

BRIDGE CONSTRUCTION

Juan Antonio Ferriz Papí



Every bridge can be divided broadly into 3 parts:

Foundation

- Transfers loads to the bearing strata

- Shallow or deep foundations depending on geotechnical properties of the bearing strata

- Usually piles or well foundations

Substructure

- Supports the superstructure and transfers loads to the foundations

- Mainly piers and abutments

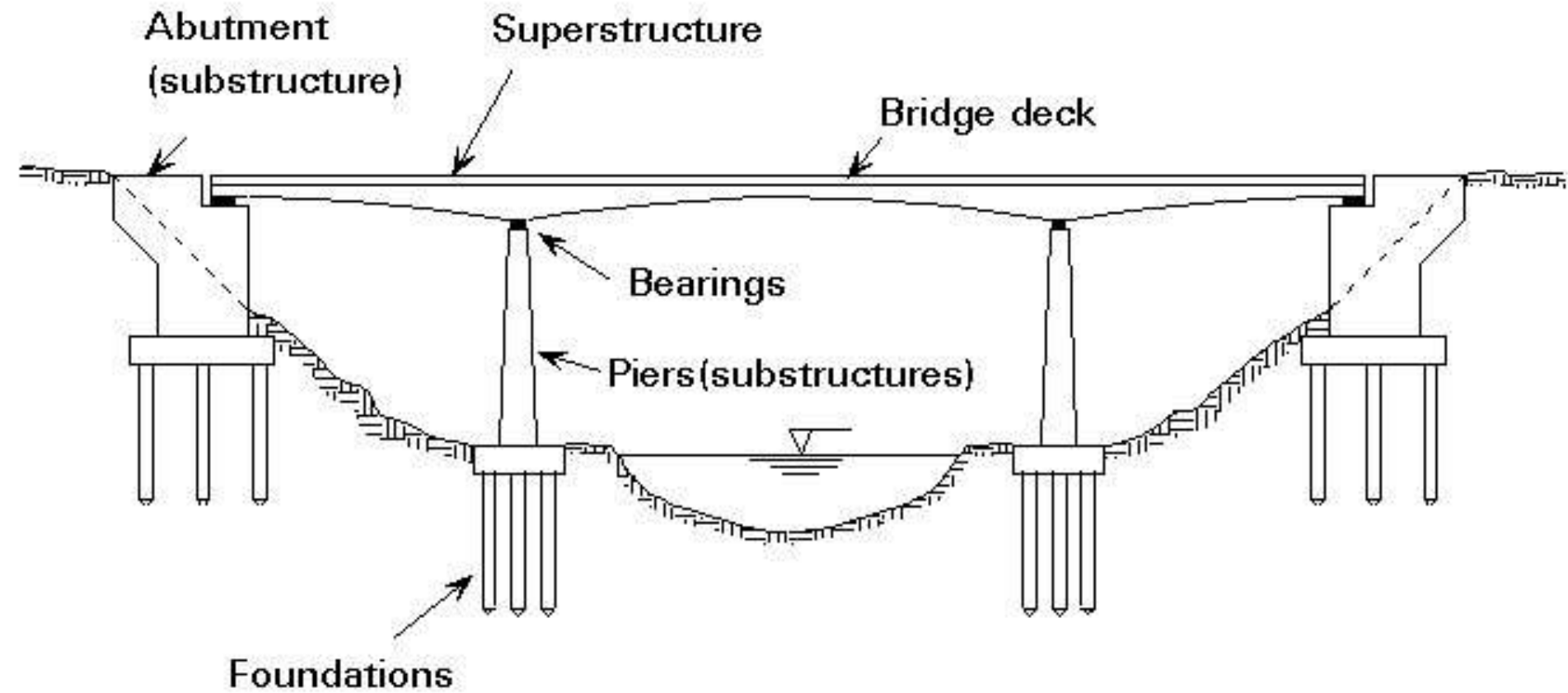
Superstructure

- Supports traffic

- It includes deck, slab and girders

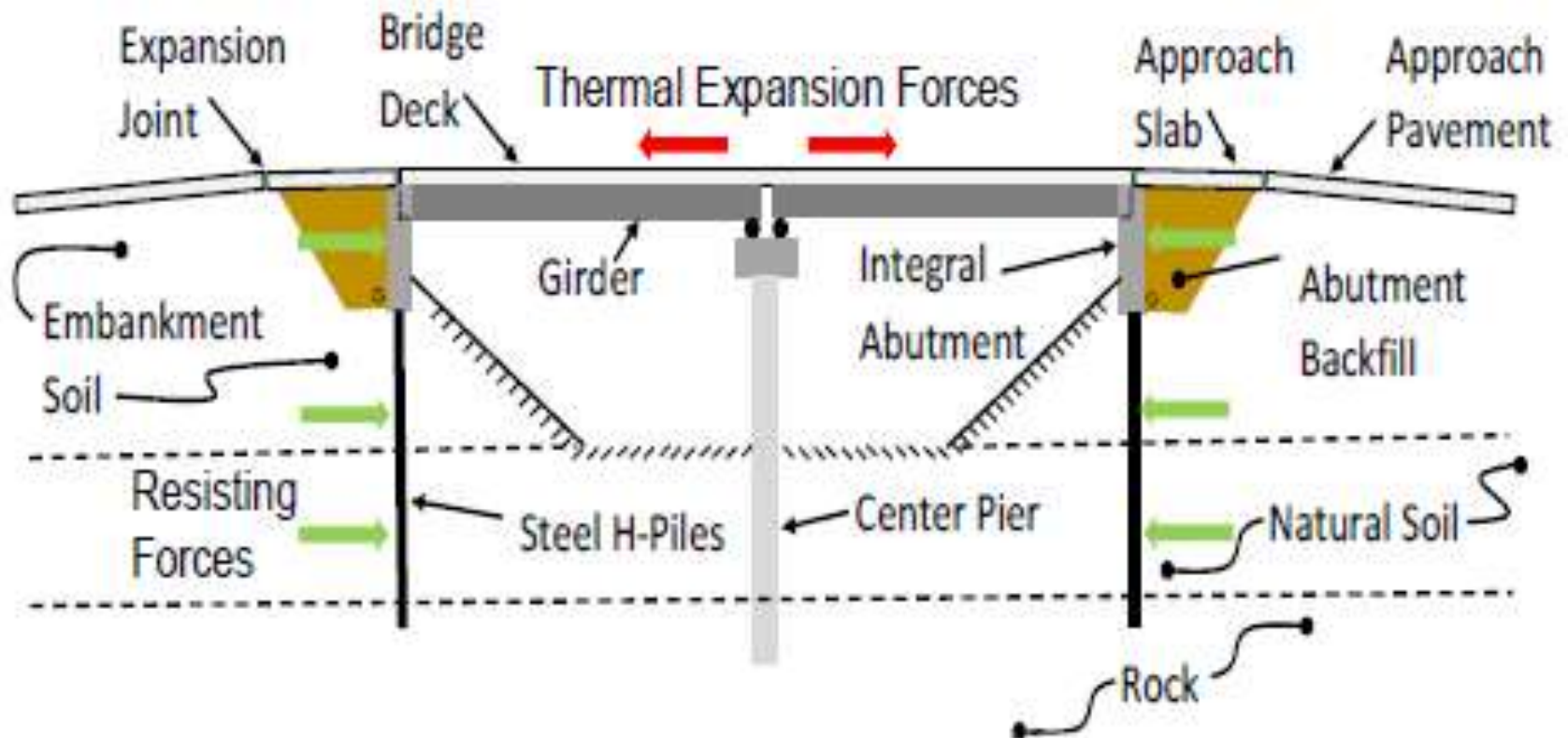


PARTS OF A BRIDGE

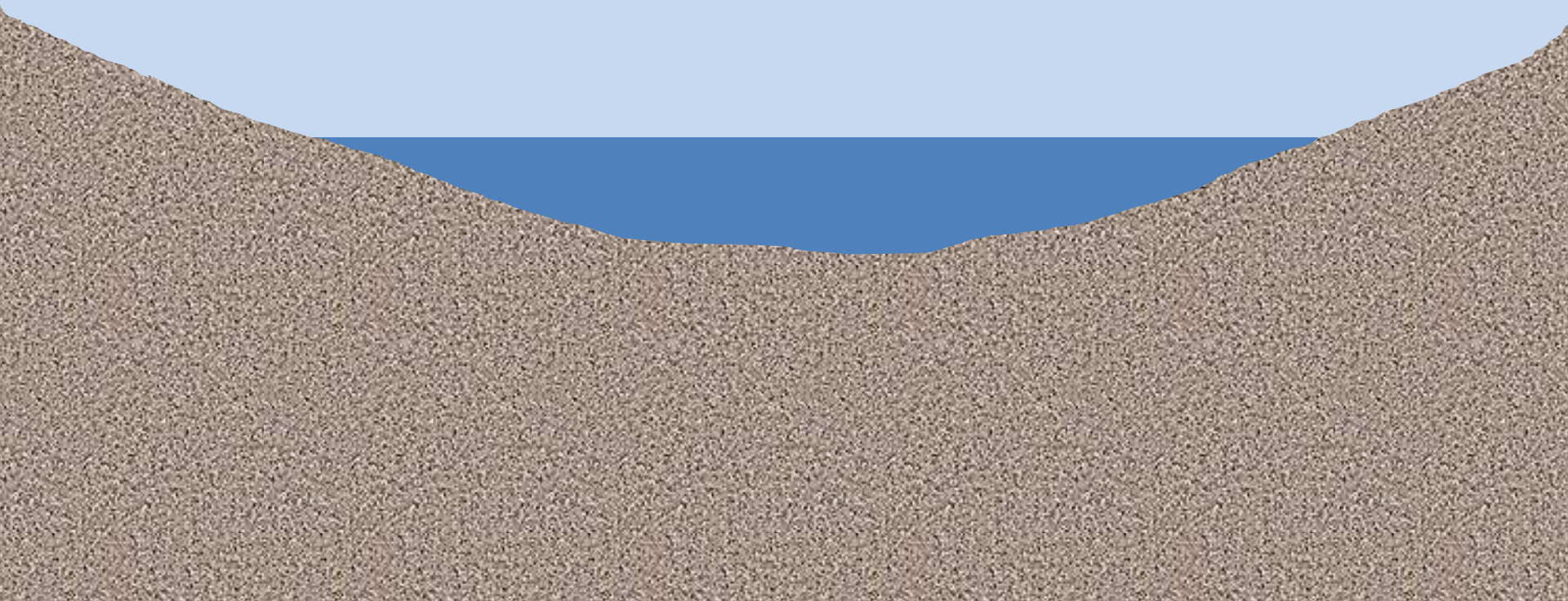
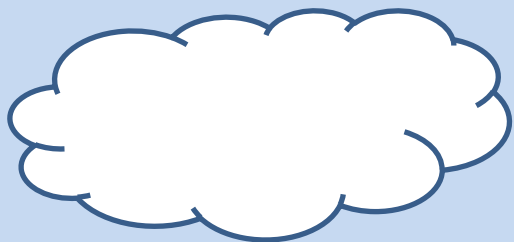




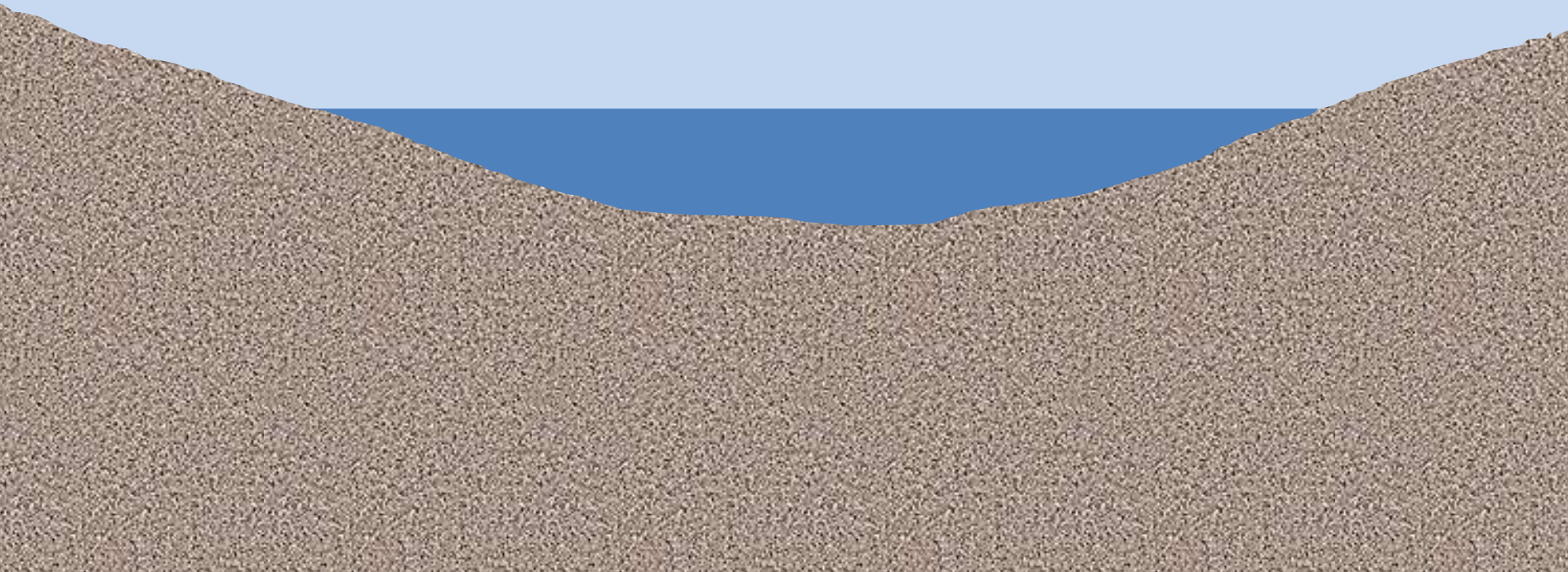
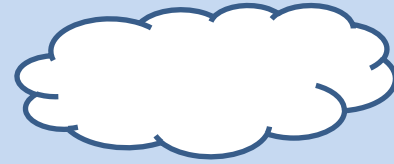
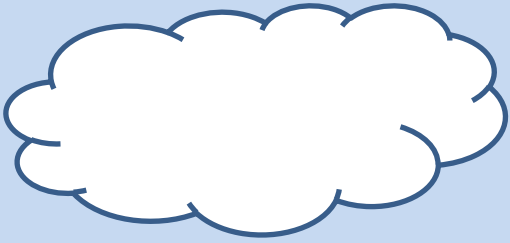
PARTS OF A BRIDGE



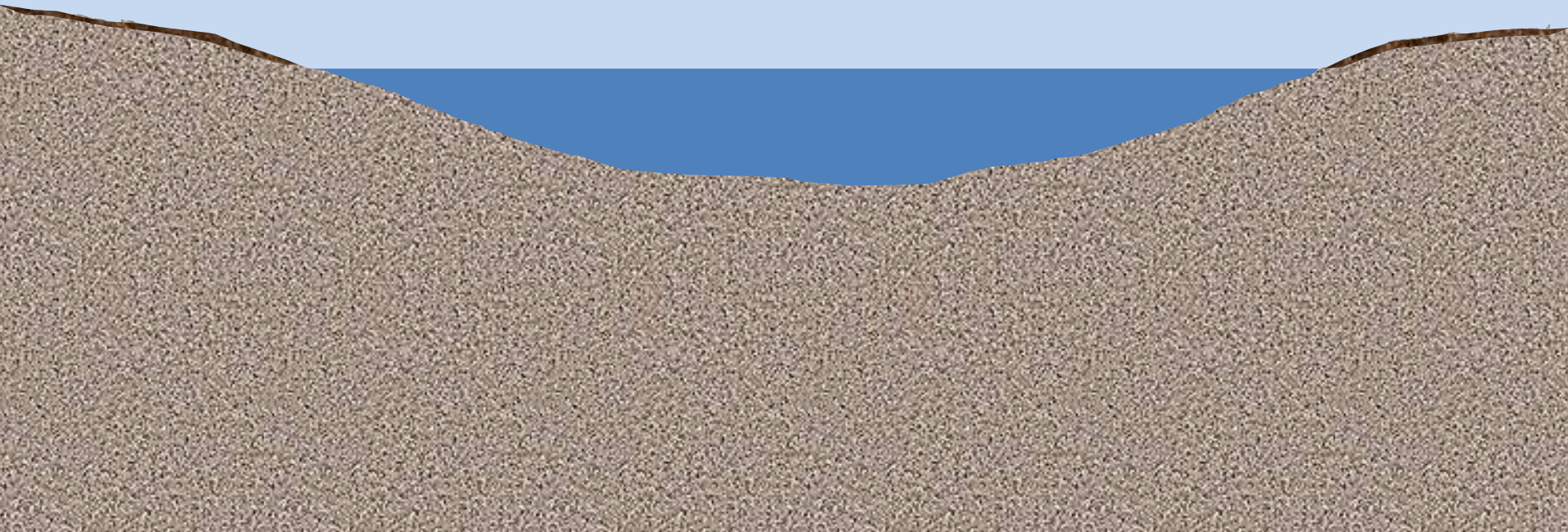
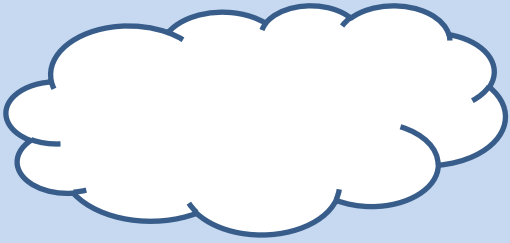
BRIDGE CONSTRUCTION VIDEO



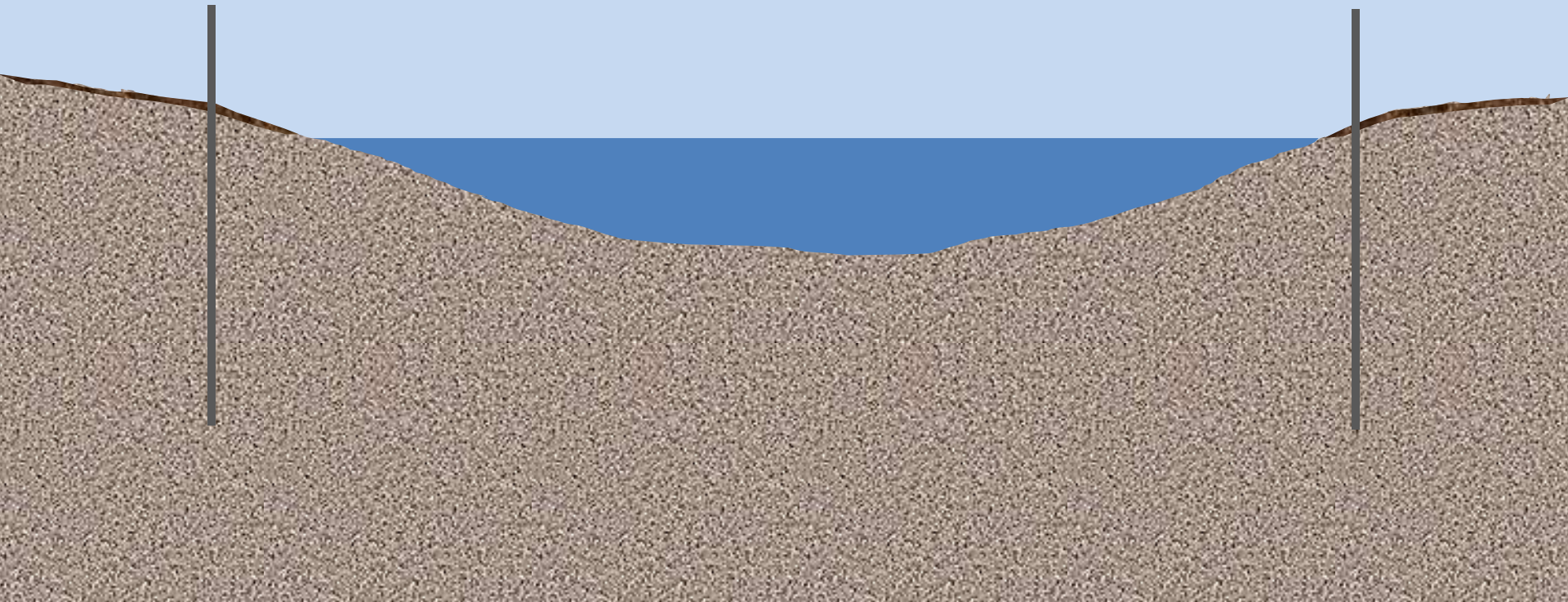
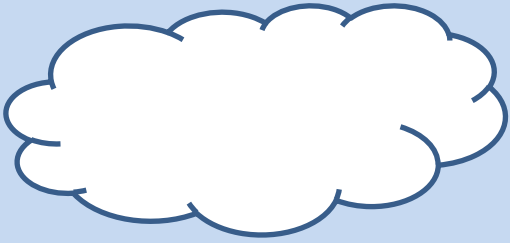
SITE LAYOUT AND EXCAVATION



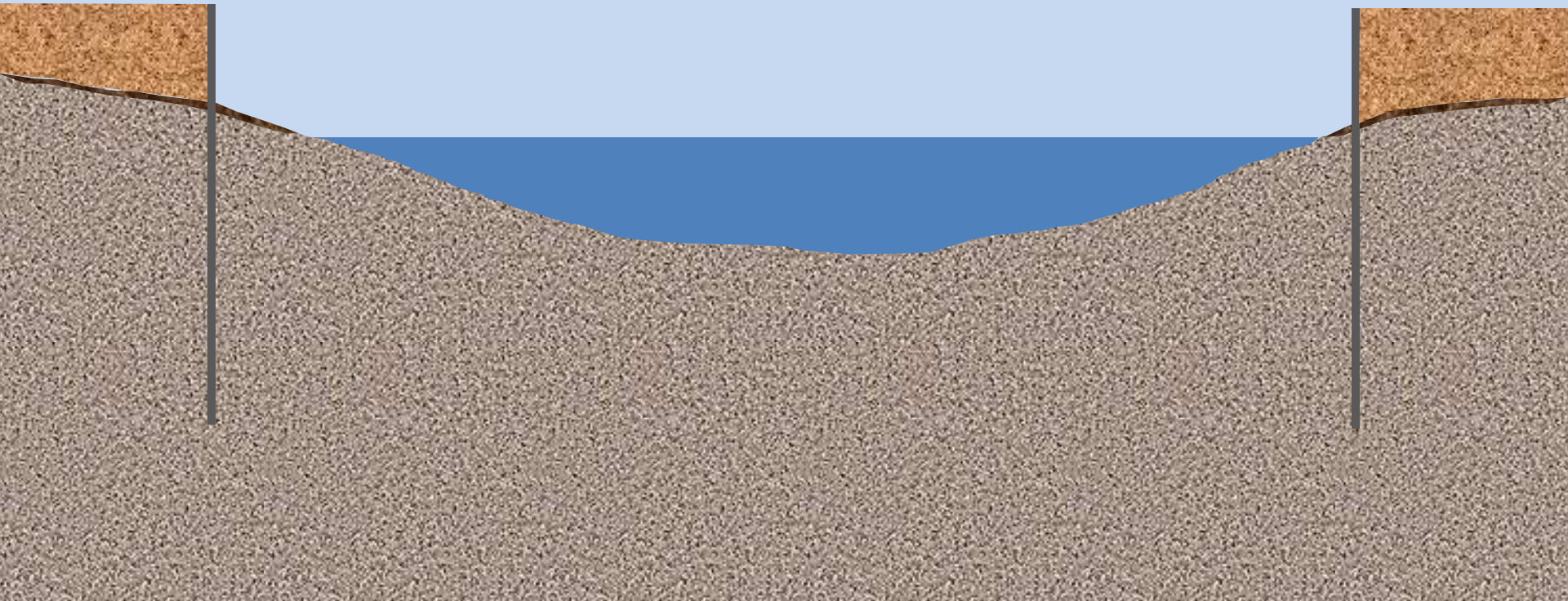
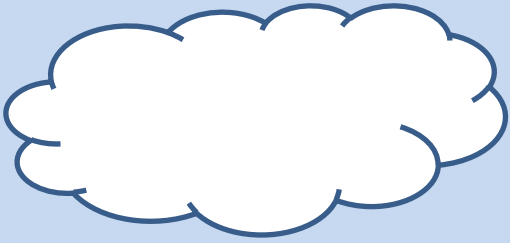
SITE LAYOUT AND EXCAVATION



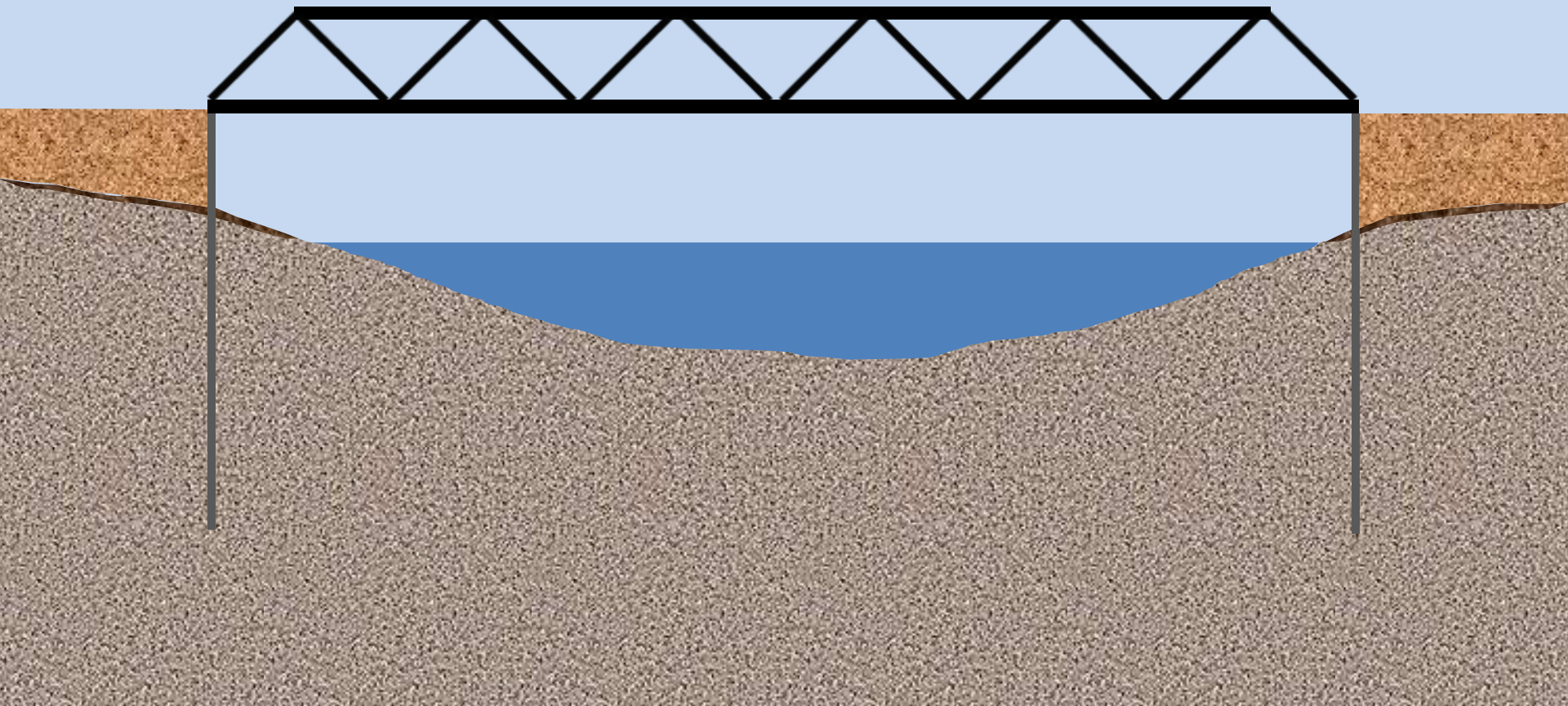
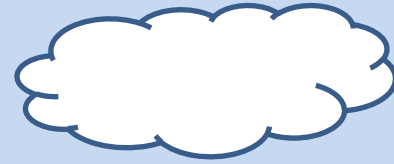
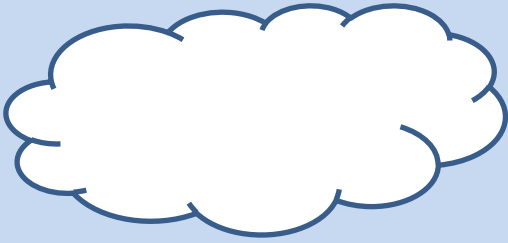
ABUTMENTS



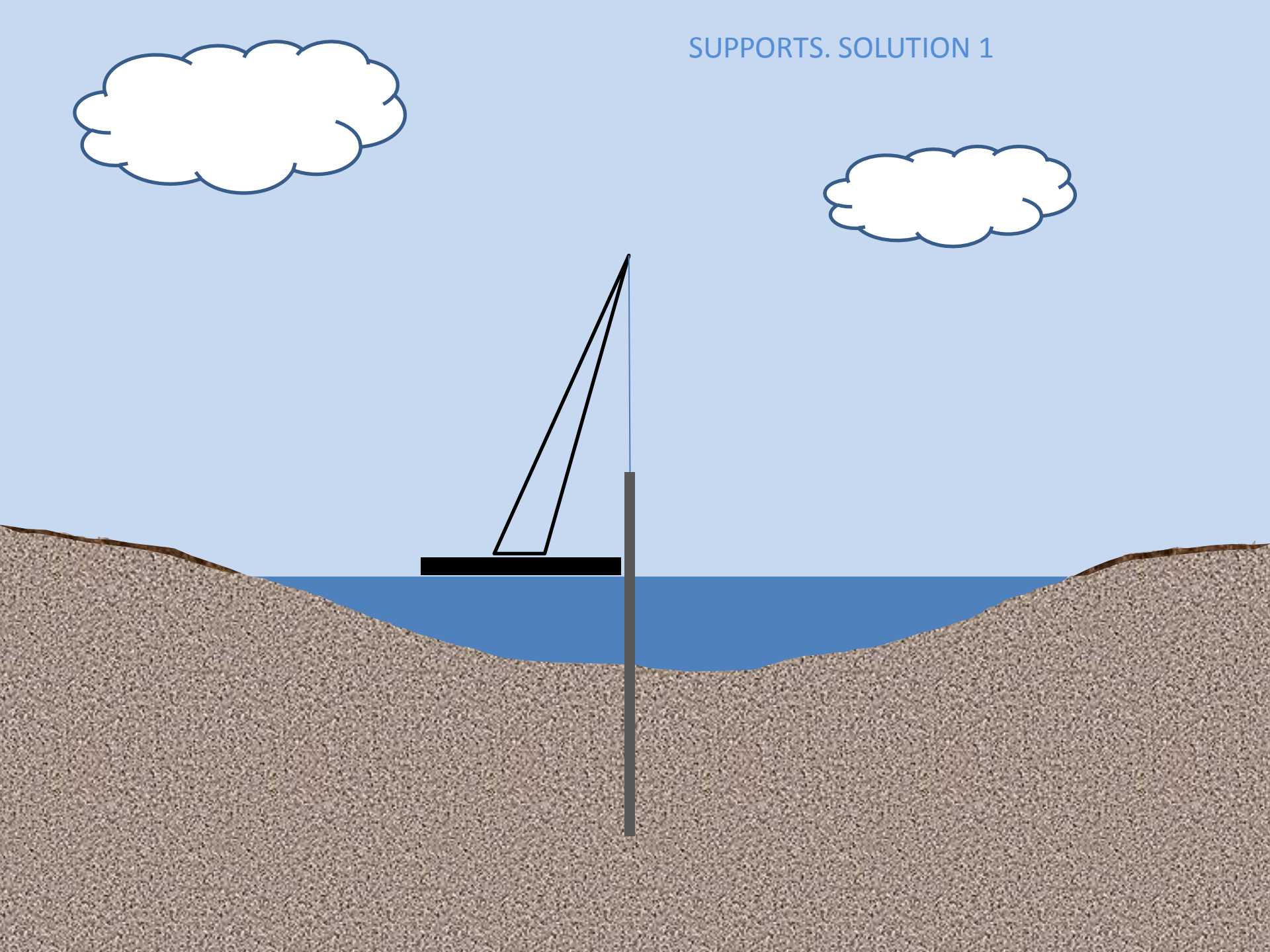
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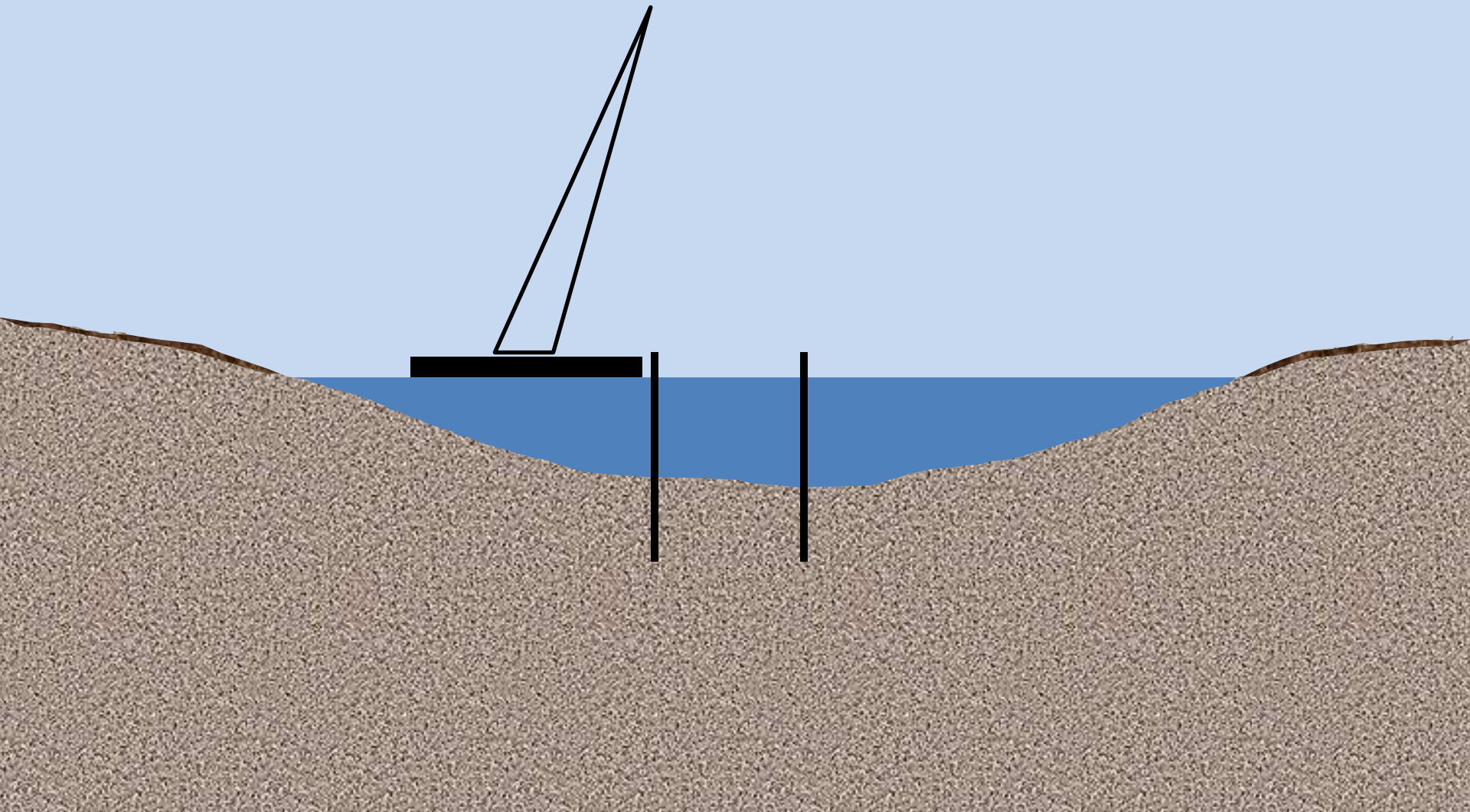
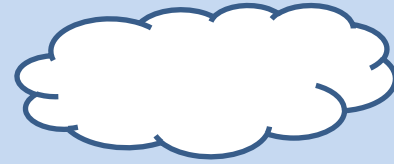
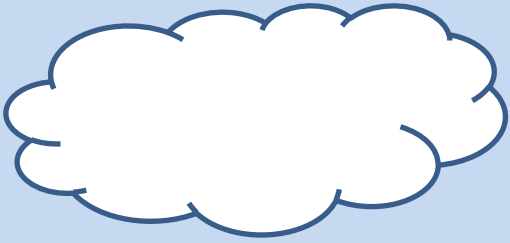


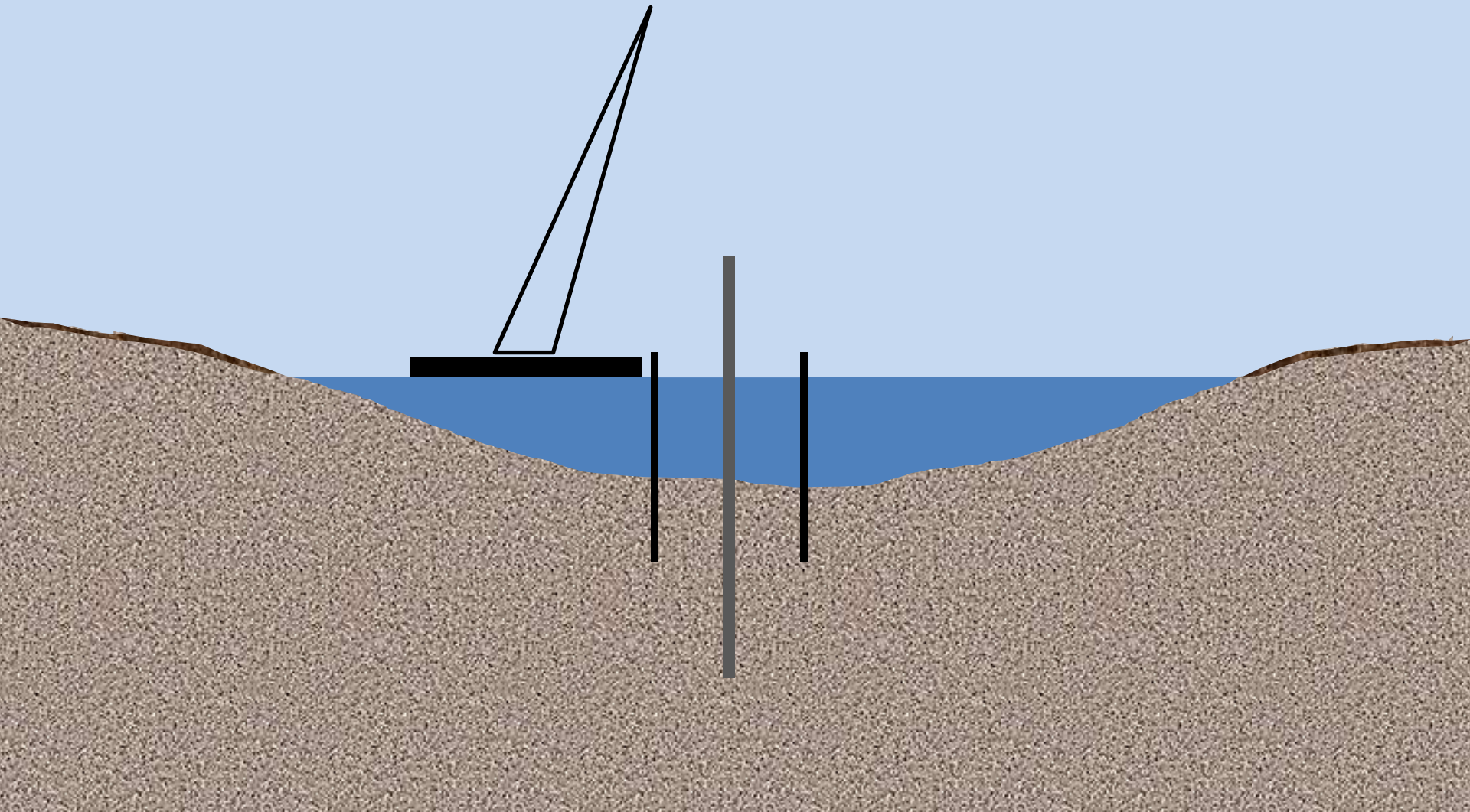
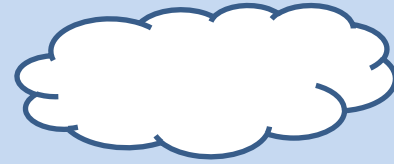
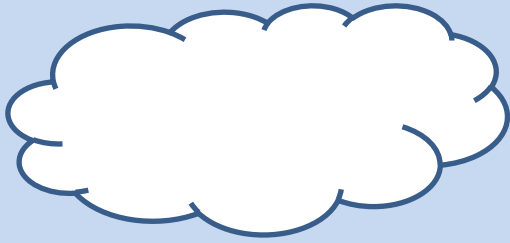
DECK CONSTRUCTION

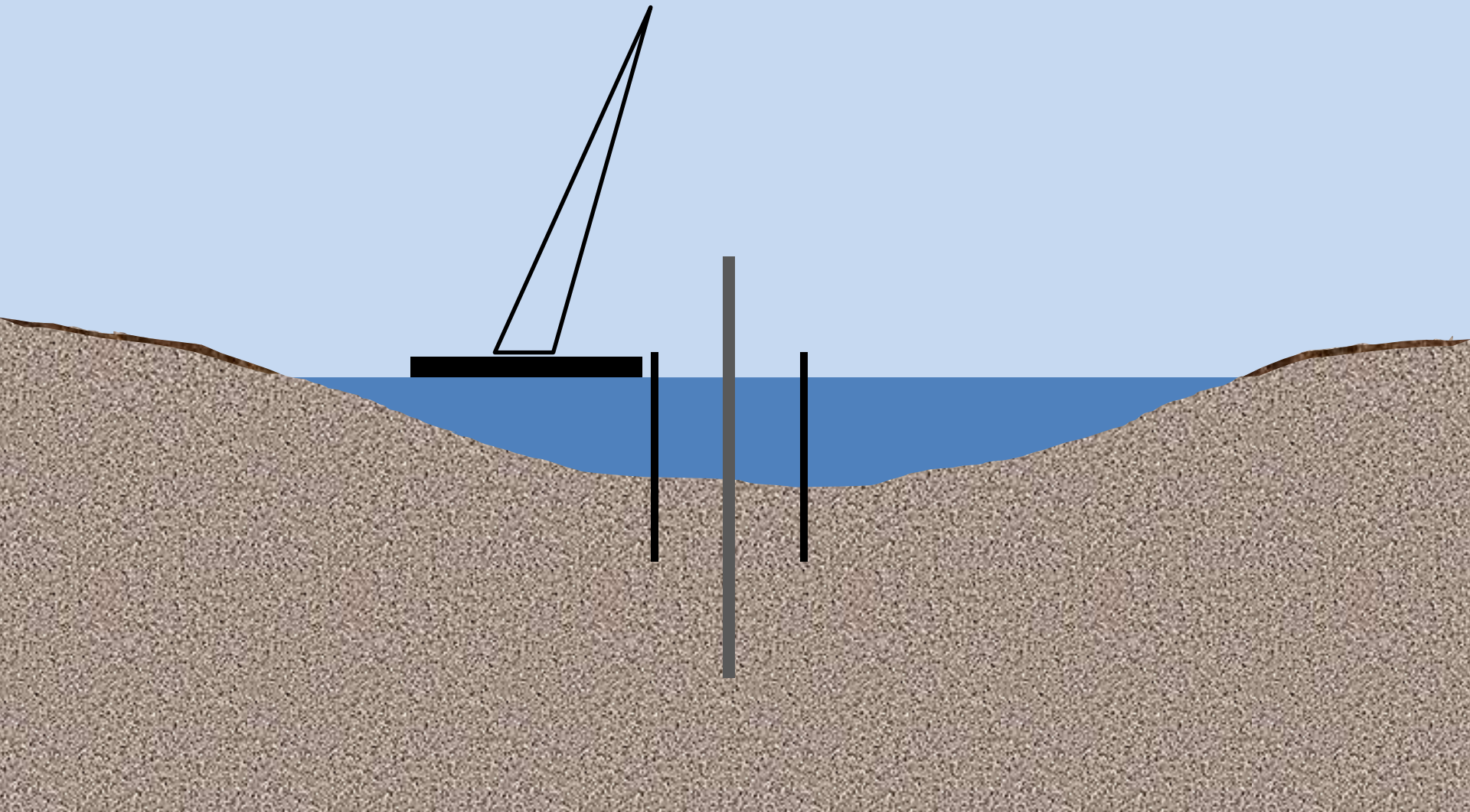
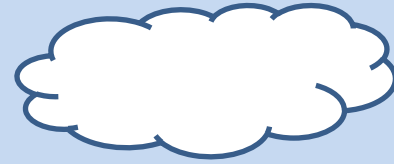
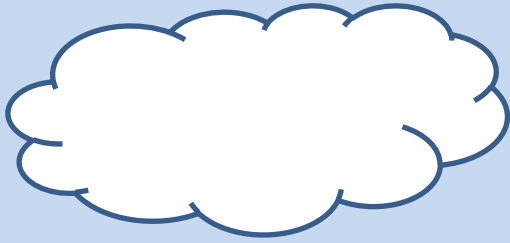


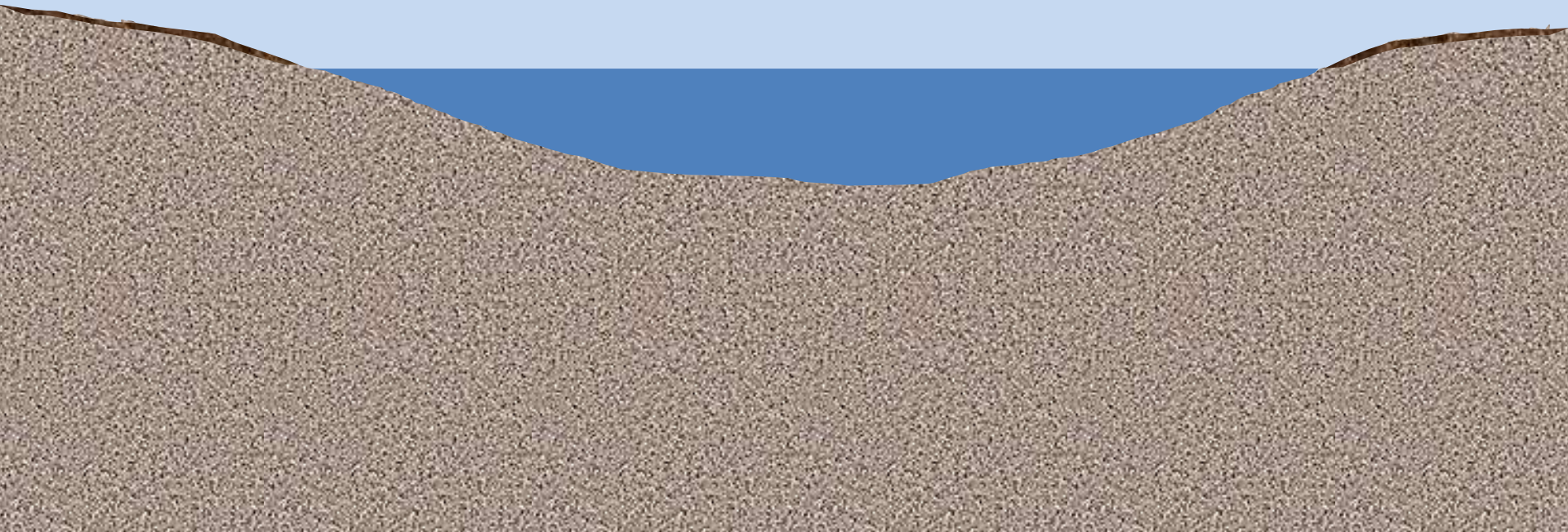
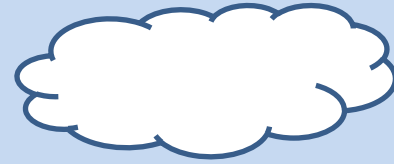
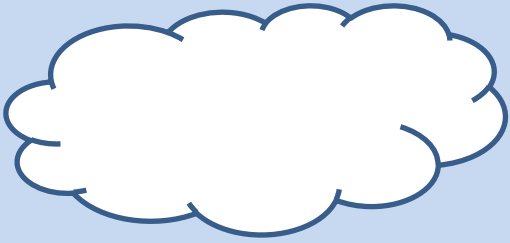
SUPPORTS. SOLUTION 1

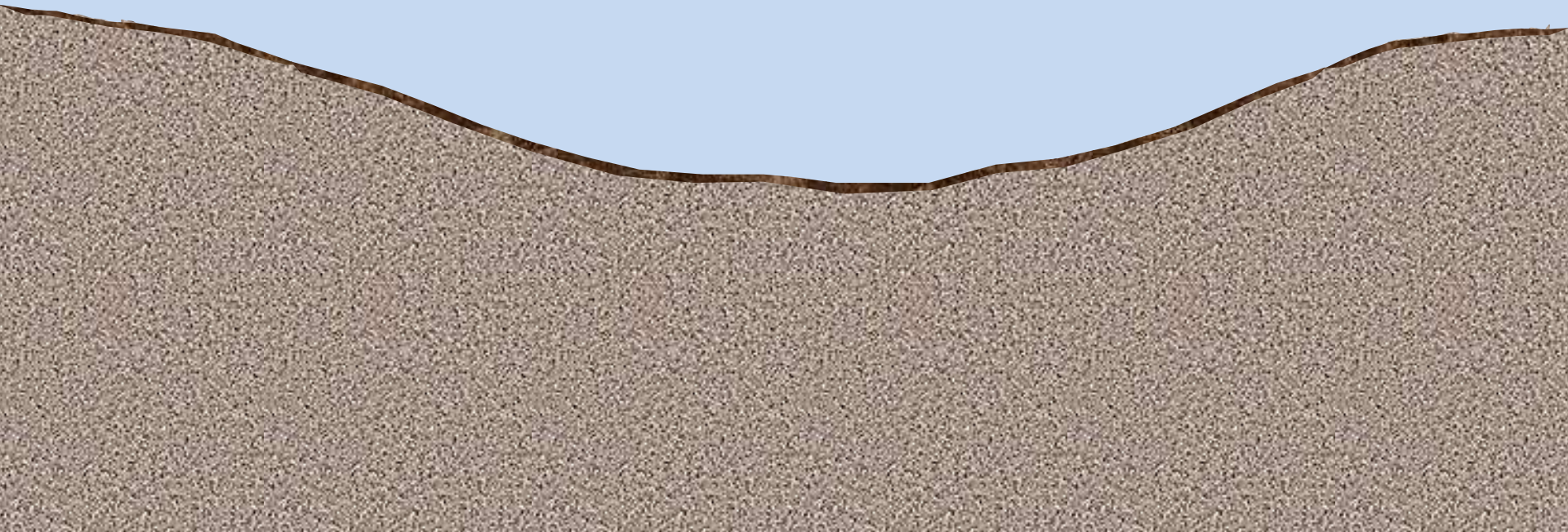
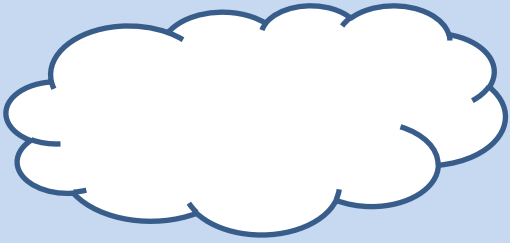


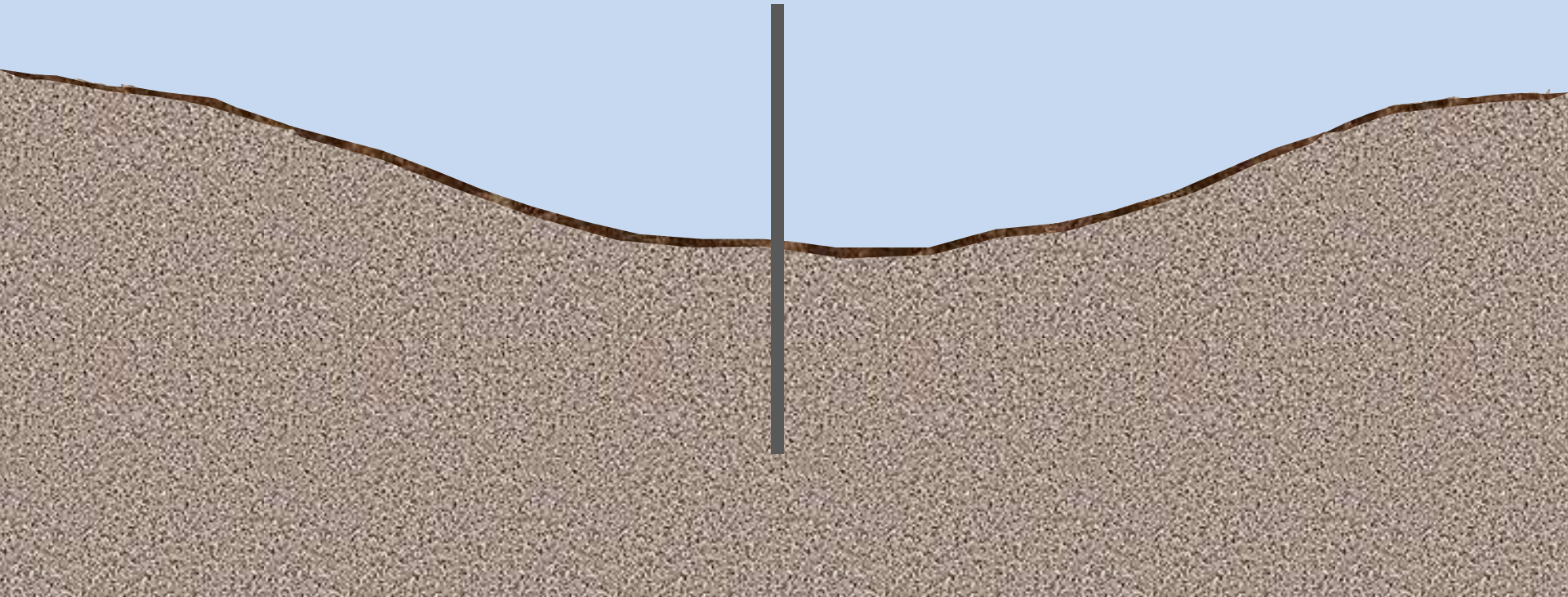
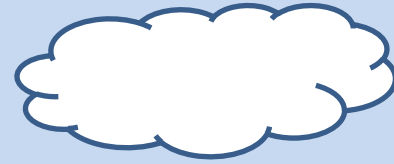
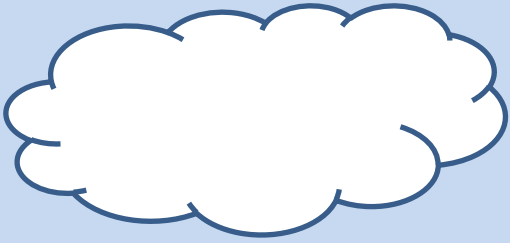




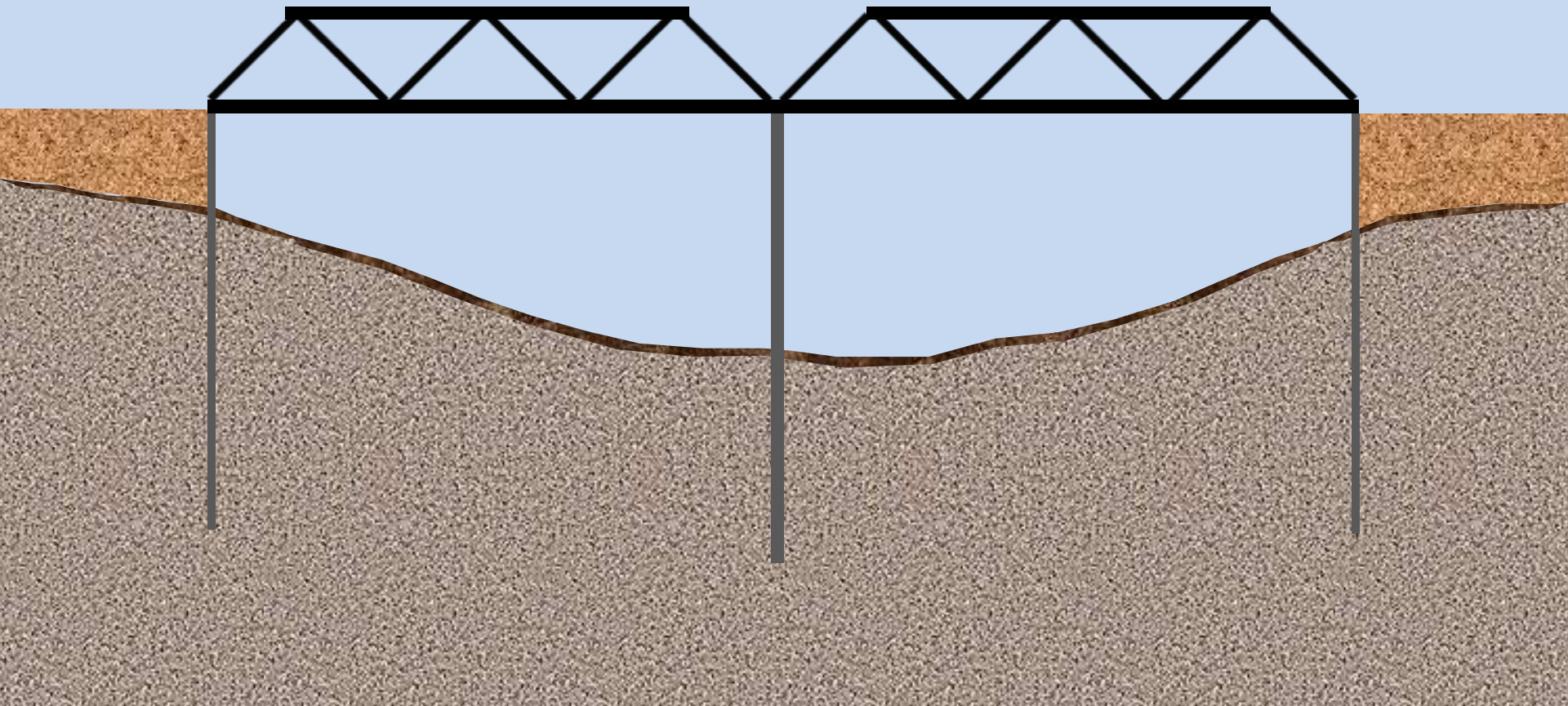
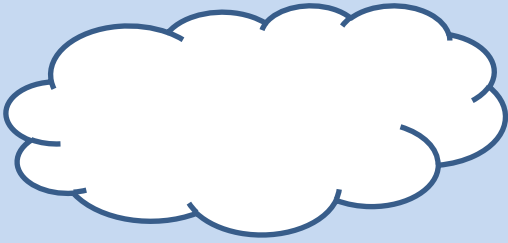


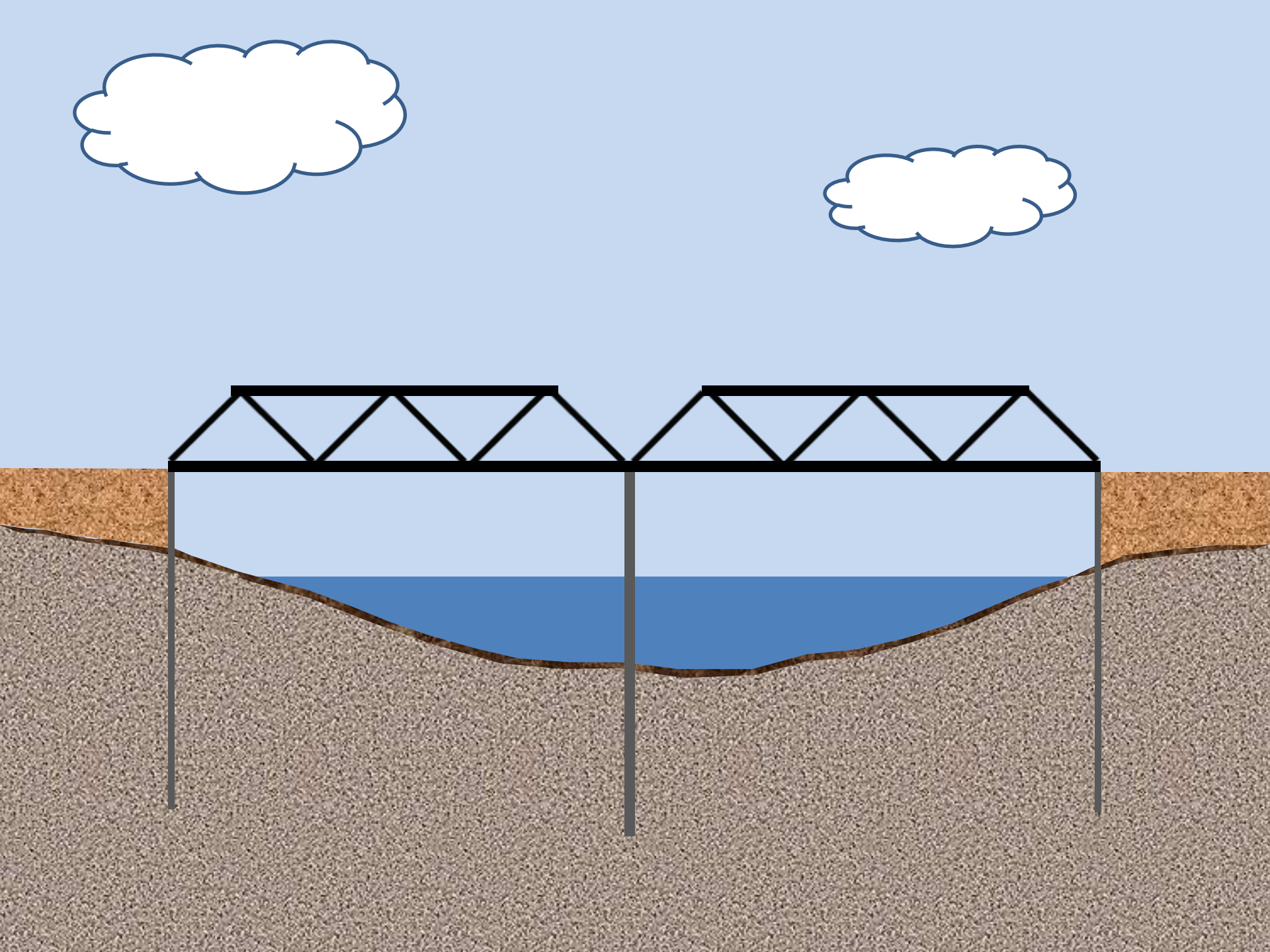






DECK CONSTRUCTION







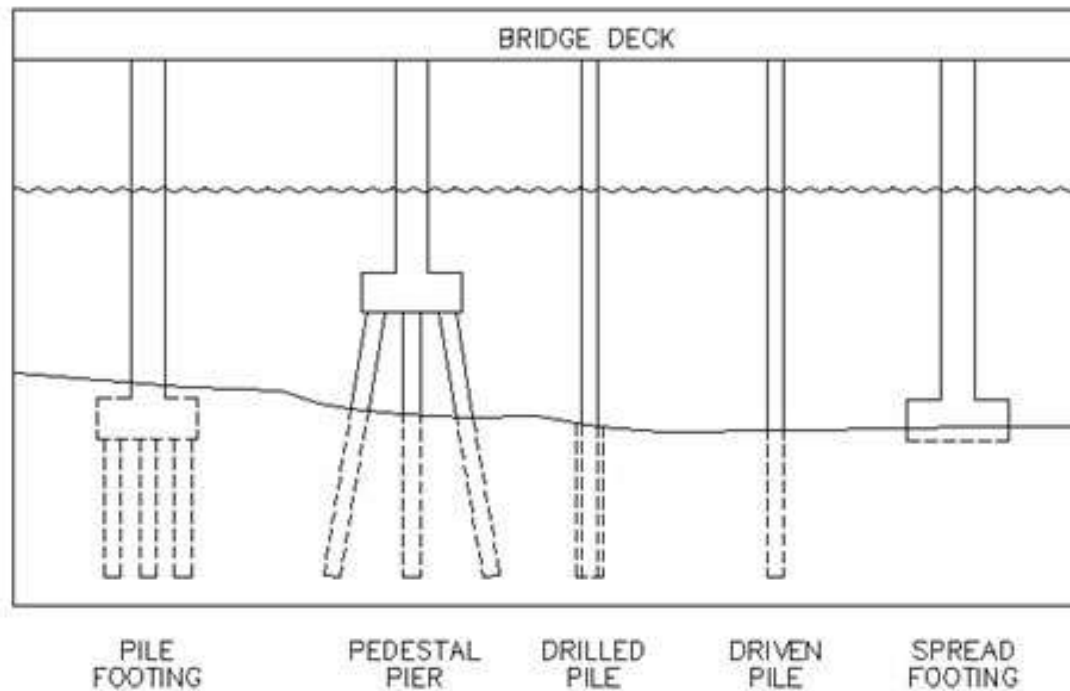
PARTS OF A BRIDGE

FOUNDATIONS

Transfer loads to the bearing strata

Shallow and deep foundations.

Deep foundations usually made with **piles**



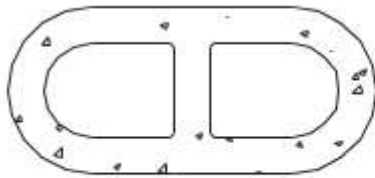


PARTS OF A BRIDGE

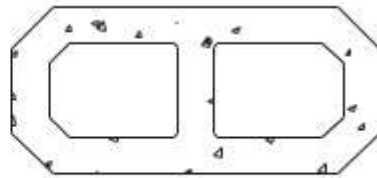
FOUNDATIONS

Wells

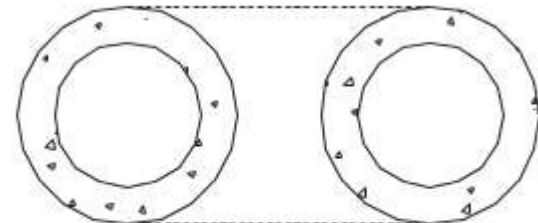
They can be single circular, double D-type, Dumbell type, Twin circular



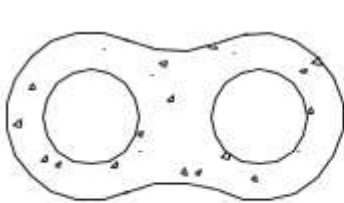
(a) DOUBLE-D



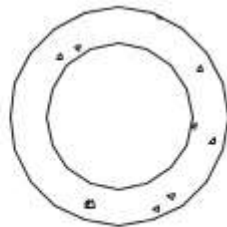
(b) OCTAGONAL



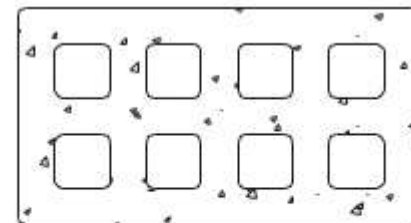
(e) TWIN CIRCULAR



(c) DUMB-BELL



(d) SINGLE CIRCULAR



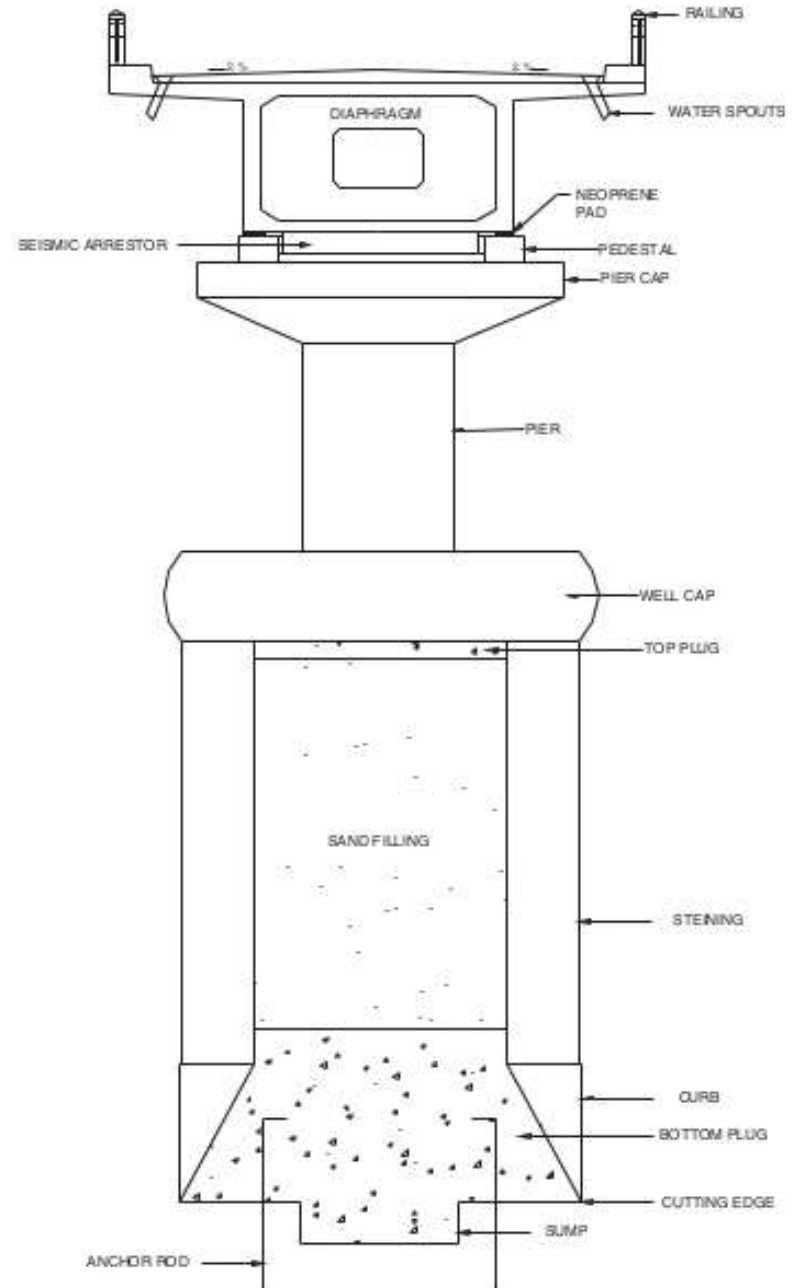
**(f) MULTI-DREDGE HOLE
MONOLITH**



PARTS OF A BRIDGE

FOUNDATIONS

Typical section of wells





How to build bridge foundations

<https://www.youtube.com/watch?v=fO5yYxpOsLo>

Bandra Worli Sea link

<https://www.youtube.com/watch?v=p47V6-x0YAE>

Hong Kong – Zhuhai – Macao Bridge

<https://www.youtube.com/watch?v=mdp80kxTx1g>



PARTS OF A BRIDGE

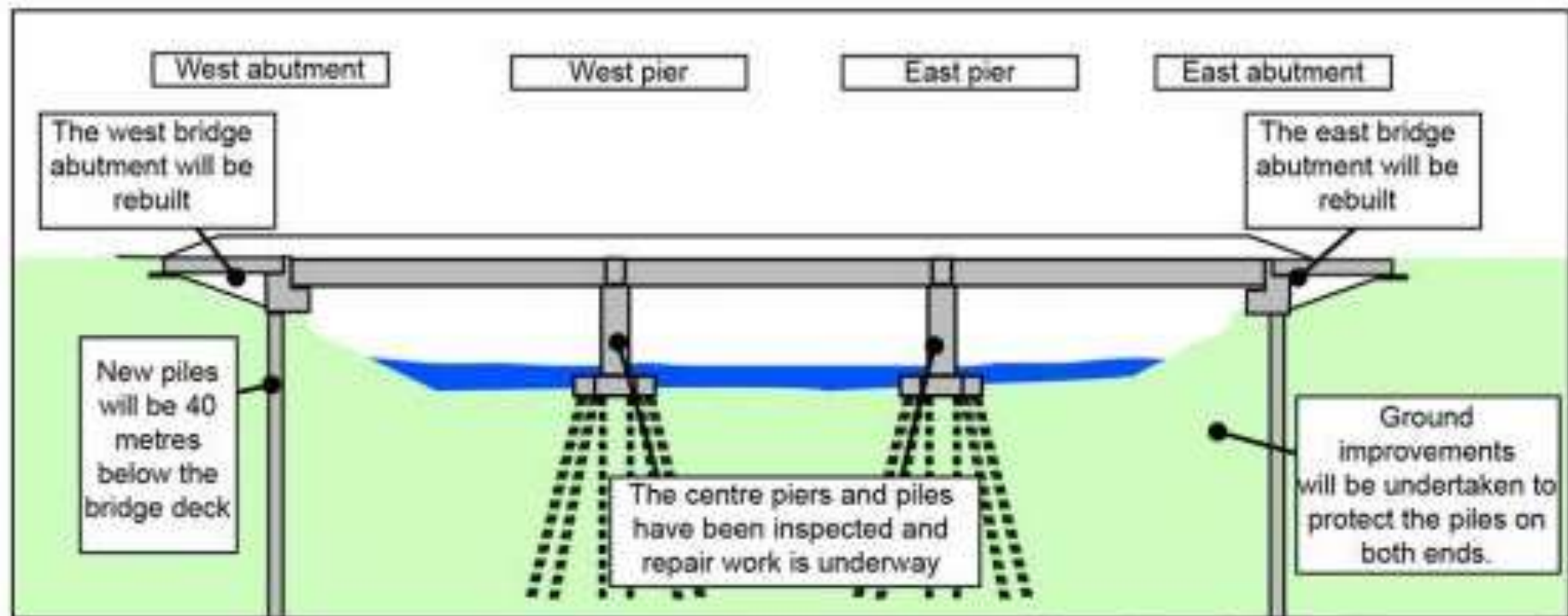
ABUTMENTS

Substructure at the ends of a bridge span whereon the deck rests or contacts
Provide vertical and lateral support for the bridge and acts as a retaining wall

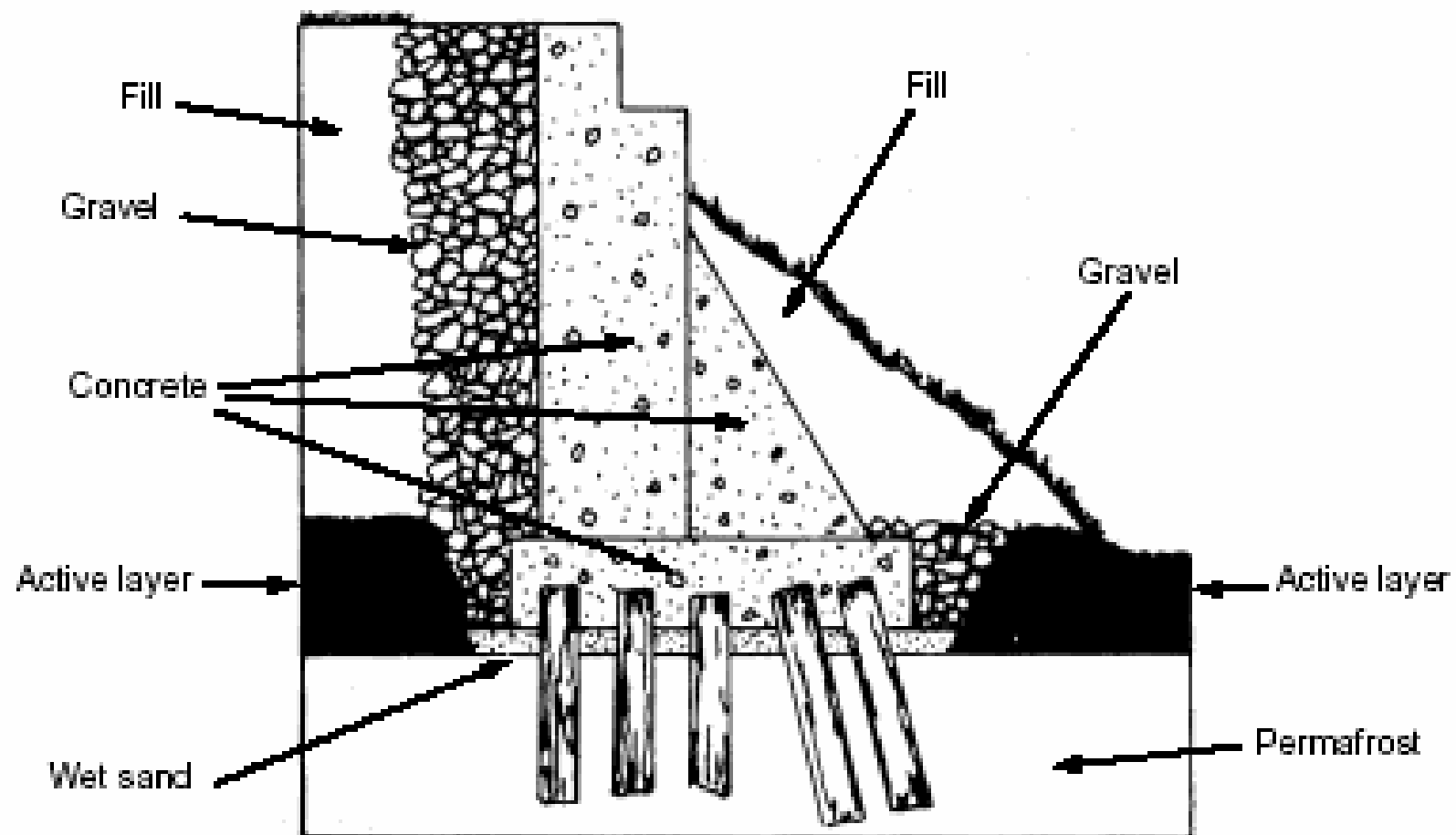
Types:

- Gravity: resists horizontal earth pressure with its own dead weight
- U-shaped: U shaped gravity abutment
- Cantilever: Cantilever retaining wall designed for large vertical loads
- Full Height: Cantilever abutment that extends from the underpass grade line to the grade line of the overpass roadway
- Stub: Short abutments at the top of an embankment or slope. Usually supported on piles
- Semi-Stub: Size between full height and stub abutment
- Counterfort: Similar to counterfort retaining walls
- MSE (Mechanically Stabilised Earth) systems, “Reinforced earth” system: modular units with metallic reinforcement





Above diagram for illustration purposes only.





PARTS OF A BRIDGE

PIERS

Support the deck and all loads transferred from them to the foundations

Wherever possible, slender piers should be used so that they have enough flexibility to allow temperature, shrinkage and creep effects to be transmitted to the abutments

Consideration of pin joints with the deck so that bending moments are not transmitted

Horizontal loads can also transmit bending moments

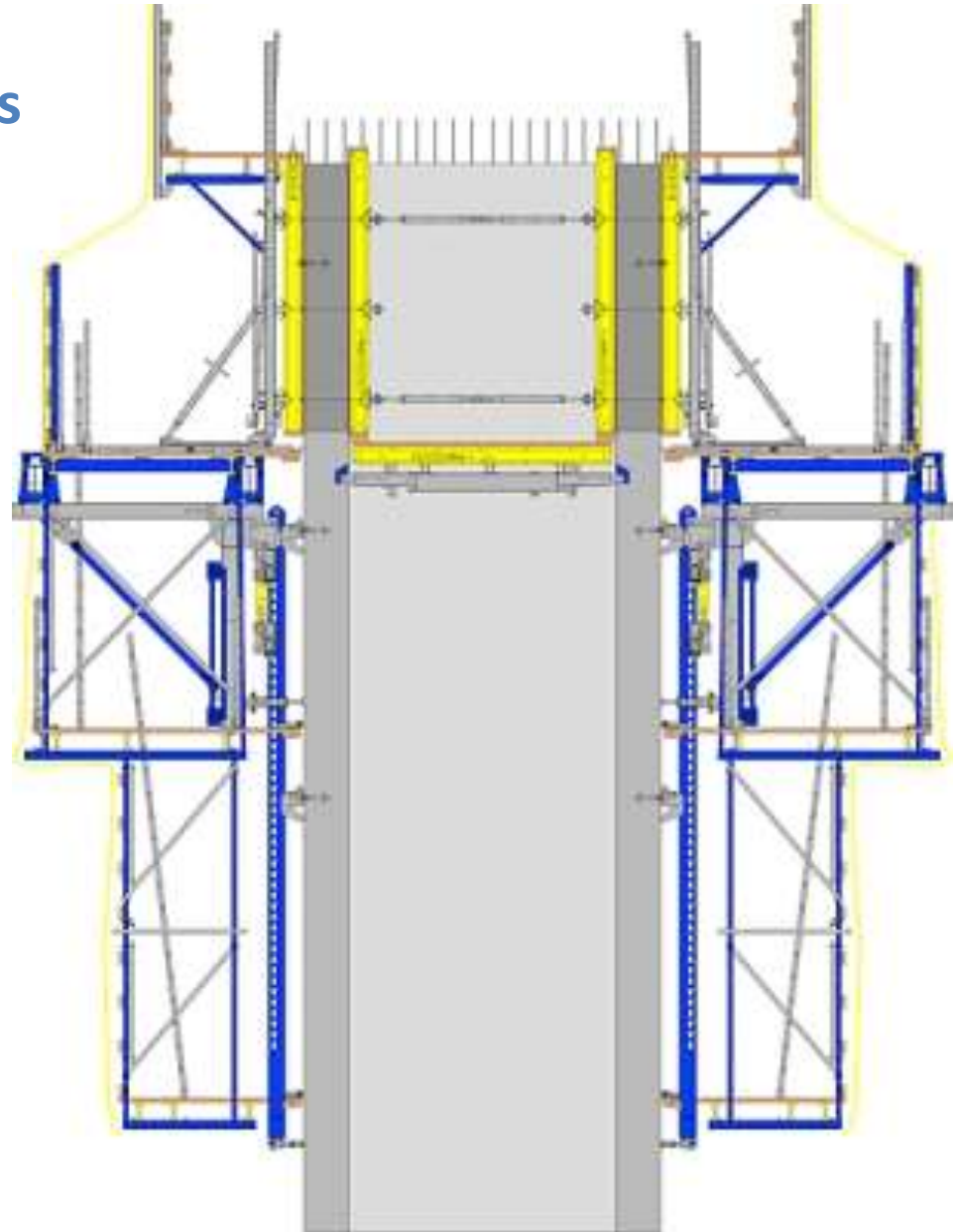
Construction of concrete piers

<https://www.youtube.com/watch?v=sbTUZNo6xmY>





Climbing formwork systems



ULMA video





PARTS OF A BRIDGE

PIER CAPS

Transfer the loads from the deck to the piers

Provide seating for the bridge girders

Disperse the loads from the bearings to the piers





PARTS OF A BRIDGE

BEARINGS

- Transfers loads from the girders to the pier caps
- Permits angular and linear movement between parts
- Avoids or reduces the transmission of bending moments to the pier
- Allows slenderness of piers

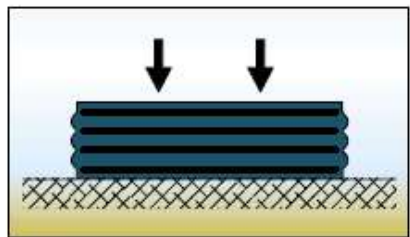




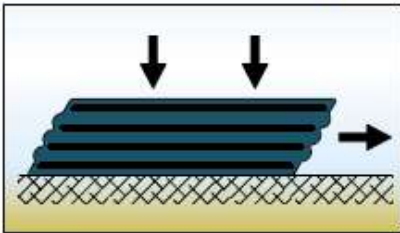
PARTS OF A BRIDGE

BEARINGS

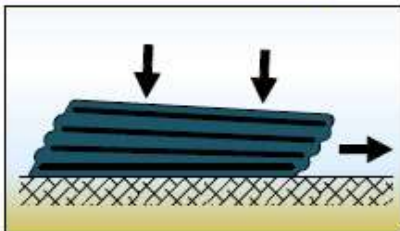
Elastomeric bearing pad



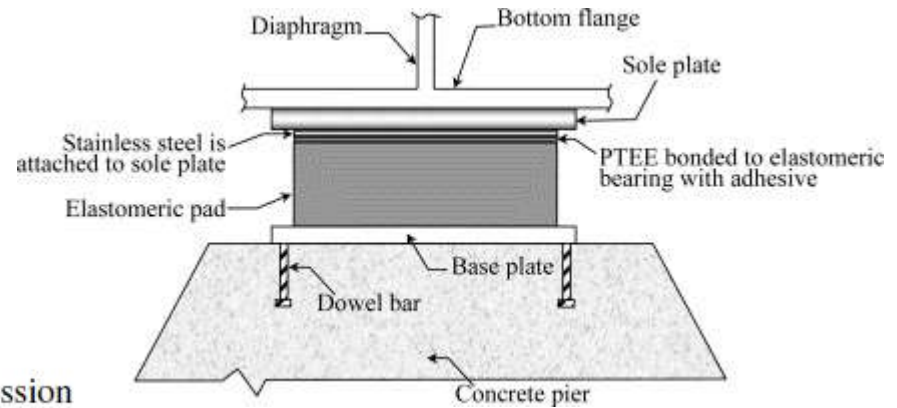
Elastomeric Bearing under Compression



Elastomeric Bearing under Compression and Shear



Elastomeric Bearing under combined Compression, Shear & Rotation





PARTS OF A BRIDGE

GIRDERS

Part that is under bending along the span
Supports the deck
Steel, reinforced concrete or precast



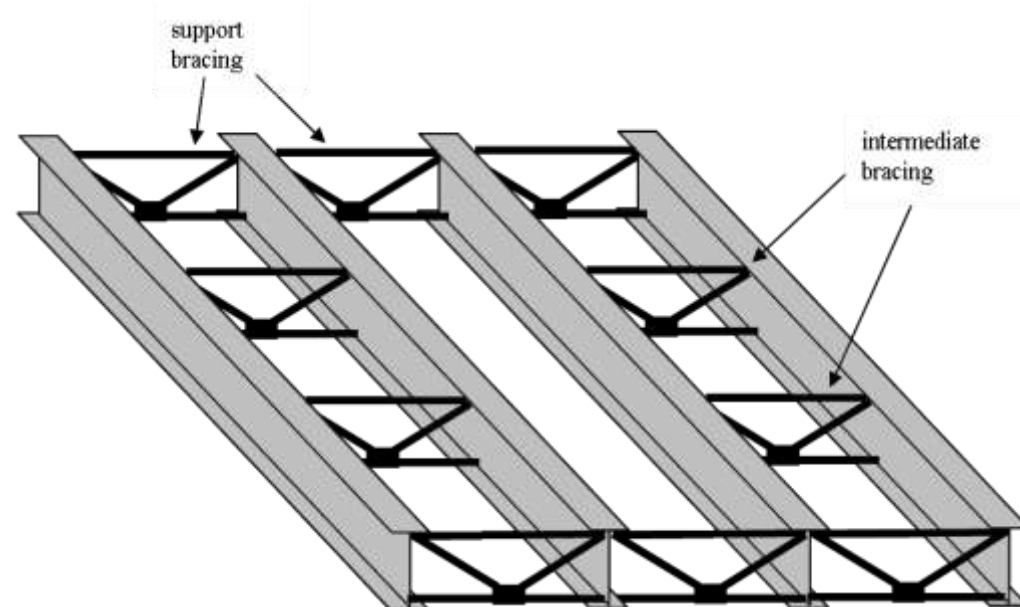


PARTS OF A BRIDGE

BRACING

Secondary structure for bridges

- Stabilize the main girders during construction
- Contribute to the distribution of load effects
- Provide restraint to compression flanges or chords to avoid any lateral buckling



DECK CONSTRUCTION METHODS



DECK CONSTRUCTION METHODS

PREFABRICATED STEEL AND PRECAST CONCRETE BEAMS LIFTED INTO PLACE OVER FULL SPAN

It covers the whole span

Only supported

Used of pretensioned sections and form a camber

Limited span to the beam length possibilities

(fabrication, transport and put on site)

Requirement of additional machinery to lift the element







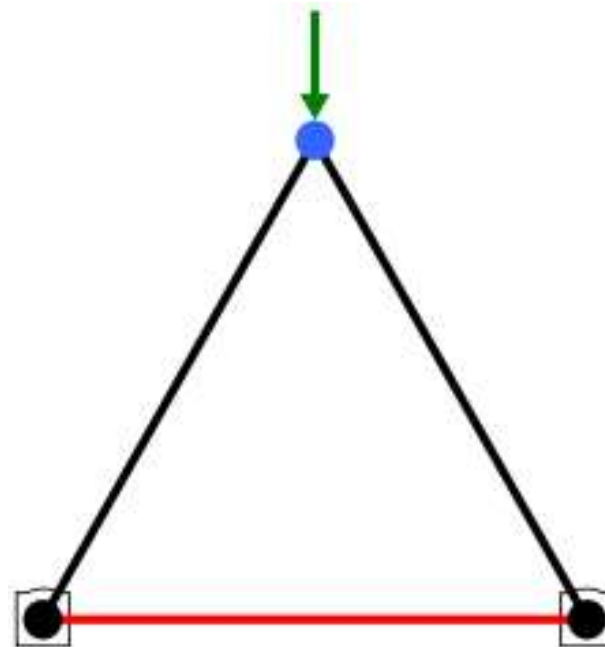


DECK CONSTRUCTION METHODS

PREFABRICATED STEEL AND PRECAST CONCRETE BEAMS LIFTED INTO PLACE OVER FULL SPAN

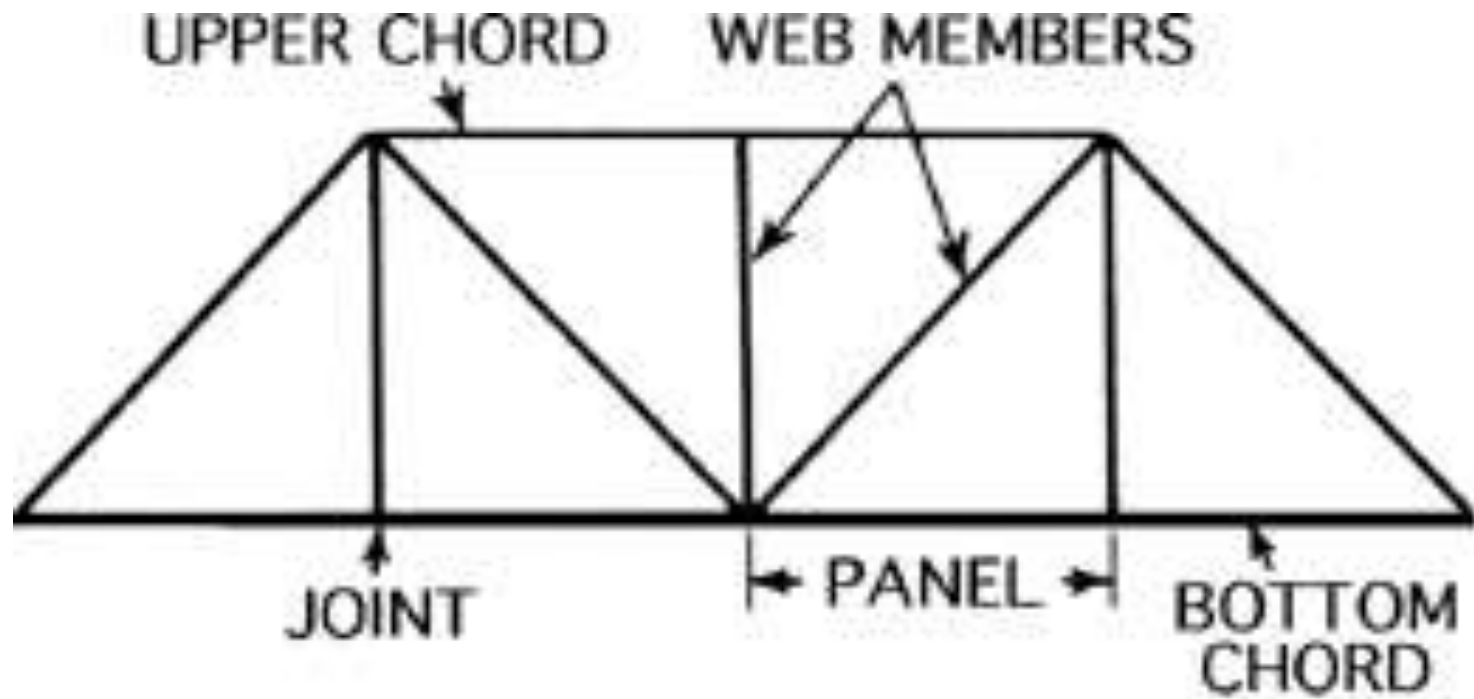
These beams can also be constructed with trusses

Basic organisation: triangles



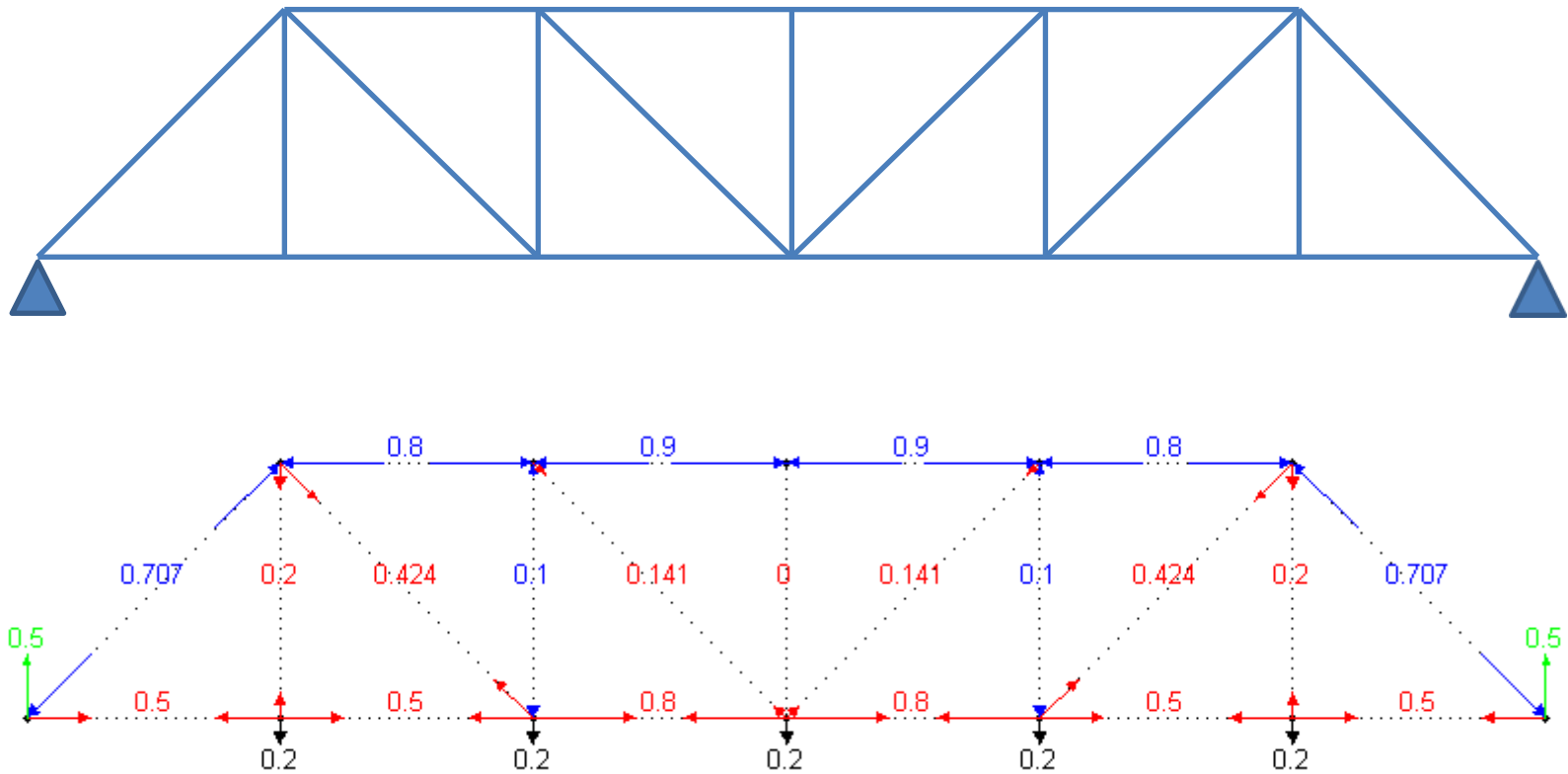


Lattice trusses





Lattice trusses





Lattice trusses



Railway bridge to Llanelli crossing river Tawe. Swansea



DECK CONSTRUCTION METHODS

BEAMS PLACED BY A GANTRY GIRDER

Long bridges (600m or more)

Regular, simple supporting spans predominate

Construction of the deck working with a gantry girder

Transport of beams over deck by bogies on rails





DECK CONSTRUCTION METHODS

STEPPING FORMWORK CONSTRUCTION

For long bridges (300m or more)

Appropriate for a bridge constructed over poor soil, water or high above ground

In situ deck supported on movable girders

Two methods:

- With auxiliary girders
- Without auxiliary girders



DECK CONSTRUCTION METHODS

STEPPING FORMWORK CONSTRUCTION

With auxiliary girders

The stepping girders are slightly larger than the span being cast

For concrete in situ

Forward end of stepping girder is supported on a collar attached to the pier

The rear end is carried on a beam hung below the completed deck

After finishing this span, the stepping girders are moved to the following one



DECK CONSTRUCTION METHODS

STEPPING FORMWORK CONSTRUCTION

Without auxiliary girders

The stepping girders are twice as large as the span length

The complete unit is carried on collars fixed temporarily to the columns



图例一：桥墩式主梁，主跨主梁跨长1~10米，桥墩及梁体中主梁与副主梁的距离为两个桥车的轮距，使副主梁的跨距满足整机设计的要求，当梁中主梁与副主梁的跨距满足此要求时，

图例二：桥墩式主梁，主跨主梁跨长10~15米，桥墩及梁体中主梁与副主梁的距离为两个桥车的轮距，使副主梁的跨距满足整机设计的要求，当梁中主梁与副主梁的跨距满足此要求时，

图例三：梁体式主梁，副主梁和桥墩式主梁，梁中主梁跨长10~15米，桥墩及梁体中主梁与副主梁的距离为两个桥车的轮距，使副主梁的跨距满足整机设计的要求，当梁中主梁与副主梁的跨距满足此要求时，

图例四：梁中主梁跨长10~15米，桥墩及梁体中主梁与副主梁的距离为两个桥车的轮距，使副主梁的跨距满足整机设计的要求，当梁中主梁与副主梁的跨距满足此要求时，

图例五：梁体式主梁，主跨主梁，中主梁，副主梁和桥墩式主梁，梁中主梁跨长10~15米，桥墩及梁体中主梁与副主梁的距离为两个桥车的轮距，使副主梁的跨距满足整机设计的要求，当梁中主梁与副主梁的跨距满足此要求时，



Without auxiliary girders

VIDEO





DECK CONSTRUCTION METHODS

CONSTRUCTION WITH FALSEWORK

If the deck is near ground level

Developed on site

Quality depends on quality control













DECK CONSTRUCTION METHODS

INCREMENTAL LAUNCHING OR PUSH-OUT METHOD

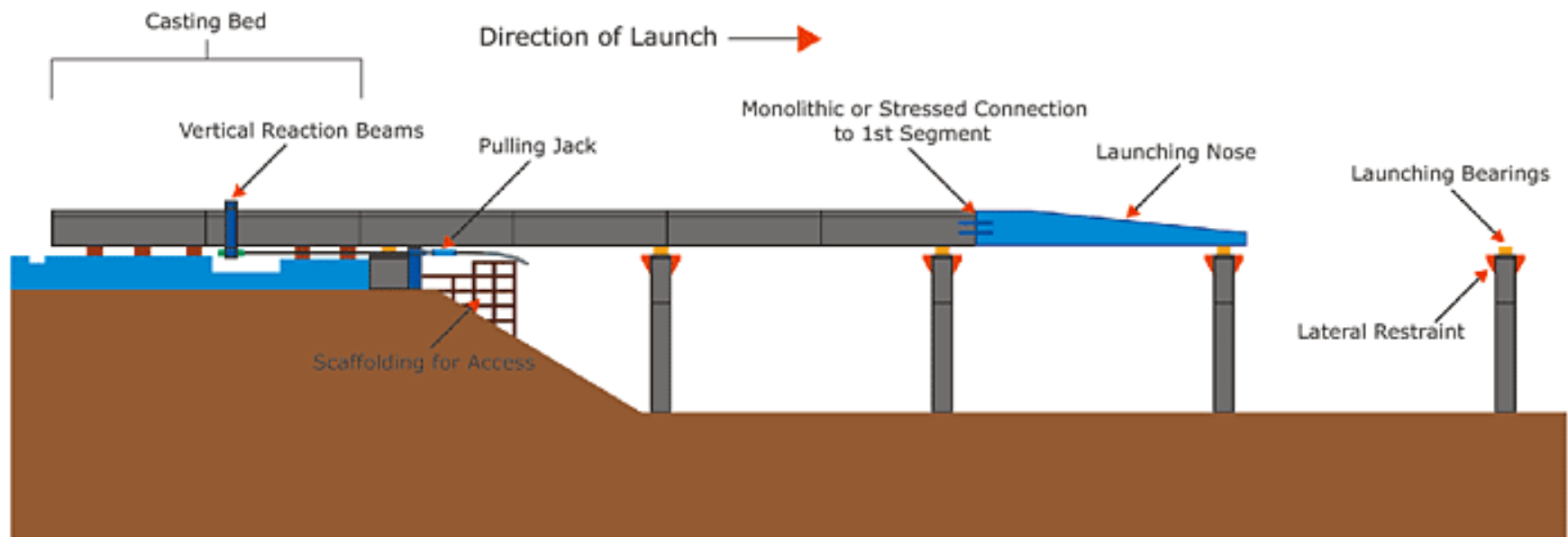
Deck pushed across the span with hydraulic rams

Only applied when horizontal and vertical alignments are perfectly straight

An aluminium launching nose is the head of the deck

Segments are cast on beds near the abutments and transferred by rail

VIDEO





DECK CONSTRUCTION METHODS

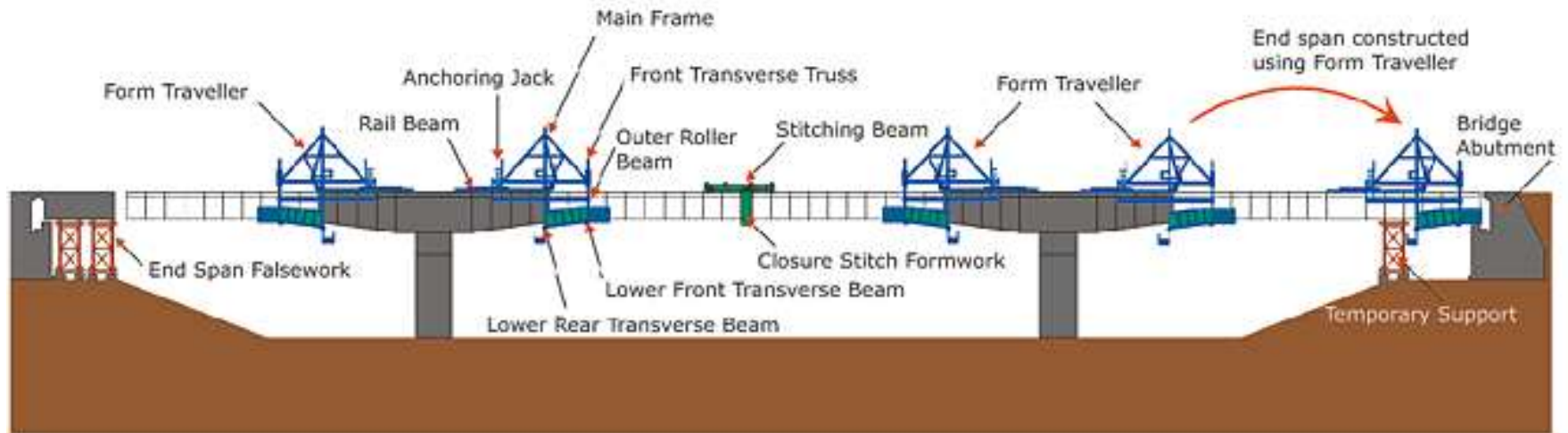
CANTILEVER CONSTRUCTION WITH PRESTRESSED CONCRETE

The segment immediately above each pier is cast in situ or placed
The deck is formed by adding sections symmetrically either side

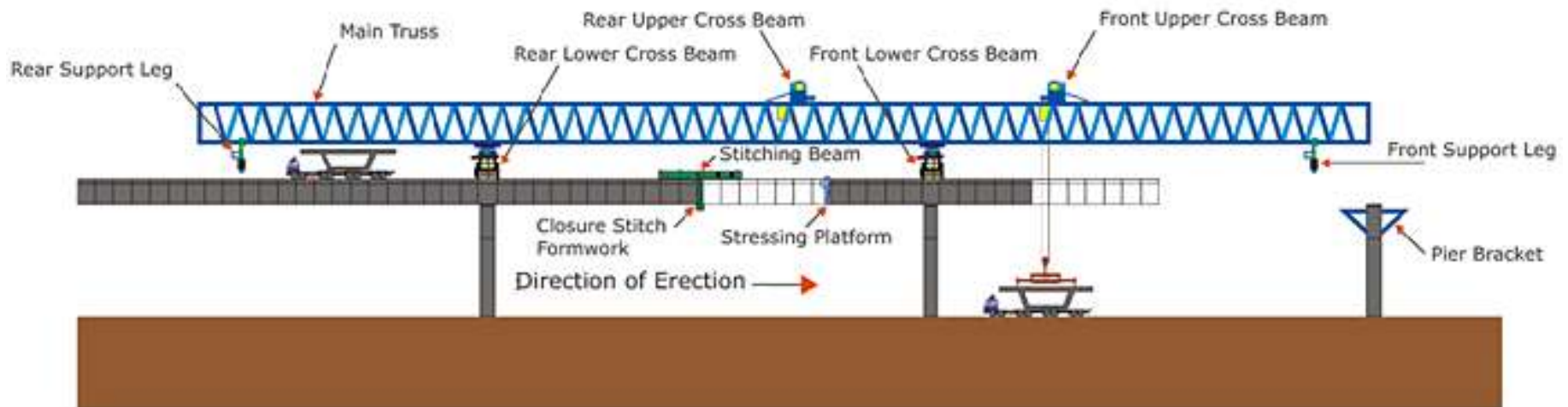




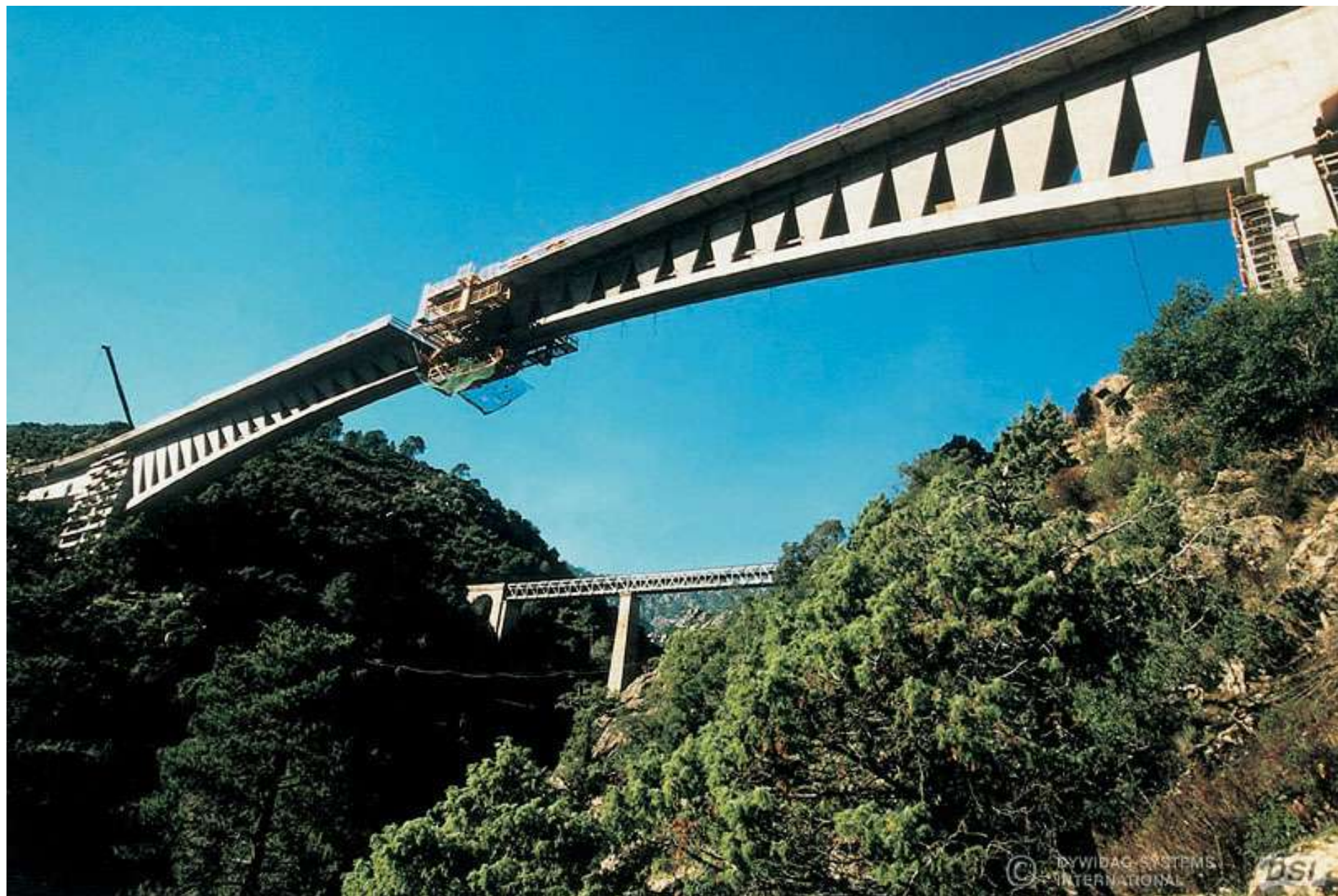
Free cantilever method



With launching gantry











DECK CONSTRUCTION METHODS

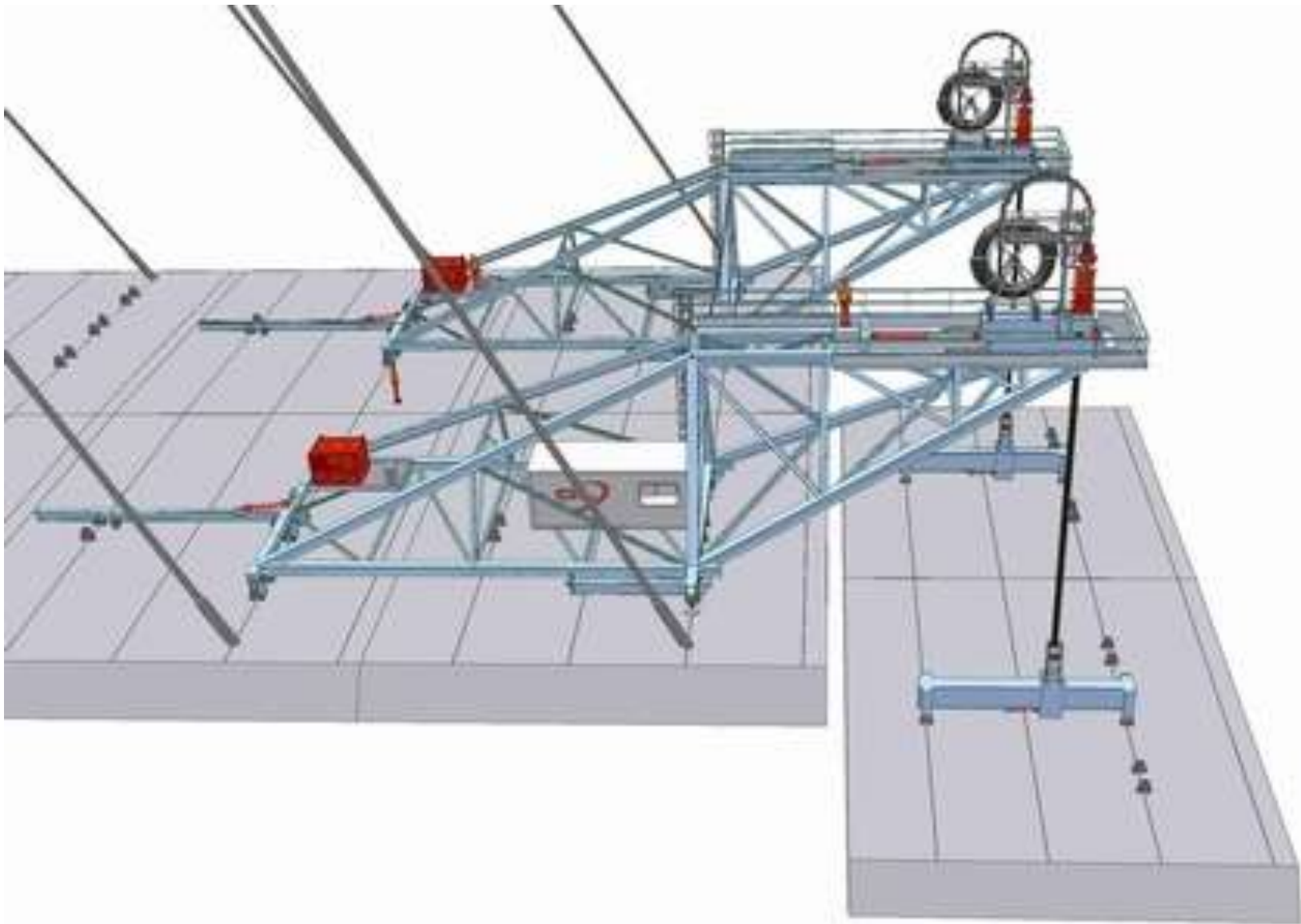
SEGMENTS STAYED BY CABLES

Cantilever construction technique

Precast or in situ concrete or steel box segments

Supported by cables and stayed to a tower









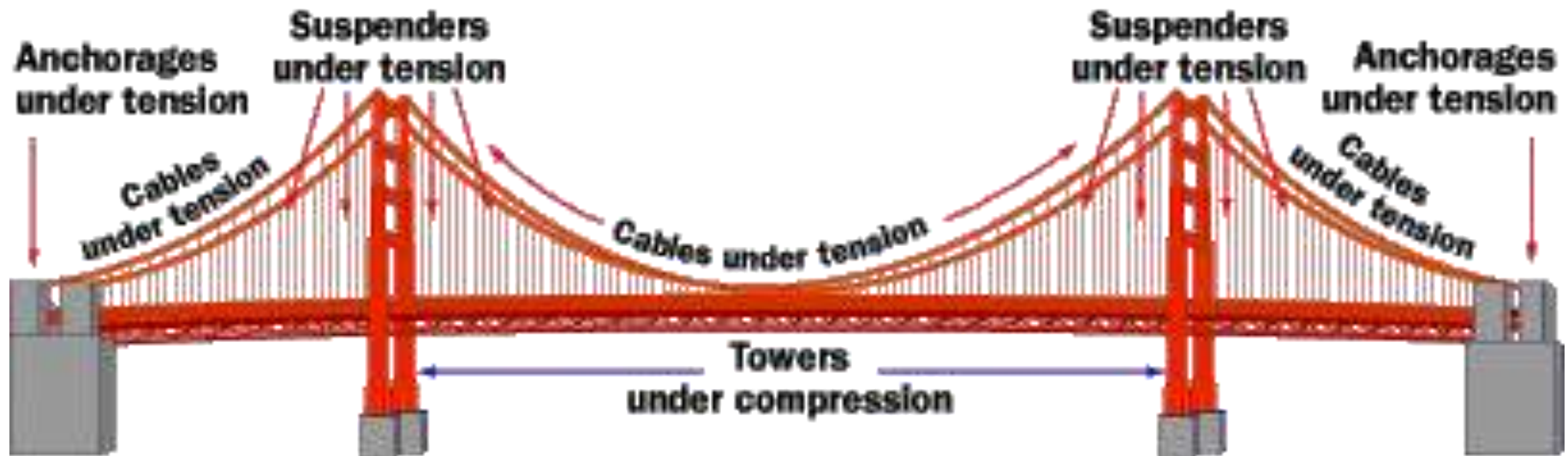
DECK CONSTRUCTION METHODS

SUSPENSION BRIDGES

Cables slung over two towers

The deck units are hung from the cables

The bridge towers can be assembled in segments or formed from in situ concrete







Golden Gate Bridge. San Francisco





Hokkaido suspended Bridge



**HOW ARE THESE BRIDGES
CONSTRUCTED?**



Railway bridge to Llanelli crossing river Tawe. Swansea



Ouaquaga Bridge, New York State



The Clifton suspension bridge. Bristol

William Henry Barlow and John Hawkshaw



Sail bridge. Swansea.



Samuel Beckett bridge. Dublin.

Santiago Calatrava



Millenium bridge. London.

Arup Group, Foster and Partners and sir Anthony Caro



COMPLEMENTARY REFERENCES

<http://www.bridgedesign.org.uk/index.html>

<http://civildigital.com/the-five-major-parts-of-bridges-concrete-span-bridge/>

<http://www.bridgeweb.com/>

<http://www.aboutcivil.org/Bridge-designing.html>