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Technical Letter
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Engineering and Design
NAVIGATION LOCK GUARD WALLS

1. Purpose.

The purpose of this Engineer Technical Letter (ETL) is to provide design guidance for upper lock approaches, including parameters for the geometric layout of upper approach guard walls.

2. Applicability.

This ETL is applicable to all USACE Commands having Civil Works responsibilities. It applies to all studies and designs of upper lock approaches.

3. Distribution Statement.

Approved for unlimited public release.

4. References.

a. **ERDC/CHL, EM 1110-2-1611, Dec 1980, Layout and Design of Shallow-Draft Waterways.[1]**

b. **ERDC/CHL, CHETN-IX-6, Dec 2001, Modeling Navigation Conditions at Lock Approaches, Richard L. Stockstill.**

c. **ERDC/CHL, CHETN-IX-8, June 2002, General Guard Wall Design Considerations for Tow Entry and Exit, Howard Park.**

5. **Discussion.**

Upper lock approach guard walls are structural members used by downbound towboats to align with and enter the lock chamber. The performance of these guard walls drastically impacts the functional efficiency of any given lock. Guard wall efficiency can be measured in units of time. An efficient guard wall results in minimal maneuvering for a downbound tow to come to rest or near rest on the guard

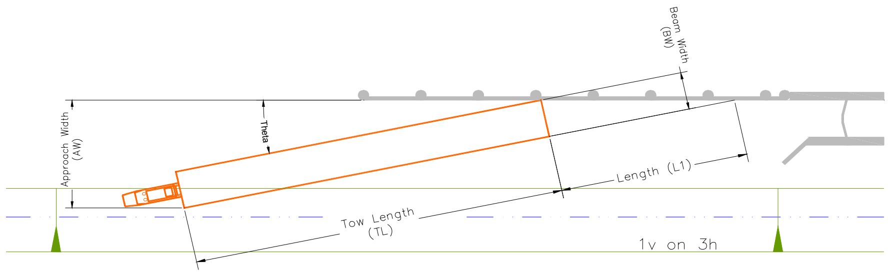
[1] This engineer technical letter supersedes information found in Chapter 10 of this reference.

wall and align with and enter the lock chamber. The performance or efficiency of the upper approach lock guard wall is greatly impacted by two major factors: outdraft and draw towards the guard wall. Outdraft is defined as the flow in the upper lock approach that cannot be passed under or through the guard wall, and thereby moves across the upper lock approach or around the end of the guard wall and towards the dam. The outdraft, if severe, tends to move the head (bow) of the tow out of alignment with the guard wall and requires that the pilot increase maneuvering. Draw towards the wall is defined as the flow in the upper lock approach that moves towards and under the guard wall towards the dam. Excessive draw towards the guard wall can cause downbound tows to strike the wall at excessive speeds and could cause damage to the barges and/or guard wall. Furthermore, if the draw towards the guard wall is excessive, it could inhibit an upbound tow from departing the lock and proceeding upstream. Upper approach guard walls should be designed to minimize the negative impacts that outdraft and draw towards the wall can have on the navigability of tows entering and leaving the lock chamber. By balancing and minimizing the outdraft and draw towards the wall, pilot maneuvering for tow entry and exit can be kept to a minimum, thus decreasing passage time for tows and providing a safer project.

Generally speaking, there are three basic types of guard walls normally used in upper lock approaches. These are multi-cell (ported or non-ported), long span, and floating guard walls. Multi-cell guard walls consist of a series of circular driven-sheet-pile cells spaced about 50 feet on center with a concrete cap connecting them. The openings between the cells and below the concrete cap are the ports. The ports in the guard wall allow the flow in the lock approach to move through and under the guard wall towards the dam. The flow through the ports can be altered with draft curtains between each of the cells. Long span guard walls are basically the same as multi-cell guard walls with span widths typically around 100 to 125 feet. The cap connecting the cells is normally a pre-cast concrete beam that serves as the rubbing surface. Draft curtains can also be attached to the beam to regulate flow thru the guard wall. Floating guard walls are generally a large hollow concrete pontoon. Floating walls are generally about 30 to 40 feet wide and draft about 10 feet. Flow under these walls may also be adjusted using draft curtains attached to the bottom of the pontoon.

6. <u>Recommendations</u>.

The approach configuration is based on the lock’s design tow size. The appropriate approach width for the tow must first be determined. A general guideline that can be used to establish the approach width is to consider an angle of approach to the lock of 12° to 15°, as shown in Figure 1.



$AW = \sin(\Theta) * (TL + L1)$

where $L1 = BW / \tan(\Theta)$
Θ = maximum approach angle (12° to 15°)
BW = width of tow
TL = length of tow

$AW = \sin(\Theta) * (TL + (BW / \tan(\Theta)))$

Figure 1. Determining Approach Width (AW)

Park (2002) and Stockstill (2002) suggest that optimizing the ratio of the sum of the total port area (ΣA_{ports}) in the guard wall to the sum of intercepted cross-sectional area (ΣA_{xs}) would balance the outdraft and draw toward the wall. Based on laboratory experiments, the ratios of $\Sigma A_{ports} / \Sigma A_{xs}$ listed in Table 1 were determined to provide acceptable navigation conditions for a single multi-cell, long span, and floating guard walls with nominal lengths of 1200 ft and approach widths of 300 ft. Note that the recommended ratio for the multi-cell guard wall is lower than those observed with the long span and floating guard walls. This is due to the vane action induced by the circular cells. That is, the cells in the multi-cell guard wall tend to train the flow more normal to the wall.

Laboratory experiments also showed that, in some cases, improved guard wall performance could be achieved by reducing the height of the ports in the downstream one-fourth to one-third of the guard wall length. This is particularly helpful when high velocities are encountered in the lock approach. By reducing the size of the downstream ports, more flow is forced through the upstream ports. When sized correctly, the flow along the wall will become more uniformly distributed.

A wider approach width of 550 ft. was evaluated with similar guard wall configurations previously tested in the 300 ft. approach width. The intercepted cross-sectional area, A_{xs}, was increased by almost 200% while port openings remained constant. Therefore, the $\Sigma A_{ports} / \Sigma A_{xs}$ ratios decreased (approximately 50%) with respect to the narrower approach width. Laboratory experiments showed that while wider approach widths do provide more available space for pilot maneuvering, increased maneuvering may be required for tows to align with and enter the lock chamber due to the likelihood of increased outdraft. As noted earlier, increased maneuvering will result in increased transit times, defeating the purpose of optimizing guard wall design. Further, in order to maintain balance between outdraft and draw toward the wall, longer guard walls would likely be required to accommodate the increased approach width. In conclusion, wider approach widths allow additional room for pilot maneuvering; however, they do not necessarily improve the navigation conditions or transit times for the lock approach.

Table 1. Recommended design ratios for effective guard wall geometry

Approach Width = 300 ft		
Wall Type	**Length**	$\Sigma A_{ports} / \Sigma A_{xs}$
Multi-cell guard wall	1200 ft	0.9
Long-span guard wall	1200 ft	1.4
Floating guard wall	1200 ft	1.9

FOR THE COMMANDER:

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