= 220.09 m^2

Effective Area = AC =843.05 – 220.09 = 62.96 m^2 = 6702.05 m^2

Specific gravity = Density of fluid / Density of water

Density = 0.879 x 1 gm/cc = 0.879 kg/ m^3

Benze (Liquid) = Calorific value = CV = 17986 BTV/LB

Specific gravity = 0.879@20°c

Density = Mass/ Volume

Therefore, Mass = Volume x density

= 700 x 879

= 615,300 kg

= 615,300 x 2.2

= 1,353,660 Lbs

Therefore for 2 tanks = 2 x 1,356,660 = 2,707,320 Lbs

Fire load = (Weight of combustible material x CV)/ Floor area under consideration

= (2,707,320 x 17,986) / 6,702

= 726,558 BTU/ ft^2.

Which is 100,000 BTU/ ft^2. (for shops and factories).

Hence, dyke walls of 230 mm thick also suits.

(**Note:** Refer Figure-7 of various other cross sections and shapes of the dyke walls keeping the top width to minimum of 250 mm with widened base).

3. ADVANTAGES OF A DYKE WALL

Dyke walls built around storage tanks used to store various petrochemical products very important/essential. The volume within the dyke around the storage tank should be more than the volume of the tank (This exaggerated thought of idea is an phenomenal design thought at extreme/worst conditions; However, a reasonable thought of design while planning network chambers to be worked out). The walls around the tank shall sustain the sudden impact of heat at the time unexpected event of the spill out material.

The most common benefits of Dyke walls are:

- ✓ Environment protection purpose.
- ✓ Prevent; a) Contamination of; land surrounding ,underground water as well as surface water.
  b) Contact of spills with incompatible reactive materials.
- ✓ Corrosive; limiting the spread of spills to the tank proper/related equipment & supporting structures (even though the said ones shall be placed over RCC/PCC media.

4. FACTORS CONSIDERED DURING THE DESIGN OF DYKE WALLS

i. Economically; use of locally available materials.
ii. Heat resistant.
iii. Use of alternative materials in line with PCC.
iv. Fire load calculations; keeping in view **Dyke** wall height, thickness & increase in floor area.

Quality: The following quality aspects need to be considered during the construction of Dyke walls:

- ✓ quality of construction materials,
- ✓ grade of cement and steel,
- ✓ workmanship and other design aspects specific to IS standards.

Safety: All precautionary care and measures are to be implemented while on construction work activities. Prolific experience and expertise with civil engineering skill; will be an added advantage in handling such challenging works. Though RCC walls are strong and rugged, to introduce any sleeve for accommodating/replacing service pipes (due to design changes/ repairs/ emergency replacement). Despite; strictly following the shutdown procedures with all care; there may be chances of fire accident due to the arc produced while chipping concrete/intact aggregates; requires emergency attention.

5. SPECIAL ASPECTS TO BE CONSIDERED DURING CONSTRUCTION

1. Simultaneous Operational measures to be implemented during construction phase in case of brown field project where the adjacent/existing plant is in operation stage.
2. Plant construction;operational /Shut down and maintenance stages for effective implementation to be well planned.

The above said aspects have to be studied professionally along with safety, and integration aspects during design and construction of Dyke walls.

6. CONCLUSION

The above study clearly demonstrates the importance of Dyke walls in an Petrochemical Projects. More emphasis is given for utilization of locally available construction materials. Other important aspects like quality, safety, design, construction of Dyke walls, workmanship, time and cost has been covered within this technical paper.

Dyke walls be constructed at petrochemical/likewise petrochemicals units in an industrial areas which are unique of its own kind & exceptionally distinct in operation and expected to stand for many years in steel plants/chemical industries/ Petrochemical industries & other such connected.

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