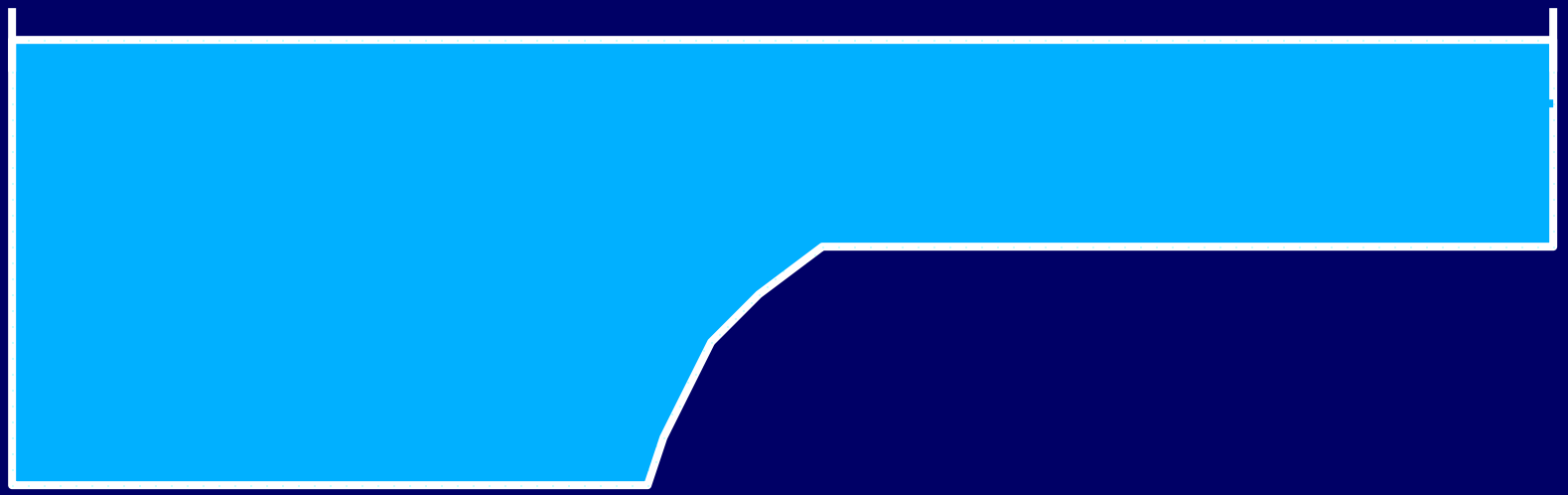
LIQUID RETAINING STRUCTURES



DR. MUHAMMAD IRFAN-UL-HASSAN.

LIQUID RETAINING STRUCTURES

References

Concrete Liquid Retaining Structures

J. K. Green and P.H. Perkins

Design of Liquid Retaining Concrete Structures

R.D. Anchor

LIQUID RETAINING STRUCTURES

Codes of Practice
ACI 350 R 05
BS 5337

SCOPE

- Storage tanks
- reservoirs
- swimming pools
- elevated tanks
- ponds
- basement walls ※

GENERAL DESIGN OBJECTIVE

- The structure designed to retain liquids must fulfil the requirements for normal structures like
  - STRENGTH
  - DURABILITY
  - LIMITED DEFLECTION and CRACKING.

GENERAL DESIGN OBJECTIVE

In addition, the liquid should not be allowed to

- LEAK

or

- PERCOLATE through concrete structures ※

FUNDAMENTAL REQUIREMENTS

- The requirements for the structure without
  - UNDUE MAINTENANCE and
  - ADEQUATE COVER to reinforcement are essential

- The concrete must be of good quality
- It may be necessary to use increased cement contents
- Special cements may also be required※

FUNDAMENTAL DESIGN METHODS

- Historically the liquid retaining structures have been designed by elastic theory for working loads.
- More recently limit state methods have been introduced, providing a more realistic basis for determining factors of safety.

FUNDAMENTAL DESIGN METHODS

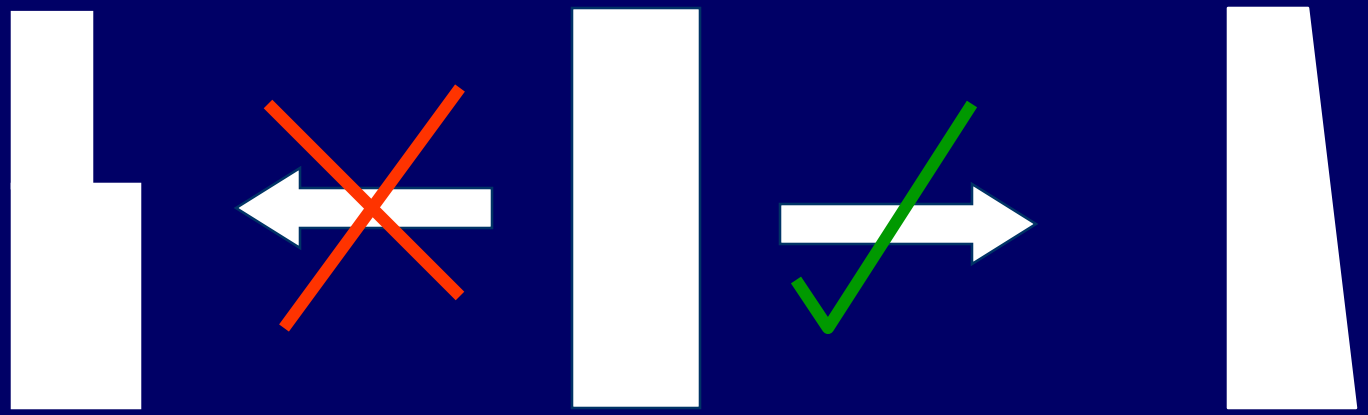
- The liquid retaining structures designed by elastic theory are subjected to so small material stresses that no flexural cracks are developed. But this is achieved at the cost of too thick sections with excessive amounts of reinforcement.
- The probability of shrinkage and thermal cracking is not dealt with properly. ※

STRUCTURAL LAYOUT

- The lay out of the proposed structure and the estimation of member sizes must be made prior to detailed analysis.
- Structural schemes should be considered from the viewpoints of STRENGTH, SERVICEABILITY, ease of CONSTRUCTION and COST. ※

STRUCTURAL LAYOUT

- It is particularly necessary to avoid sudden changes in section, because they cause concentration of stress and hence increase the possibility of cracking.※



STRUCTURAL LAYOUT

- It is good practice to carry the structural loads as directly as possible to the foundation, using the fewest structural members.
- It is preferable to design cantilever wall as tapering slabs rather then as counter fort walls with slabs and beams.※

STRUCTURAL LAYOUT

- The floor of a water tower or the roof of a reservoir can be designed as a flat slab.
- Underground tanks and swimming pools are generally simple structures with constant-thickness walls and floors.※

STRUCTURAL LAYOUT

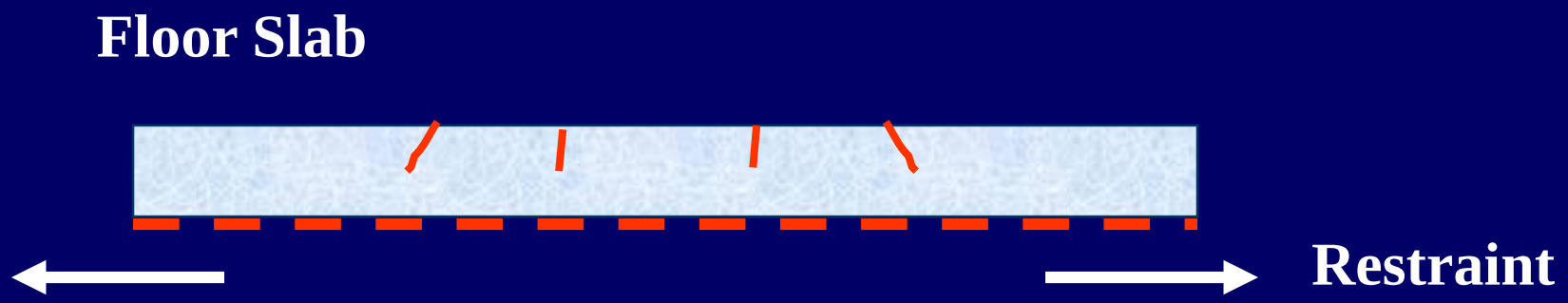
- It is essential for the designer to consider the method of construction and to specify on the drawings the location of all construction and movement joints. ※

STRUCTURAL LAYOUT

- Important considerations are the provision of KICKERS against which formwork may be tightened, and the size of wall and floor panels to be cast in one operation. ※

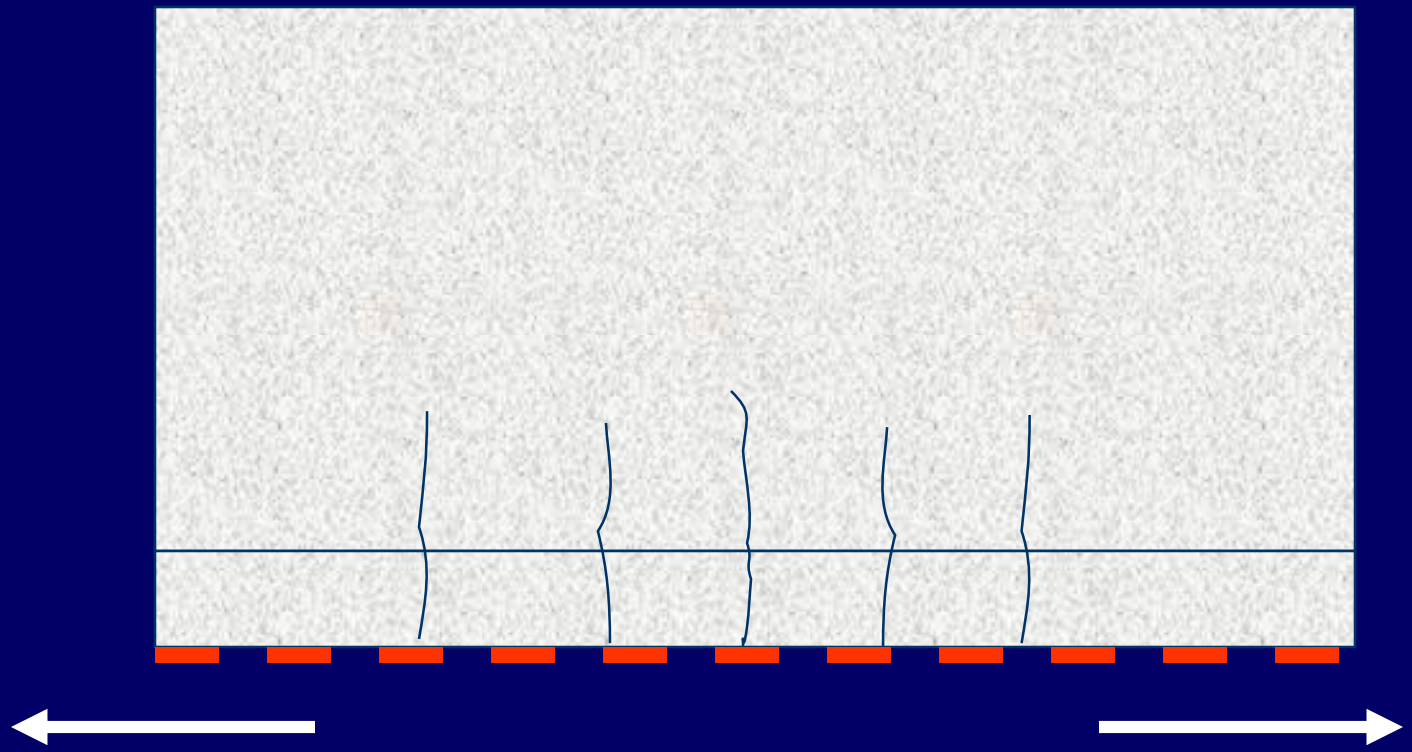
Influence of Construction Methods

- The soil at foundation level exerts a restraining force on structure which tends to cause cracking.※



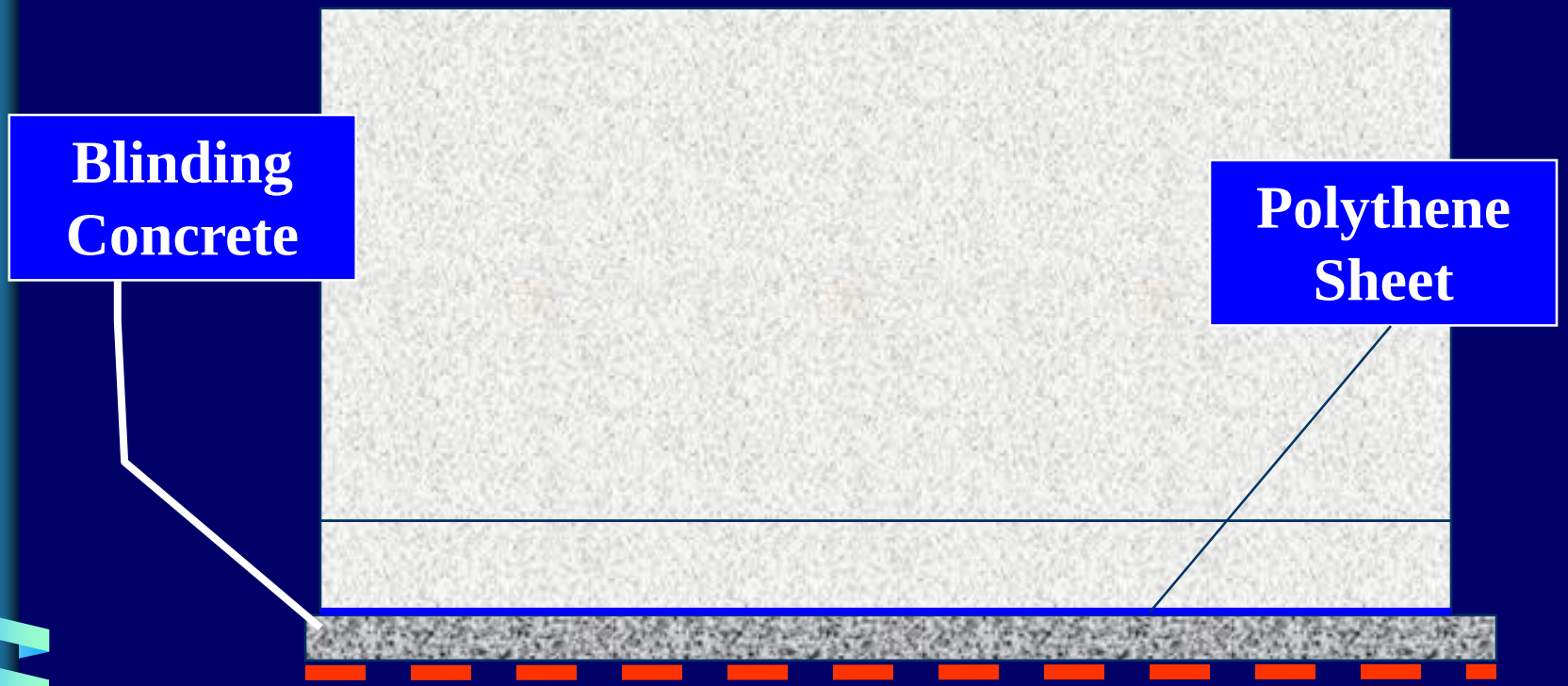
Influence of Construction Methods

WALL



Influence of Construction Methods

Solution is to lay a sheet of 1000g polythene or other suitable material on a 75 mm layer of blinding concrete

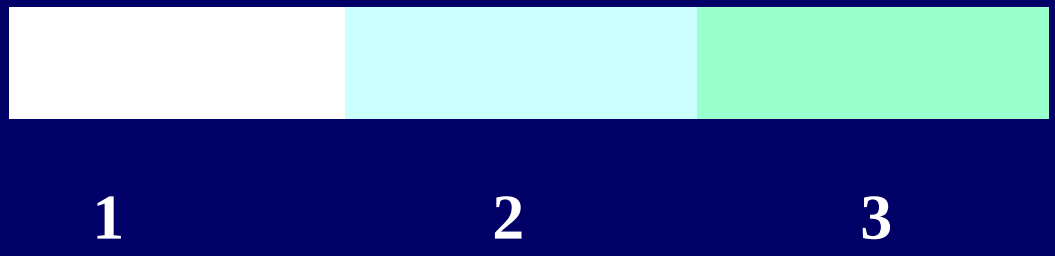


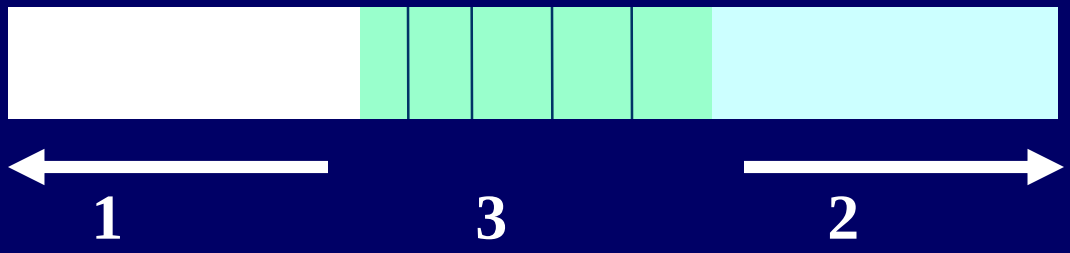
Influence of Construction Methods

- The foundation and floor slabs are cast in sections which are of convenient size and volume to enable construction to be finished in the time available.
- The sections terminate at a construction or movement joint※

Influence of Construction Methods

- The construction sequence should be continuous to avoid restraints from adjacent panels.※





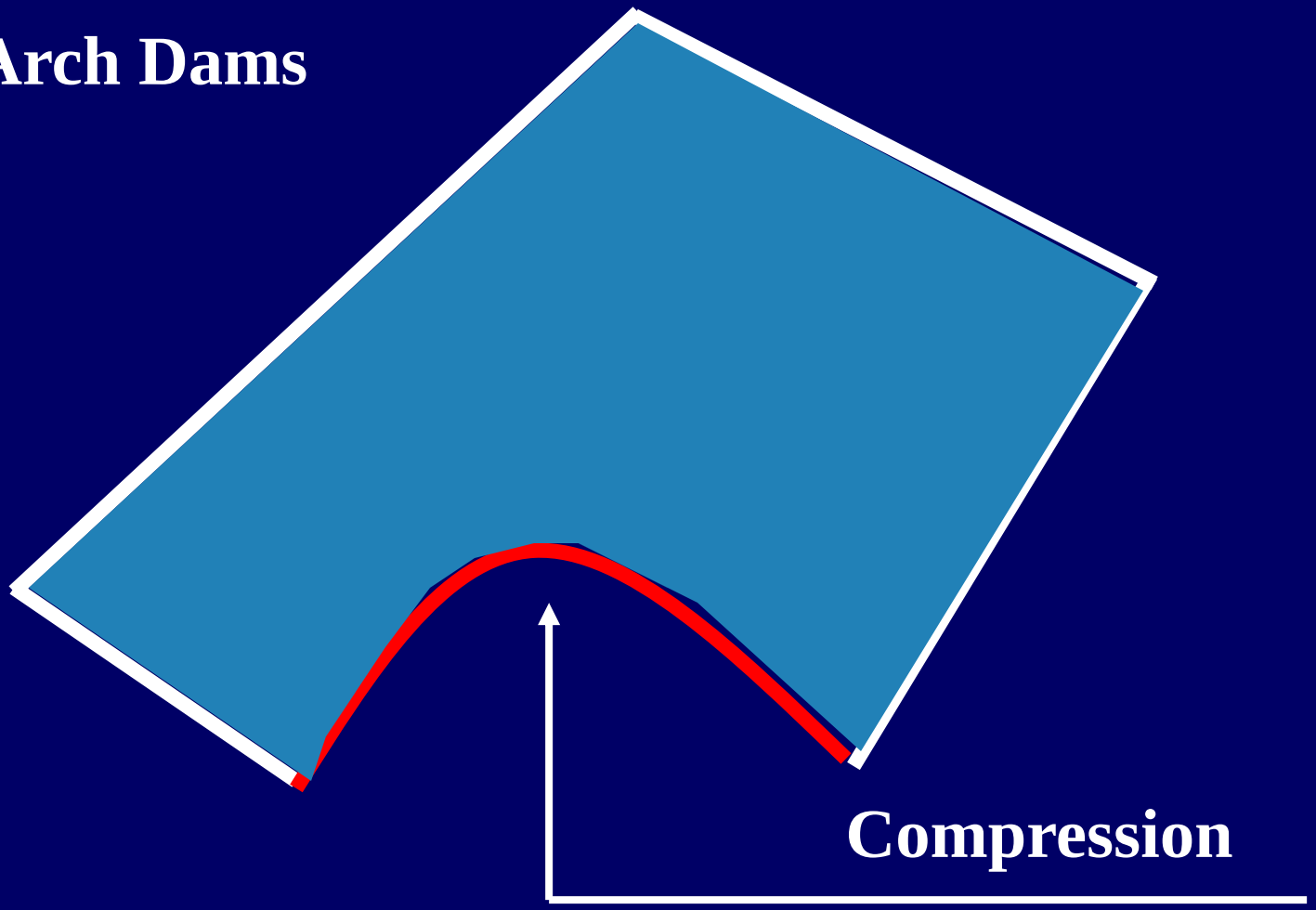
STRUCTURAL ACTION

- All liquid retaining structures are required to resist horizontal forces due to liquid pressures.
- There are two ways in which the pressures can be contained:

* By forces of direct TENSION or COMPRESSION
* By FLEXURAL resistance. ※

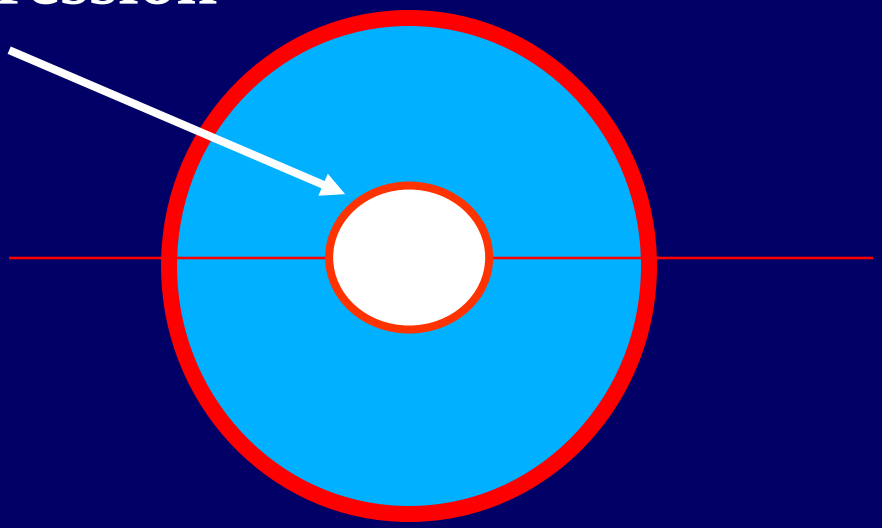
TENSION or COMPRESSION

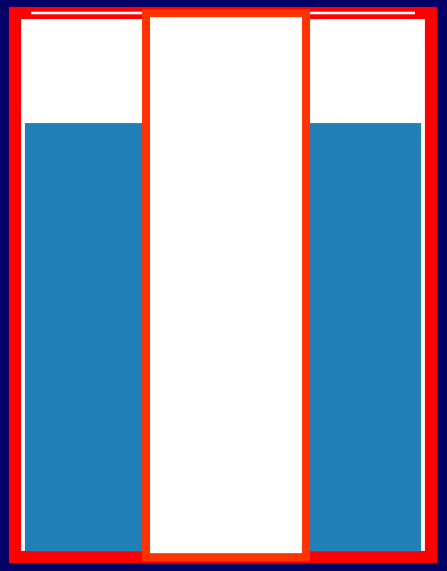
Arch Dams



TENSION or COMPRESSION

Compression



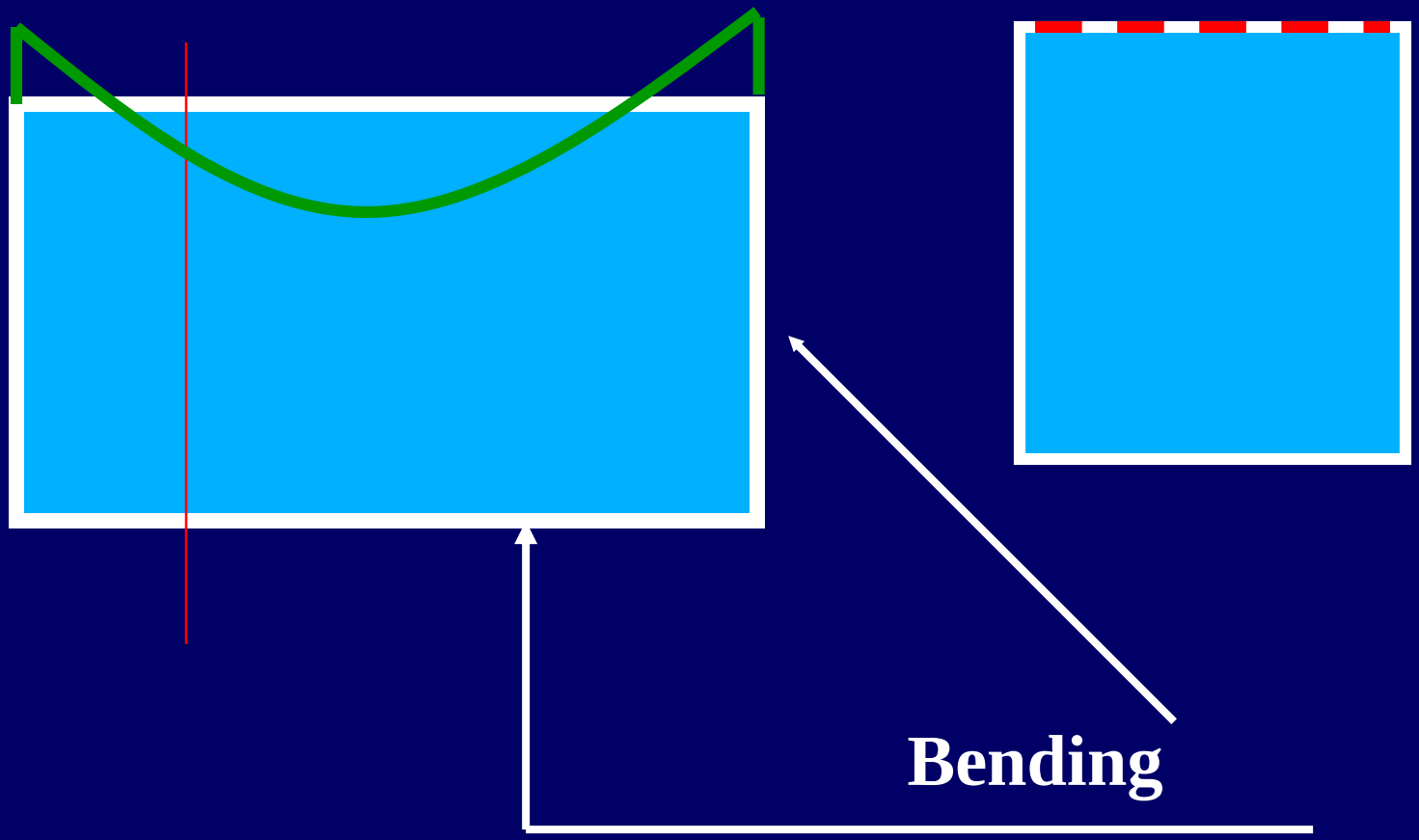


Circular Tanks

May be prestressed

BENDING

Rectangular Tanks

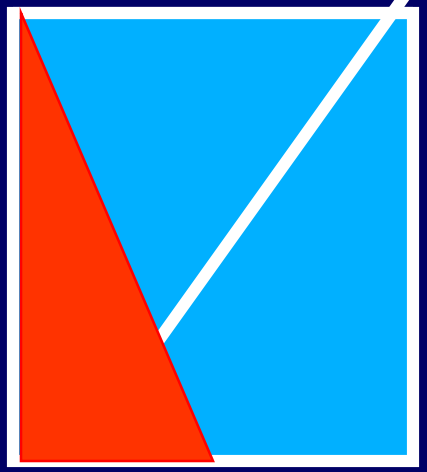


CRITICAL LOADING STATES

- There are two critical loading states for a water compartment:

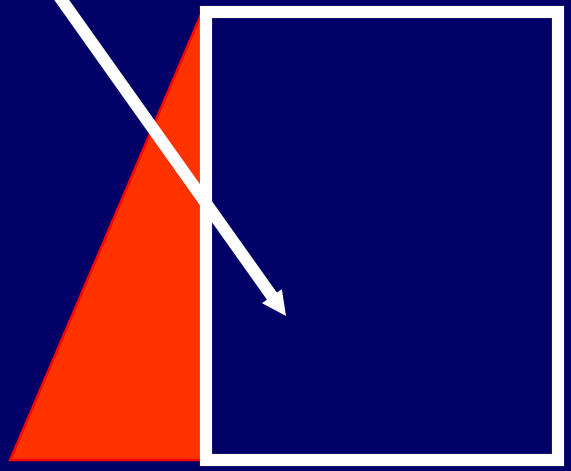
A: The TANK IS FULL

Liquid Pressure



B: The TANK IS EMPTY

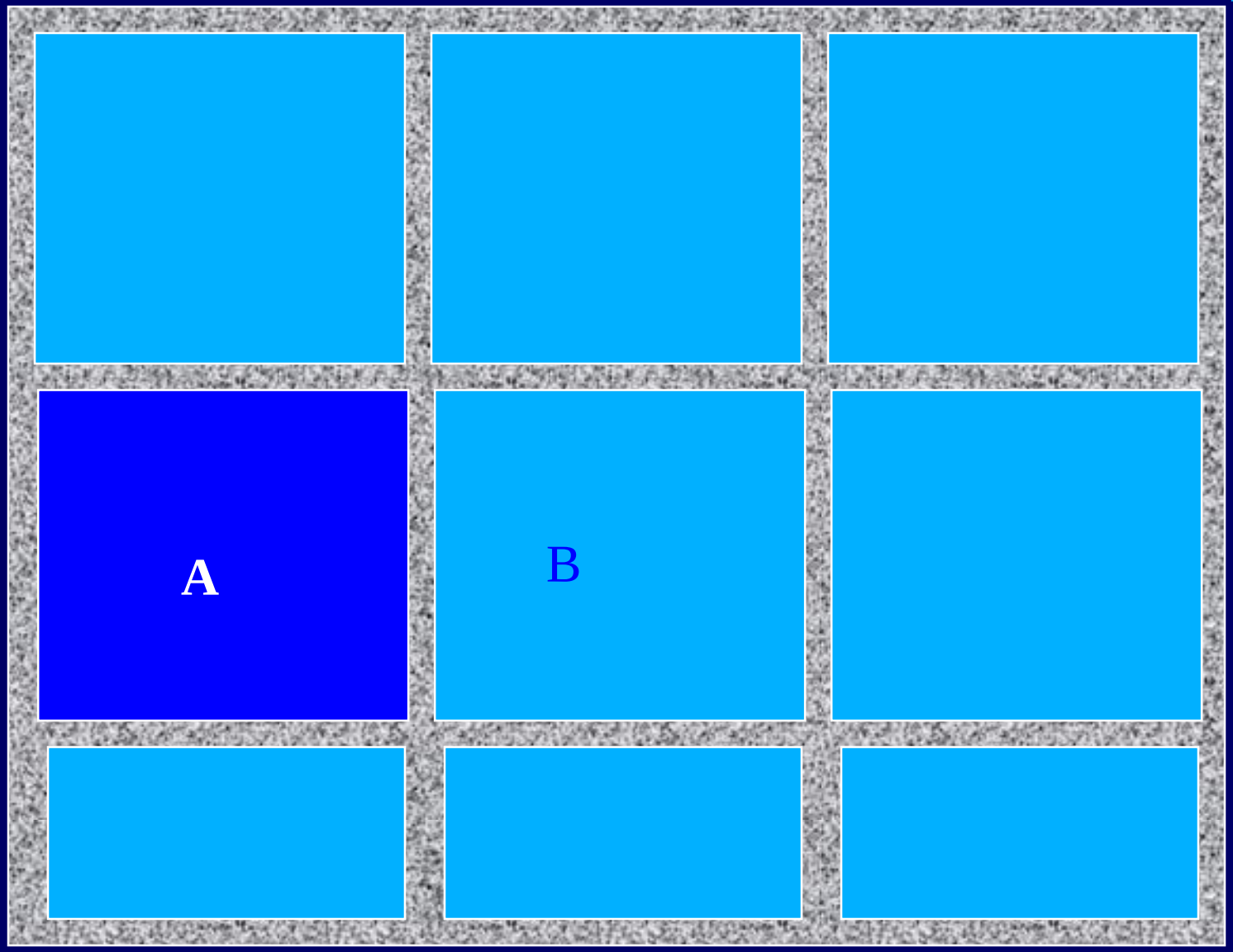
Active Earth Pressure



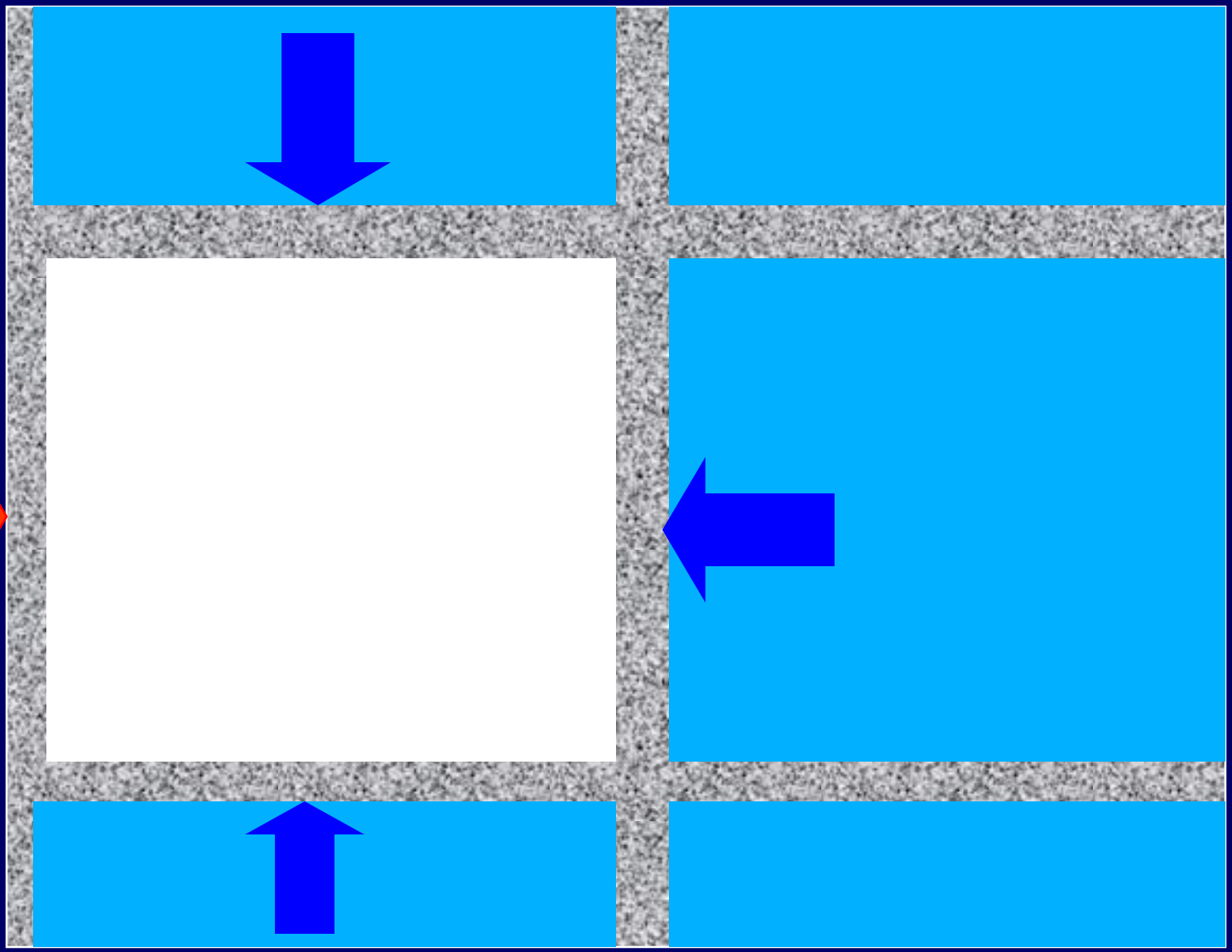
CRITICAL LOADING

- The designer must consider whether sections of the complete reservoir may be empty when other sections are full, and design each structural element for the maximum bending moments and forces that can occur. Several loading cases may have to be considered.
- Internal partition walls should be designed for liquid loading from both sides considering on one side at a time ※

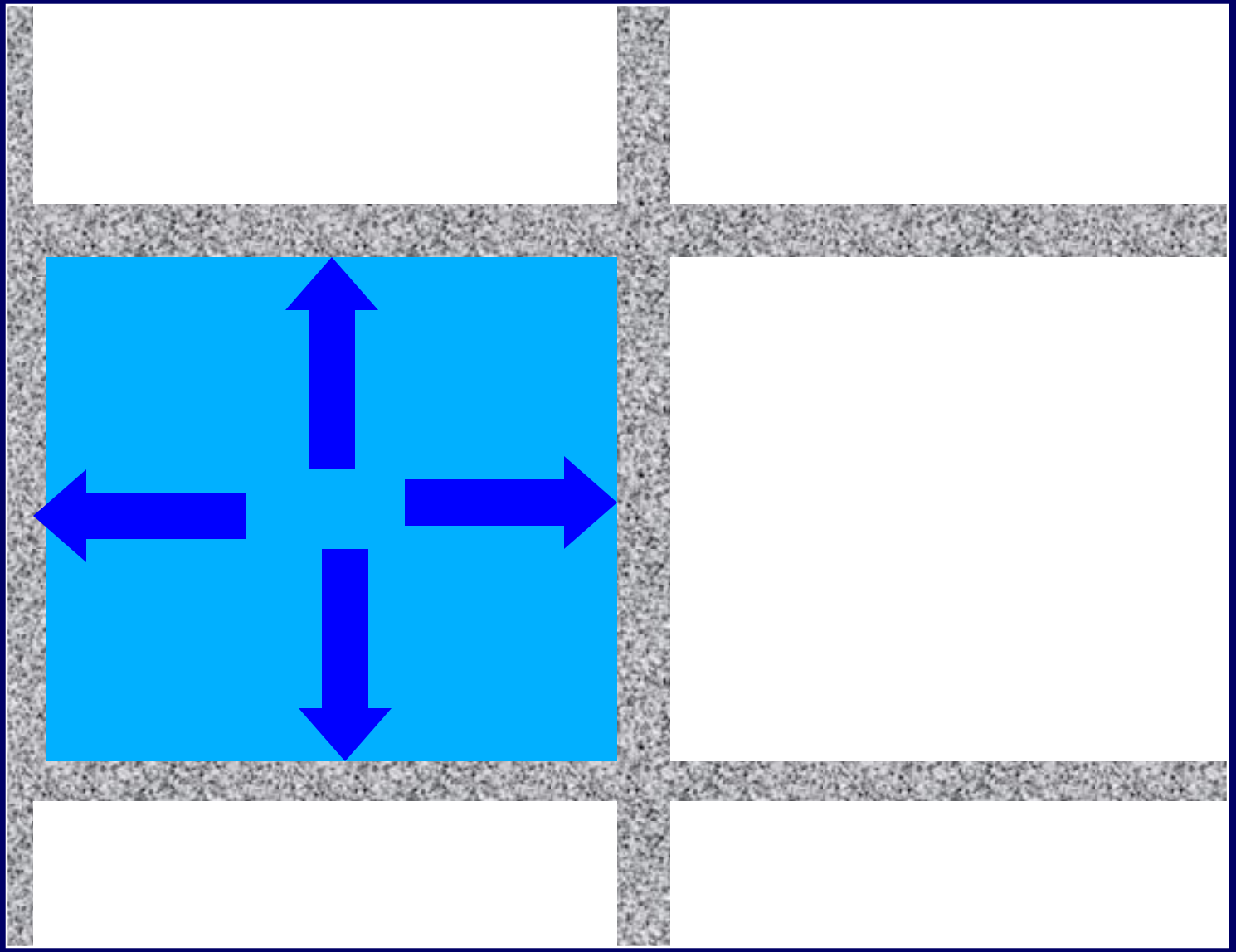
CRITICAL LOADING



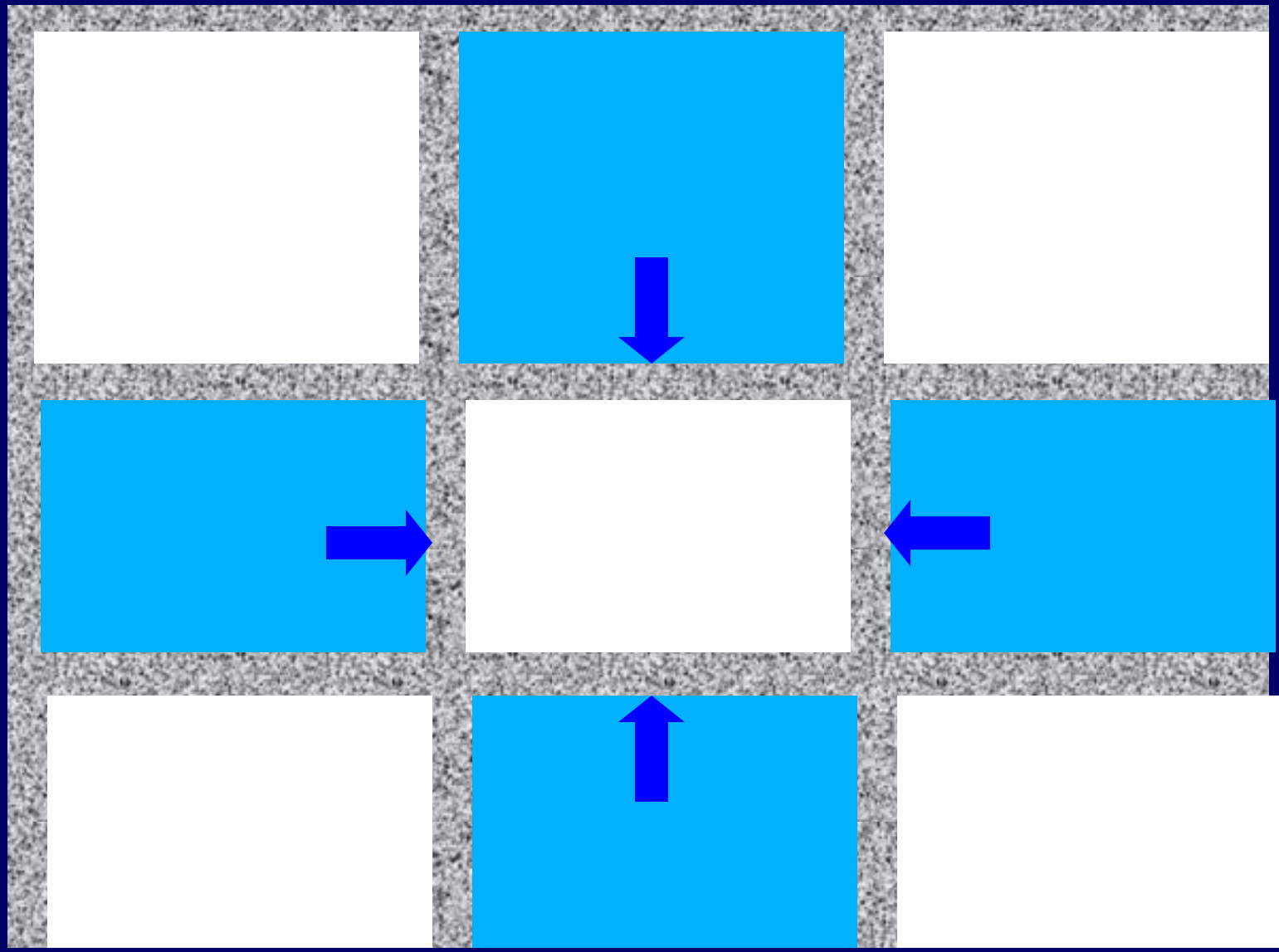
COMPARTMENT A EMPTY



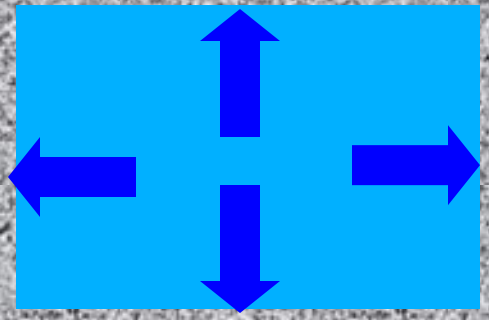
COMPARTMENT A FULL



INTERNAL COMPARTMENT (B) EMPTY



INTERNAL COMPARTMENT (B) FULL



CRITICAL LOADING (Summary)

- External reservoir walls are often required to support soil fill.
- When the reservoir is empty, full allowance must be made for the active soil pressure and any surcharge from vehicles.
- When reservoir pressure is considered with the reservoir full, no RELIEF is allowed from passive pressure of the soil. ※

FOUNDATION

- It is desirable that a liquid retaining structure is founded on good uniform soil, so that differential settlements can be avoided.
- On sites with non-uniform soils, it may be, necessary to consider DIVIDING the structure into completely separate sections.※

FOUNDATION

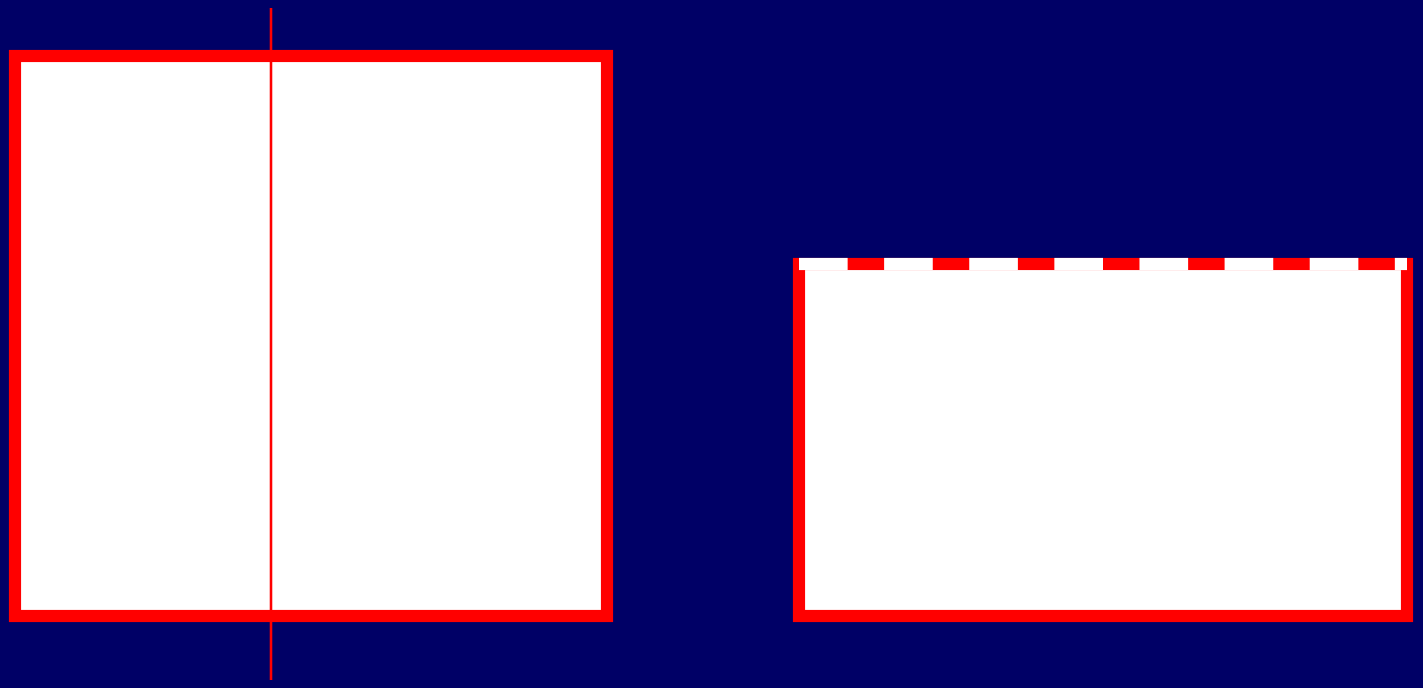
- The use of cantilever walls depends on:

1. passive resistance to the applied pressure
2. resistance to sliding being provided by the foundation soil※

FOUNDATION

- If the soil under the foundation is inundated by ground water, it may not be possible to develop the necessary soil pressure under the footing.
- In these circumstances, a cantilever design is not appropriate, and the overturning forces should be resisted by a system of beams balanced by the opposite wall.
- Or the walls must be designed as spanning horizontally if possible※

FOUNDATION



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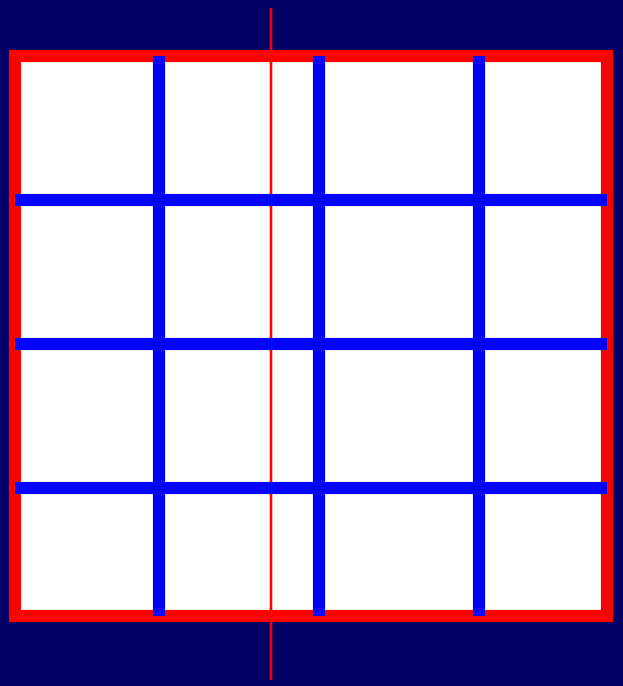
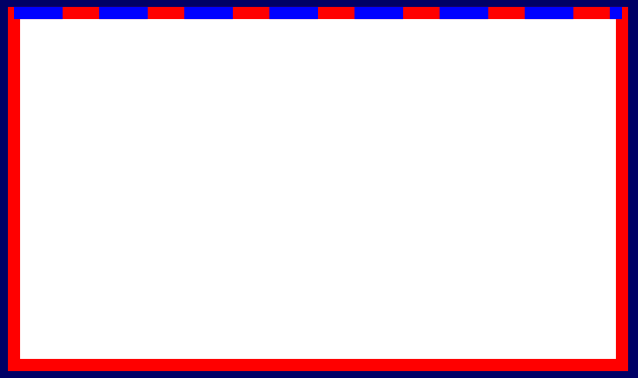
FOUNDATION





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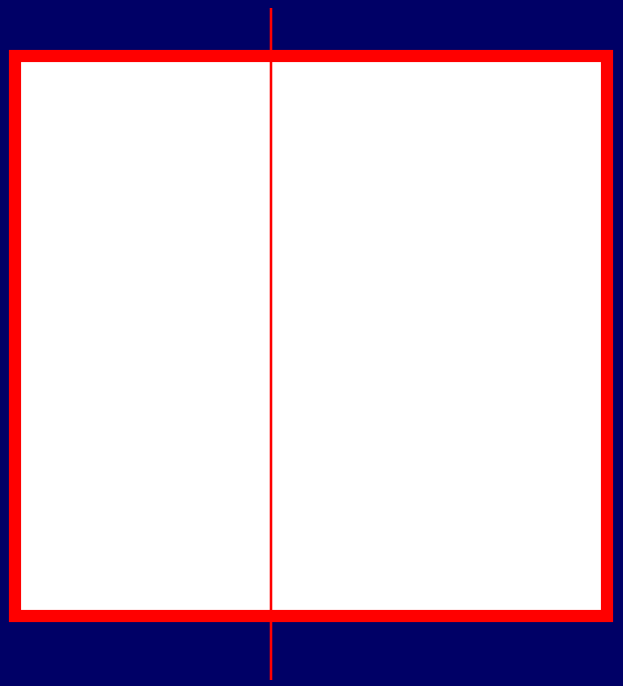
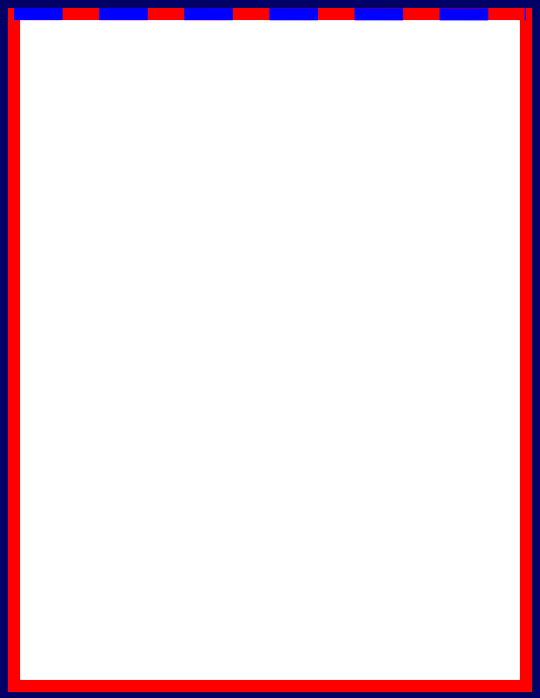
Walls Span Vertically

FOUNDATION





H

B

B/H < 0.5

Walls Span Horizontally