

TUNNELWORKS AR APP

KS4 DESIGN & TECHNOLOGY

SCREW CONVEYOR & BALANCING PRESSURE

Specification

The tunnel boring machine (TBM) featured in the Tunnelworks AR app is an earth pressure balance machine, featuring a screw conveyor, which is a type of Archimedean screw. The purpose of the screw conveyor is to transport muck away from the excavation chamber, as well as provide pressure to support the face of the tunnel and prevent collapse.

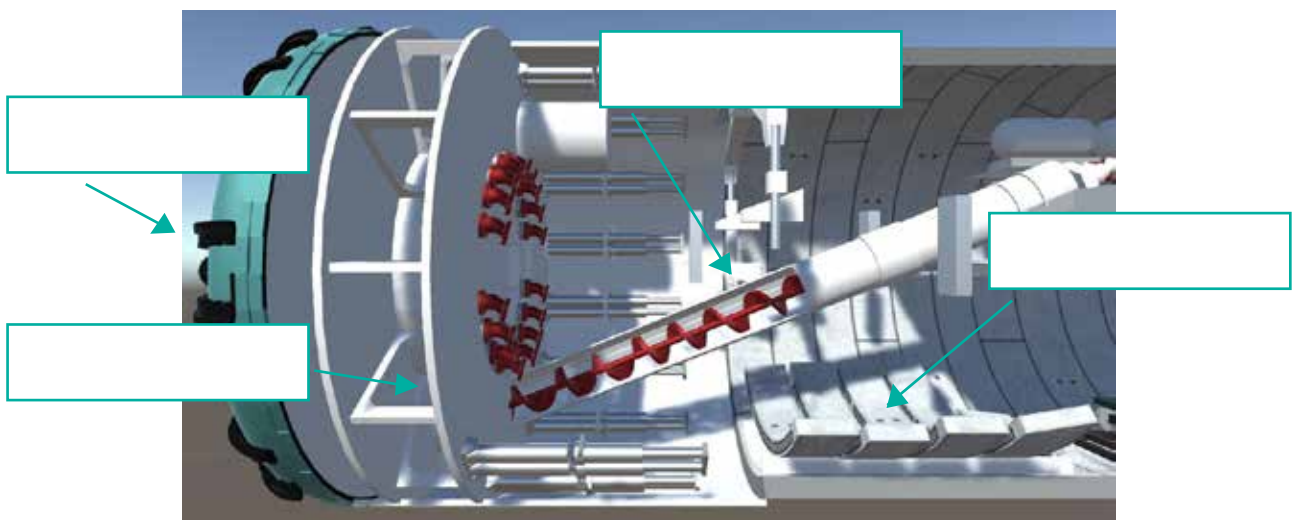
In this activity, you will learn to:

- understand the role of the screw conveyor
- understand how to calculate pressure
- apply your knowledge to understand how the screw conveyor maintains face support pressure in an earth pressure balance machine.

Explore the Tunnelworks AR app or use your teacher's guidance to help complete the challenges below. You may also need to use your wider research skills.

Challenge 1: The Screw Conveyor

Label each part of the tunnel boring machine and match the names of each part to the statements below.



Cutter head	An Archimedean screw which carries excavated material from the excavation chamber.
Belt conveyor	A pressurised space behind the cutter head full of excavated material.
Excavation chamber	Carries excavated material out of the tunnel to the drive site.
Screw conveyor	A rotating disc dressed with cutting tools that grinds away at the rock.

Challenge 2: Earth Pressure

Read the following passage from Charmaine, a Tunnelling Operator working on the Thames Tideway Tunnel, and answer the following questions.

“The screw conveyor has a vital role in emptying the excavation chamber and maintaining support pressure at the tunnel face, constantly adjusting the speed of rotation in order to ensure that there is enough material and pressure in the excavation chamber to balance force of collapsing earth pushing against the front of the machine. Should this earth pressure not be matched by face support pressure in the excavation chamber, the tunnel could collapse with disastrous consequences. Though there are Tunnel Operatives working all the time on the tunnel boring machine, the pressure in the excavation chamber and at the cutter head is measured by sensors which adjust the speed of the screw conveyor automatically.”

a) What are the two main roles of the screw conveyor?

b) How does the screw conveyor regulate support pressure in the excavation chamber?

c) What is earth pressure?

d) How is the speed of the screw conveyor regulated?

e) What could happen if earth pressure exceeds face support pressure?

Challenge 3: Calculating Earth Pressure

We can calculate the earth pressure at the front of the tunnel boring machine by using the following equation:

$$\text{Pressure (Pa)} = \frac{\text{Force (N)}}{\text{Area (m}^2\text{)}}$$

Different tunnel boring machines have different sized cutter heads, and so we must take that into consideration when calculating the earth pressure.

	Force exerted on the cutter head (N)	Area of cutter head (m ²)	Surface face pressure (Pa)
a	10,000,000	50	
b	11,500,000	56	
c	3,780,000		210,000
d	11,970,000		190,000
e	13,500,230	45	
f	4,600,000	20	
g	7,200,400	30	
h	6,880,000		215,000

a) Using the equation, calculate the missing answers in the table above.

Challenge 4: Balancing Pressure

Sensors in the excavation chamber give an accurate measurement of the face support pressure in the excavation chamber. Using your answers from the scenarios above, decide whether the sensor should tell the screw conveyor to reduce pressure by increasing speed, increase pressure by slowing speed, or keep the speed the same by putting an 'X' in the correct box.

	Face support pressure (Pa)	Increase speed	Decrease speed	
a	200,000			
b	210,000			
c	220,000			
c	119,000			
d	230,000			
e	210,000			
f	240,100			
g	215,000			

EXTENSION:

Slurry shield tunnel boring machines

Specification

The tunnel boring machine featured in the *Tunnelworks AR app* is an earth pressure balance machine, used for tunnelling the clay-rich, west section of the Thames Tideway Tunnel. Slurry shield tunnel boring machines are used to excavate the central and east parts of the tunnel, where the ground is less suitable for tunnelling.

In this extension, you will learn to:

- Explain the difference between earth pressure balance and slurry shield tunnel boring machines
- Understand the different rock types found beneath London and how this affects tunnelling.

Explore the *Tunnelworks AR app* or use your teacher's guidance to help complete the challenges below. You may also need to use your wider research skills

Challenge 1: Slurry Shield Tunnel Boring Machines & The Thames Tideway Tunnel

Using the statement and diagram below, prepare a written report describing the difference between an earth pressure balance tunnel boring machine and a slurry shield tunnel boring machine and how they are used in the Thames Tideway Tunnel.

“London has a complex geology which impacts greatly on the tunnelling process, especially as the tunnel intersects the three different layers of chalk, sand and clay. London clay is the best material for digging tunnels, as it is waterproof, stopping water seeping into the tunnel. It also has a long stand-up time, meaning that it does not collapse as tunnels are being built. Sand is more difficult to tunnel, comprised of sand and gravel it is unstable and wet, collapsing more easily. Chalk is the most difficult to tunnel through, as it has high groundwater content. A slurry shield TBM must be used as the water pressure is too high for an earth balance shield TBM.”

Louisa G, Tunnelling Operative

