

Go Forth and Design

A range of CAD resources which support understanding in design and engineering, raising awareness and knowledge of the Forth Bridges and their place in Scotland's history.

Curricular Focus: Curriculum for Excellence Technologies



— THE — FORTH BRIDGES®



The Forth Bridge
inscribed on the World
Heritage List in 2015





Go Forth and Design

Curricular Focus and Level : Technologies, Second Level

Experiences and Outcomes:

- I can use a range of graphic techniques, manually and digitally, to communicate ideas, concepts or products, experimenting with the use of shape, colour and texture to enhance my work. TCH 2-11a
- I can extend my knowledge and understanding of engineering disciplines to create solution. TCH 2-12a
- I can extend and enhance my design skills to solve problems and can construct models. TCH 2-09a

Benchmarks:

- Sketches geometric shapes to create objects.
- Draws geometric shapes accurately.
- Sketches 2D and 3D drawings of objects.
- Understands the difference between different engineering disciplines.
- Builds / simulates solutions to engineering problems.
- Uses a range of methods to join and strengthen materials.
- Estimates and then measures accurately using appropriate units and tools.
- Creates a range of ideas and chooses a suitable solution.
- Evaluates solutions and explains why they are or are not suitable.

Resources:

Resources included in the pack or suggested sources which can support learners as they use the materials in this pack:

- Go Forth and Design Forth Bridge Tinkercad Resource
<https://www.tinkercad.com/things/1IzinJsMScK>
- Go Forth and Design Forth Road Bridge Tinkercad Resource
<https://www.tinkercad.com/things/eRdaMwV5zDs>
- Go Forth and Design Queensferry Bridge Tinkercad Resource
<https://www.tinkercad.com/things/6lVnPnAif3w>
- Go Forth and Design STL Files <https://glowscotland.sharepoint.com/sites/PLC/technologies>
- Go Forth and Design Photograph Resource Pack
- Forth Bridges Website <https://www.theforthbridges.org>
- Unesco World Heritage - Forth Road Bridge <https://whc.unesco.org/en/list/1485/>
- Institution of Civil Engineering - Forth Bridges / Education <https://bit.ly/2GIT4qM>



Go Forth and Design

- Young Engineers and Science Club 'Go Forth' Project <https://bit.ly/14Bms9u>
- Autodesk's Free Web based Tinkercad software <https://www.tinkercad.com>
- Go Forth Resources including STL Files, Film Clips and Images via the Glow Technologies Community (see link above).

Duration of activities:

- 3hr x Unplugged investigations and creating physical models
- 4hr x Investigating how to recreate 2D sketches into 3D Models of familiar objects then applying this to the use of modelling the Forth Bridges.

Overview of Learning

The Go Forth and Design learning resources develop knowledge and understanding of the engineering aspects of three Forth Bridges as important Scottish landmarks. These second level Technologies resources can be used in isolation or as part of a wider learning focus where learners are developing an understanding of the types of bridges, engineering and design within a STEM context.

The resources are designed to be flexible and used in a way which will support learners in gaining the core language used in the engineering of bridges. A range of complete and 3D files are included in this resource to allow learners to recreate the Forth Bridge, Forth Road Bridge and Queensferry Crossing bridges using free CAD software, Tinkercad (available to access via www.tinkercad.com). Learners will design and create a 3D bridge to solve a problem to solve an engineering problem which can be informed from or which can inform a physical model or plan. A point cloud film, created by the collection of all of the laser scanning is available, can be used to support understanding of how these skills can be developed to use within the world of work.

Pupil Objectives

- I can identify key structural features on a bridge.
- I can create a sketch and digital representation of a bridge using my knowledge.
- I can solve an engineering problem using physical and digital tools.
- I can build and test a range of physical models which I have planned using 3D drawings and software.



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Introduction

Learners are going to take on the role of an engineer for this activity. Introduce that they are going to be responsible for creating a new bridge for the Forth or a local river or space. Learners should either visit or look at images of the space where the bridge is going to go and discuss what issues may arise.

Discuss the different types of bridges which are most common, their features and which would be suited to the space or problem and why. These could include:

- Cantilever Bridge (Forth Bridge)
- Cable - Stayed Bridge (Queensferry Crossing)
- Suspension Bridge (Forth Road Bridge)
- Tied - Arch Bridge - Clyde Arc (Squinty Bridge)
- Box Girder Bridge - Kylesku Bridge or Skye Bridge
- Arch Bridge - Brig o'Doon
- Viaduct - Glenfinnan Viaduct

Pupils should be encouraged to make sketches as they record their ideas or create models to represent their concept and use these as they progress. It is important that as the engineers for this task the learners should investigate what the bridge will be used for, what materials are available, how it will be fixed in place and if the environment where it will be situated is it is stable or will change over time.

Schools may wish to invite specialists in to discuss their role in engineering, skills required and how they apply these skills to further inspire learners, suggestions for this can be found in the Extension and Further Research section of this pack.

Main Activity

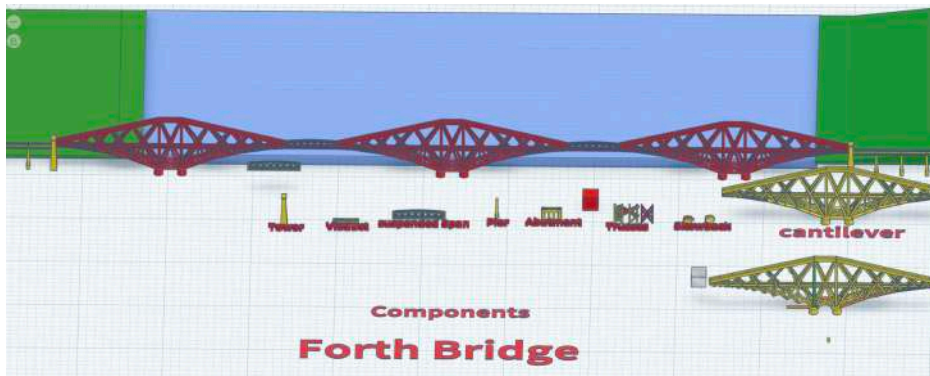
Practitioners should introduce the core components of one of the three types of bridges in the Forth using Resource Pack B - Bridge Components. These should be investigated to see how they impact and support the bridge e.g. The towers in the Queensferry crossing are attached to the deck by the cables which have to support the dead load (the weight of the bridge itself) and the load when it is in use (live load), and what features their bridge design might require and why. Once learners demonstrate an understanding of the role each part can play in the engineering process.



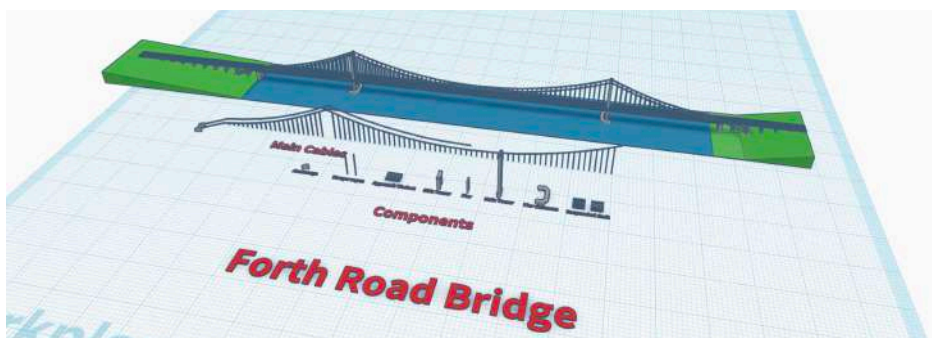
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Learners should use their sketches to create a 3D design using [Tinkercad](#) or similar with the supplied CAD resources which match those on cards with Go Forth and Design Resource Pack B. This is an opportunity to have learners use their virtual model inform a physical model which can be tested.

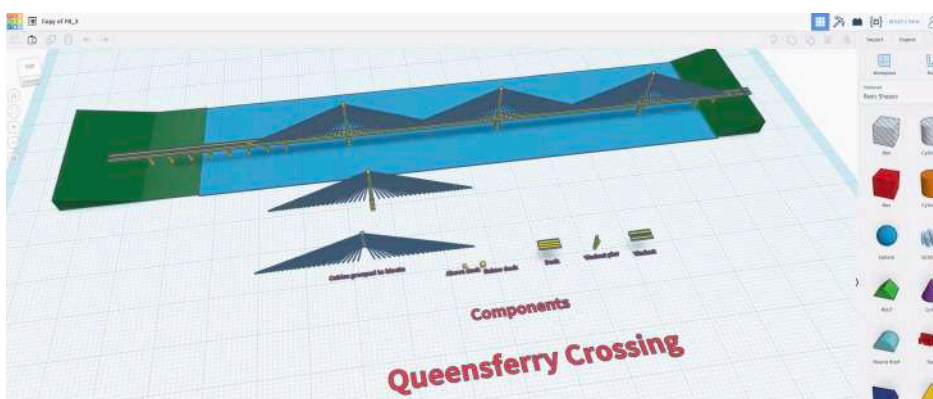
When reviewing the models, learners should discuss how loads are balanced by a bridge as they cross and how forces impact bridges with particular attention given to 'tension' when forces are pulling apart and 'compression' when forces as pushing together. These are crucial for bridge design as they ensure that a bridge is stable and does not suffer any failures.



Forth Bridge CAD and STL resources which are available in Tinkercad via <https://www.tinkercad.com/things/1IzinJsMSck>



Forth Road Bridge CAD and STL resources which are available in Tinkercad via <https://www.tinkercad.com/things/eRdaMwV5zDs>



Queensferry Crossing CAD and STL resources which are available in Tinkercad via <https://www.tinkercad.com/things/6IVnPnAif3w>



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Extension activities can be carried out to look at how the Forth Bridge was designed and the testing of the materials were selected through the images in Go Forth and Design Resource Pack A - Photographs.

These lessons can be supported through the use of a range of practical challenges including the practical project from Young Engineers and Science Club, 'Go Forth' Project <https://bit.ly/14Bms9u> or other STEM challenges.

Plenary

At the end of the design and model building activities;

- Discuss with the learners - what were the key components used in the bridge and how does it address the problem set?
- Discuss with the learners - What are the reasons some bridge styles are chosen over others?
- Discuss with the learners - What are the main considerations selecting materials and locations for bridges?
- Ask learners how they could further test their project. Suggestions could include 3D printing models to run through test scenarios.

Assessment Opportunities

- Reviewing and discussion of learners understanding of the difference between 3D models and 2D sketches including when each is most appropriate.
- Showcase of models created with presentations on how the solution fits the problem and which engineering discipline is covered.
- Display of completed 3D models which have been created and discussion of the process covered as the learner created their solution.
- Physical activities where learners identify the correct force being used and which bridge component is instrumental in load bearing.
- Observation of pupil choices of tools and accuracy when measuring.

Curriculum Links

Numeracy

- I can use the common units of measure, convert between related units of the metric system and carry out calculations when solving problems. MNU 2-11b
- Having explored a range of 3D objects and 2D shapes, I can use mathematical language to describe their properties, and through investigation can discuss where and why particular shapes are used in the environment. MTH 2-16a



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- I can draw 2D shapes and make representations of 3D objects using an appropriate range of methods and efficient use of resources. MTH 2-16c
- Having investigated where, why and how scale is used and expressed, I can apply my understanding to interpret simple models, maps and plans. MTH 2-17d

Science

- By investigating how friction, including air resistance, affects motion, I can suggest ways to improve efficiency in moving objects. SCN 2-07a

Social Studies

- I can consider the advantages and disadvantages of a proposed land use development and discuss the impact this may have on the community. SOC 2-08b
- Having explored the ways journeys can be made, I can consider the advantages and disadvantages of different forms of transport, discussing their impact on the environment. SOC 2-09a

Technologies

- I can use digital technologies to search, access and retrieve information and are aware that not all of this information will be credible. TCH 2-02a

Extension and Further Resources

To further extend learning around the Forth Bridge, you may wish to investigate and use some of the other materials from the Go Forth Bridges Project including:

Go Forth and Discover

Resources to support understanding and research around the history of The Forth Bridge and the life of a young person who built it.

Go Forth and Create

Resources to support computing science through the use of materials developed from scanning of the Forth Bridges.

Additionally, schools can access the Go Forth, See and Hear 360° Audio and Video files via The Forth Bridges Forum <https://www.theforthbridges.org> . These can be used with VR headsets such as Google Cardboard, etc to further develop learners understanding and awareness of the design, scale and function of the three Forth Bridges prior to or instead of visiting them, ensuring all learners can share in an experience. An AR App, Go Forth and Explore, is also available for download from the Google Play (<https://play.google.com/store/apps/details?id=com.simvis.frbllbm>) and Apple App stores (<https://itunes.apple.com/gb/developer/centre-for-digital-documentation-visualisation-llp/id1234262814?mt=8>). This location based image app



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will allow learners to see back through time to when the bridges were being built when standing in specific locations around the Forth Bridge and Forth Road Bridge.

Practitioners may wish to develop links with partner organisations and third parties, several of whom have supported in the creation of these resources, to further research specific workers, the engineering of the bridge, the science behind the materials used, etc.

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National Records of Scotland



National Records of Scotland collects, preserves and produces information about Scotland's people and history and makes it available to inform current and future generations. We provide a flexible service with workshops and online resources designed to support a wide range of Scottish curriculum areas to help pupils connect with Scotland's history, heritage and culture from Robert the Bruce to the results of the 2011 Census.

We are delighted to see records from our collections used in a creative and innovative way in the Forth Bridges game. We very much look forward to introducing young learners to this exciting new topic. For more information about the services we provide you can visit the [Services for Schools](#) section of our website or contact our learning team at education@nrscotland.gov.uk

The Briggers



The Briggers is a Forth Bridge research group based in South Queensferry beside the bridge. Initially they were responsible for identifying the names of the 73 men and boys who died constructing the Forth Bridge. Their research continues into the history of the bridge and the people who made and maintain it. *The Briggers* give Forth Bridge talks to adults and school children and consultancy to bridge related projects. They also hold a significant archive of images and Forth Bridge related material. Their book, "The Briggers", written by Edinburgh author and historian, Elspeth Wills and based on their research, tells the story of the Forth Bridge.

Briggers website: www.briggers.com

Briggers contact: mail@briggers.com



Go Forth and Design

Historic Environmental Scotland



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SCOTLAND

ÀRAINNEACHD
EACHDRAIDHEIL
ALBA

Historic Environment Scotland (HES) is the lead public body for Scotland's historic environment and a charity dedicated to conserving and presenting Scotland's places now and in the future. We care for over 300 prehistoric sites, castles, abbeys and industrial buildings spanning 5,000 years of Scotland's history and culture. We are Scotland's largest operator of paid tourist attractions.

The HES Learning & Inclusion Team support access to our historic sites and deliver programmes which use these special places in creative ways to support learning and wellbeing for diverse audiences.

From Edinburgh Castle to the Antonine Wall our sites are a rich national resource for learning. As well as telling Scotland's story these special places can provide inspiring and meaningful experiences, safe environments in which to learn and routes to our national culture. They provide excellent settings for exploration, discovery and inspiring creativity.

We can support schools and learning groups through:

- free Education Visits with a learning or wellbeing remit
- travel grants to support visits from Scottish schools
- advice and support to enable visits for groups with additional support Needs
- access to archives and digital resources containing millions of photographs, drawings and plans relating to national and local culture and heritage
- support from our Learning Officers who work in partnership to deliver activities and projects to support learning, creativity and wellbeing linked to our sites and collections

To find out more visit our website www.historicenvironment.scot/hes/learn



SCDI's Young Engineers and Science Clubs Scotland

SCDI's Young Engineers and Science Clubs Scotland (YESC) programme supports learners aged 3-18 and their teachers with a range of innovative STEM projects, developed with our industry partners. Our interdisciplinary projects, accompanied by resource kits and teacher CPD courses, support teachers to tackle challenging STEM concepts through engaging activities; while our annual STEM challenge gives Clubs a practical challenge to explore a topical theme.

In 2016, our Go Forth! challenge with Morrison Construction tasked teams to use a kit of lollipop sticks, cable ties and string build a suspension or cable stayed bridge to commemorate the Queensferry Crossing.

Find out more or come along to our national Celebration of STEM event at the end of term: <http://www.yescotland.co.uk/>



Go Forth and Design

DYW

The Developing Young Workforce (DYW) career pathways which can be linked to the Go Forth projects include Engineers, Civil Engineers, Town Planners, etc. many of whom have links with the STEM Ambassadors program who offer a free service to schools and teachers. <https://www.stem.org.uk/stem-ambassadors>

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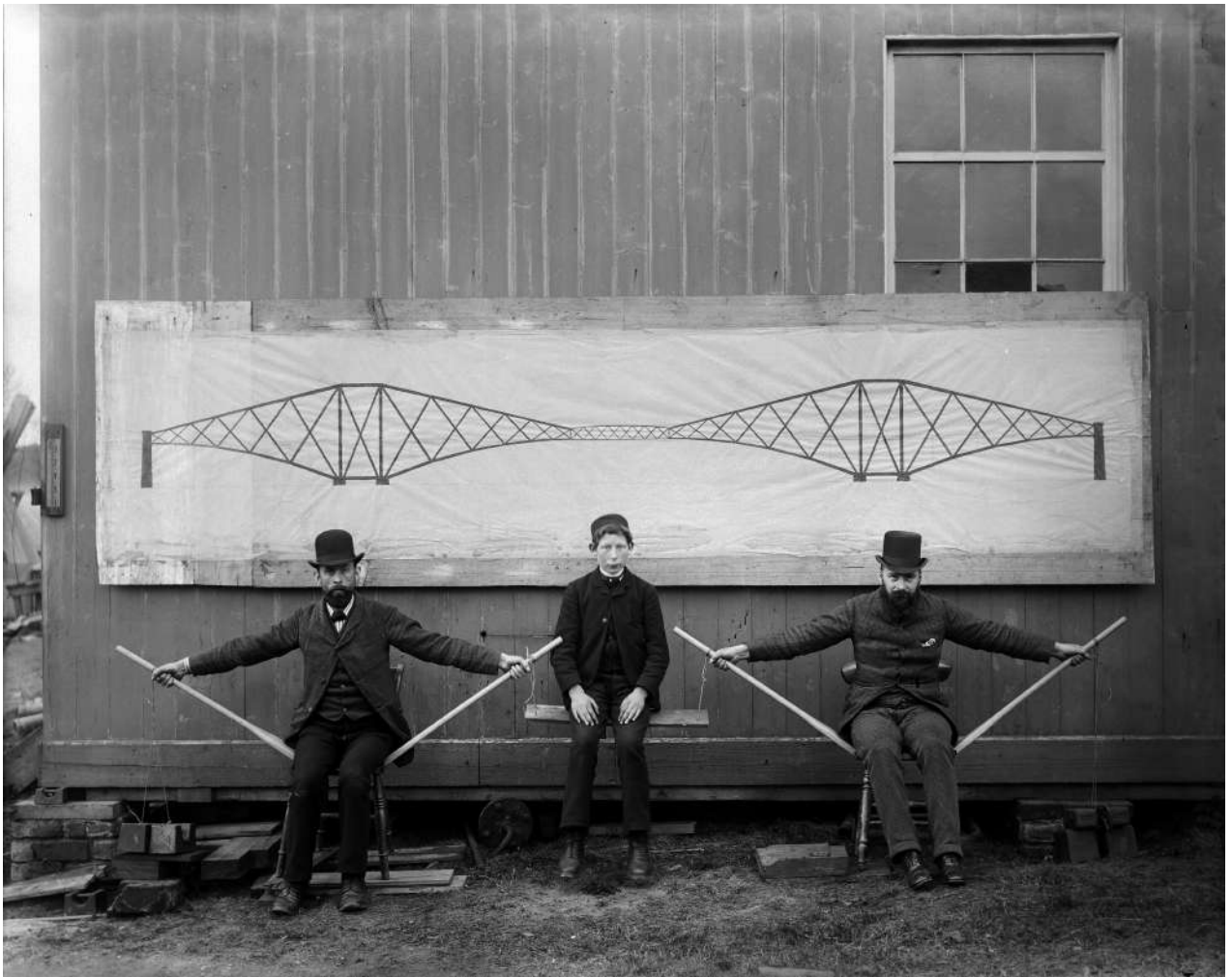
A range of CAD resources which support understanding in design and engineering, raising awareness and knowledge of the Forth Bridges and their place in Scotland's history.

Resource Pack A : Photographs

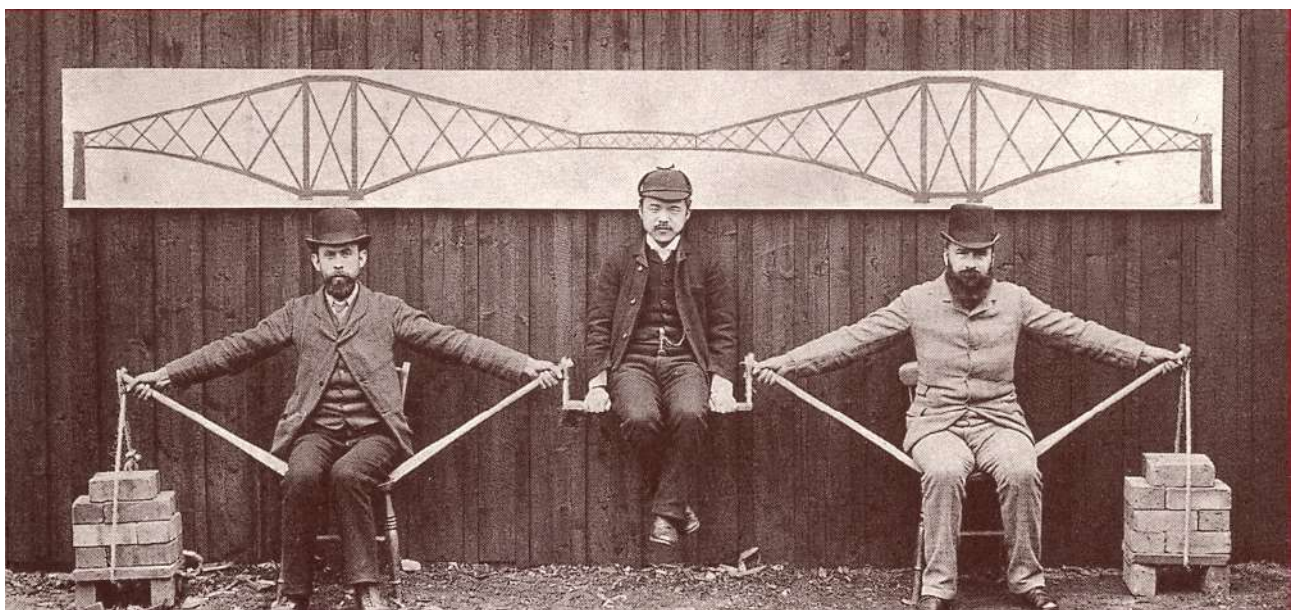


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Crown copyright, National Records of Scotland, BR/FOR/4/34/161, The human cantilever: three men positioned to model the cantilever principle, 1887



Ref: Forth Bridge Watanabe Image Courtesy of The Forth Bridges Forum



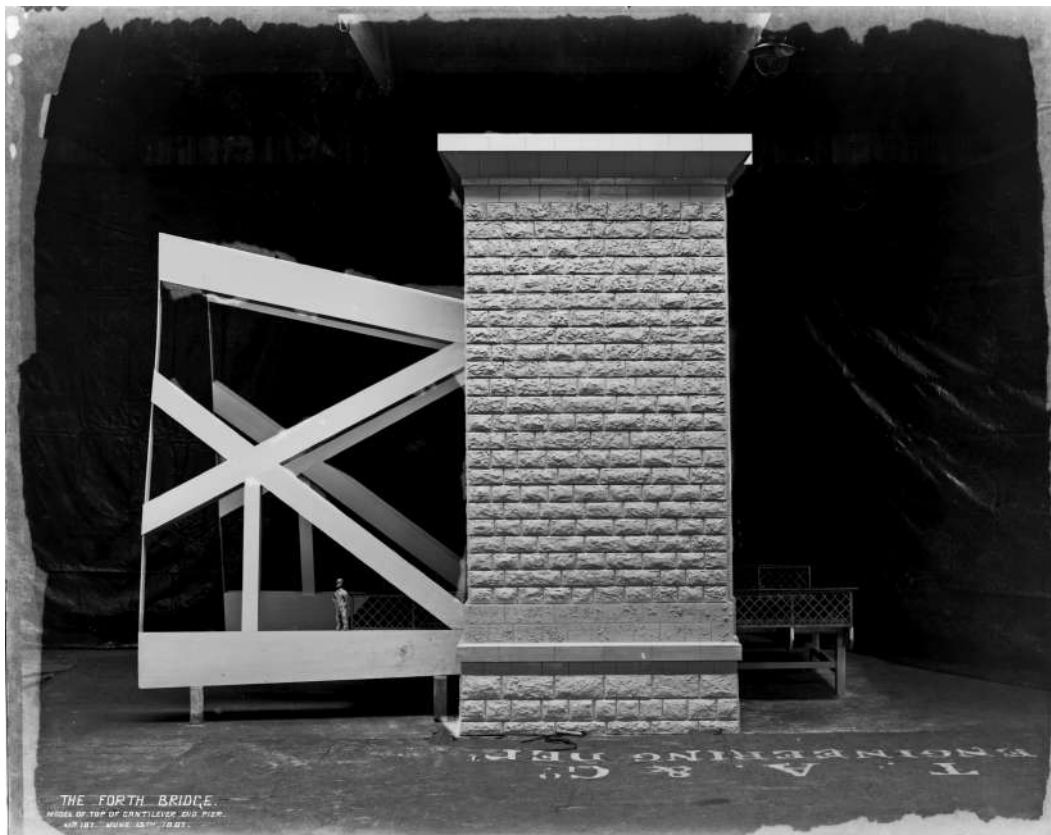
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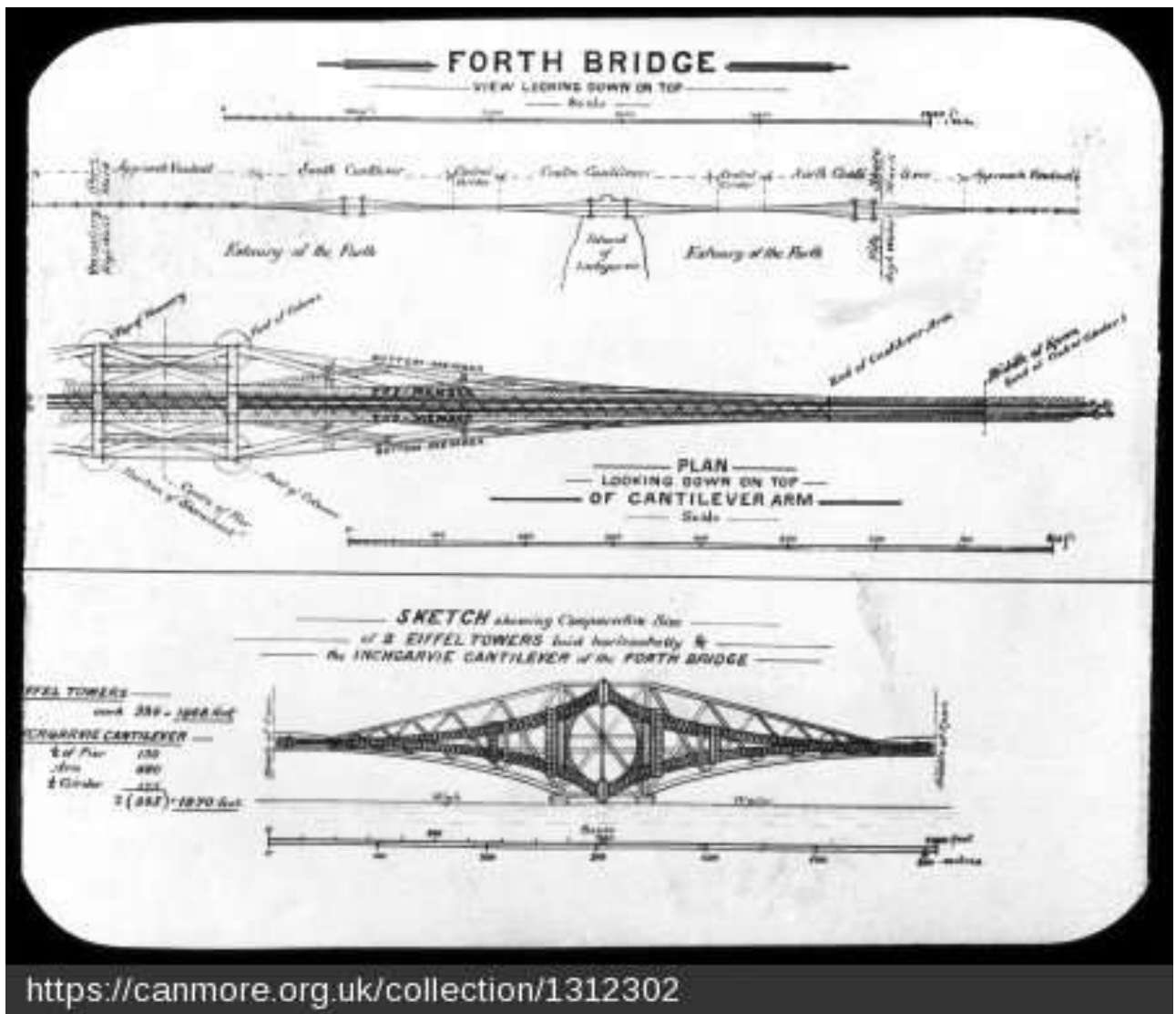
Crown copyright, National Records of Scotland, BR/FOR/4/34/123, Compressed struts, one labelled iron, one labelled steel (possibly for testing the metal), in front of two workers' sheds, 12 May 1885;



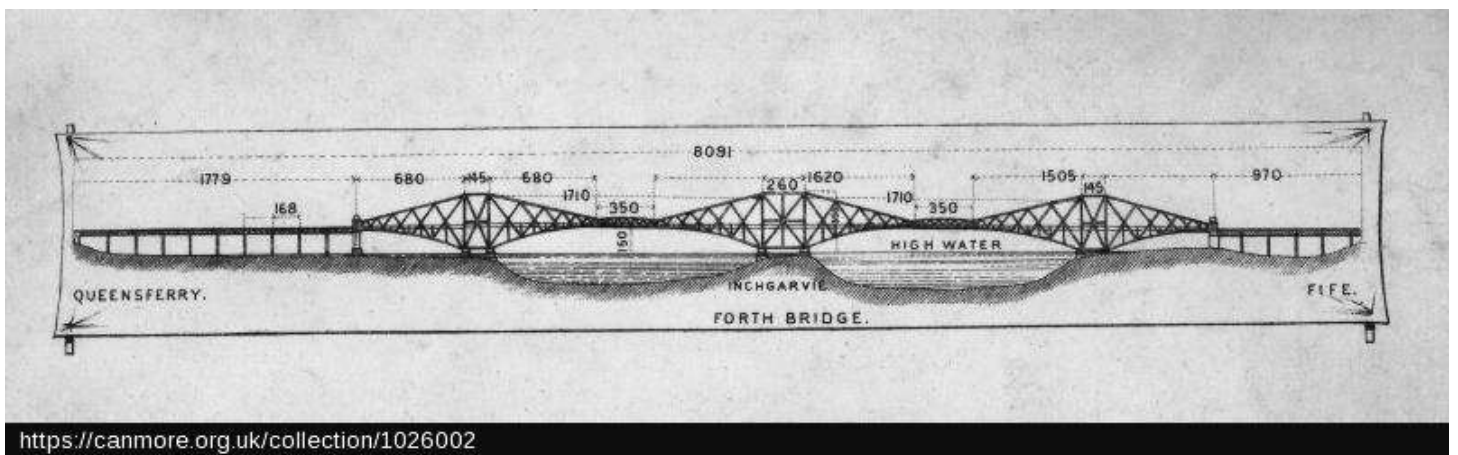
Crown copyright, National Records of Scotland, BR/FOR/4/34/124, Model of top of cantilever end pier, showing connection with the cantilever, 13 Jun e1887;



Crown copyright, National Records of Scotland, BR/FOR/4/34/126, Model of top of cantilever end pier, showing connection with the cantilever and approach viaduct girder-spans, 13 Jun 1887;

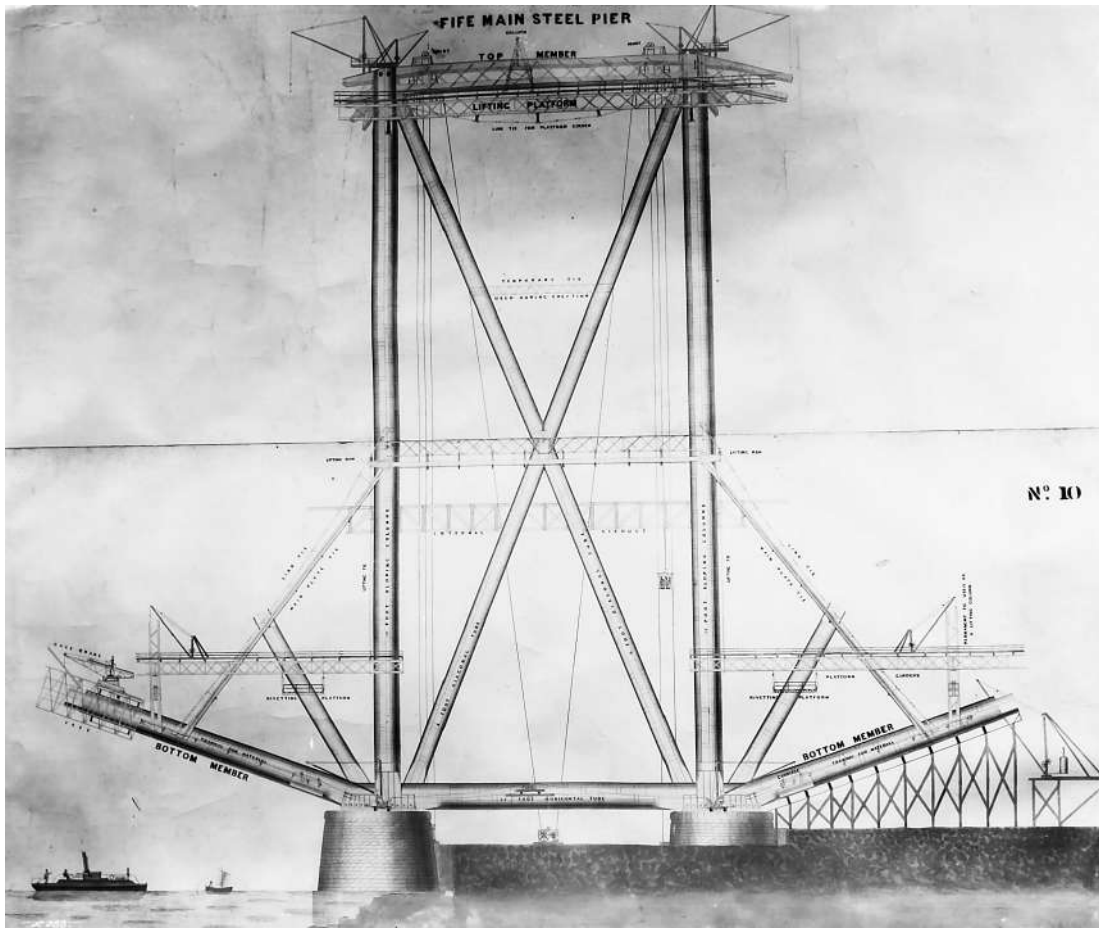


Ref: Canmore Images Reference 1312302



https://canmore.org.uk/collection/1026002

Ref: Canmore Images Reference 10626002



Ref: National Records of Scotland, AAA01308



Crown copyright, National Records of Scotland, BR/FOR/4/34/23, Engineers' drawing loft 200 x 60 feet, 4 Aug 1885

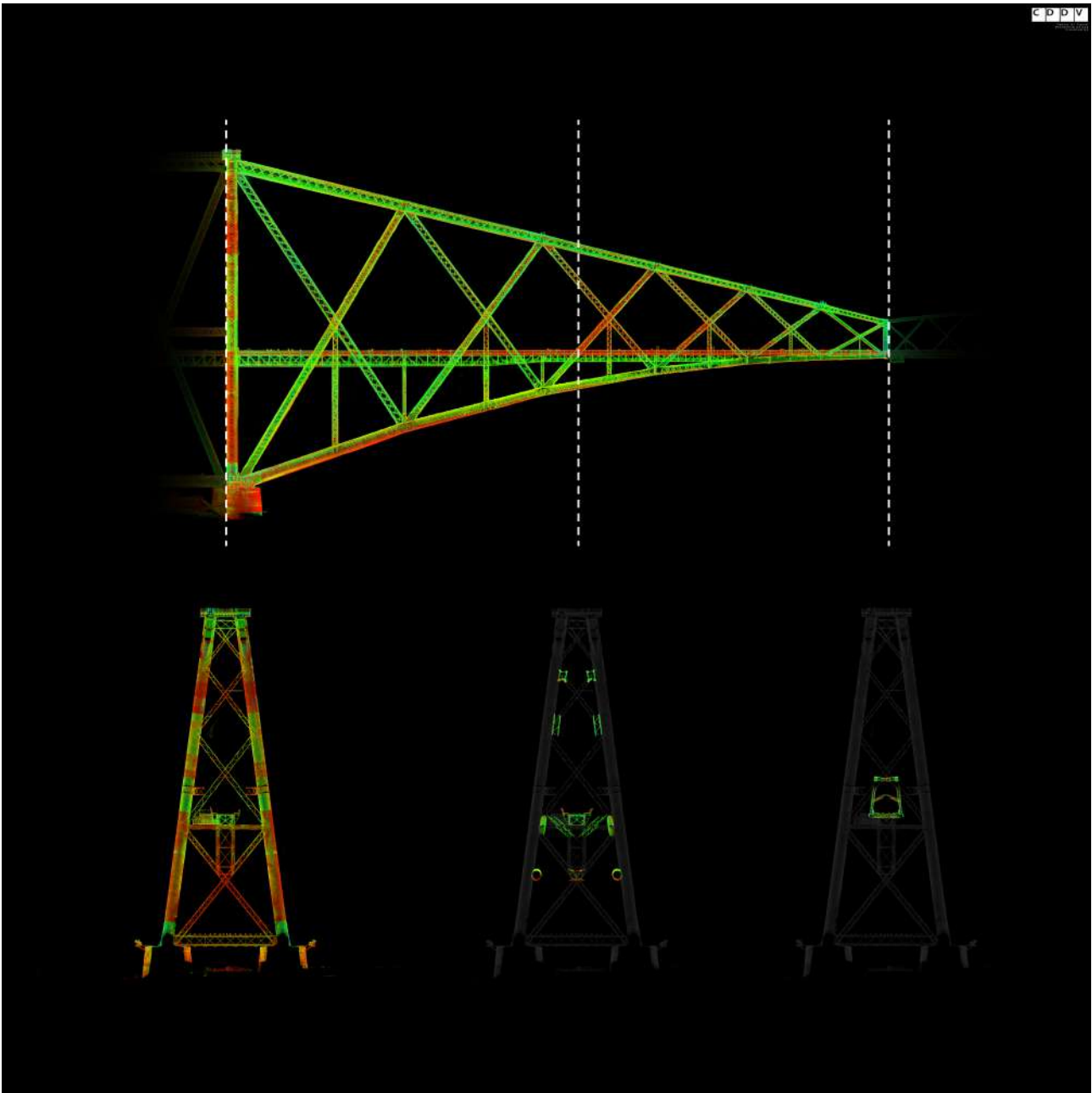


Image courtesy of CDDV, Point Cloud still from laser scanning of Forth Bridge, Cross section of Cantilever 2016



Image courtesy of CDDV, Point Cloud still from laser scanning of Forth Bridge, North Elevation 2016

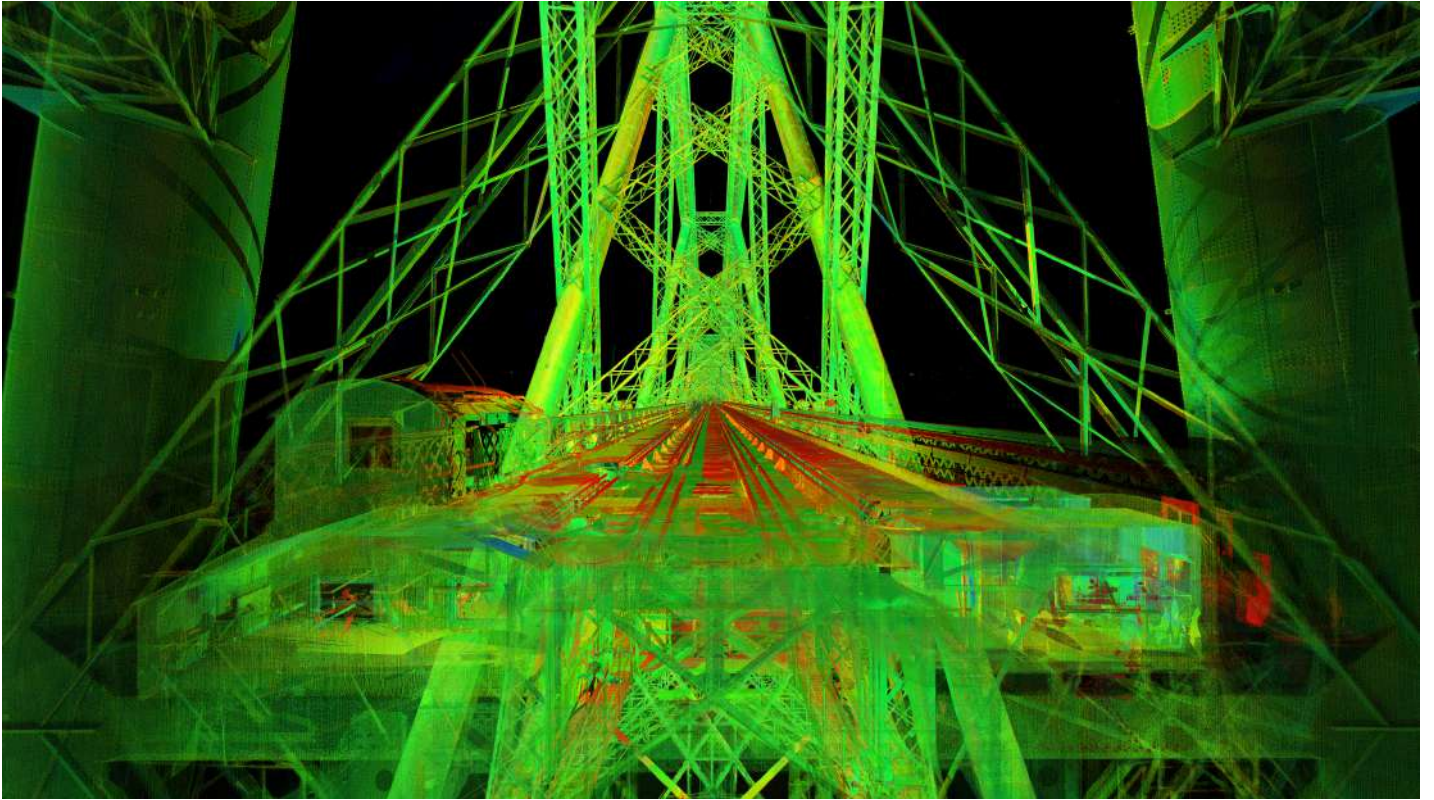


Image courtesy of CDDV, Point Cloud still from laser scanning of Forth Bridge, 2016

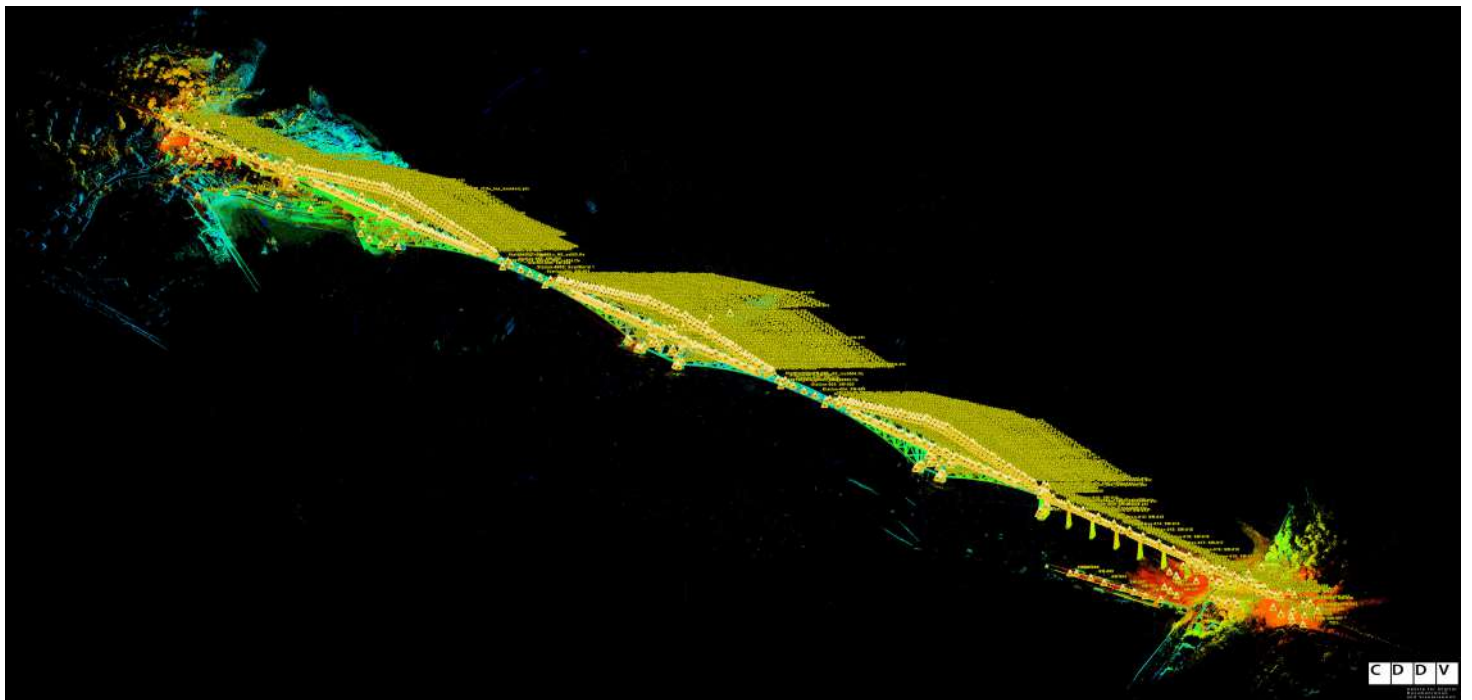
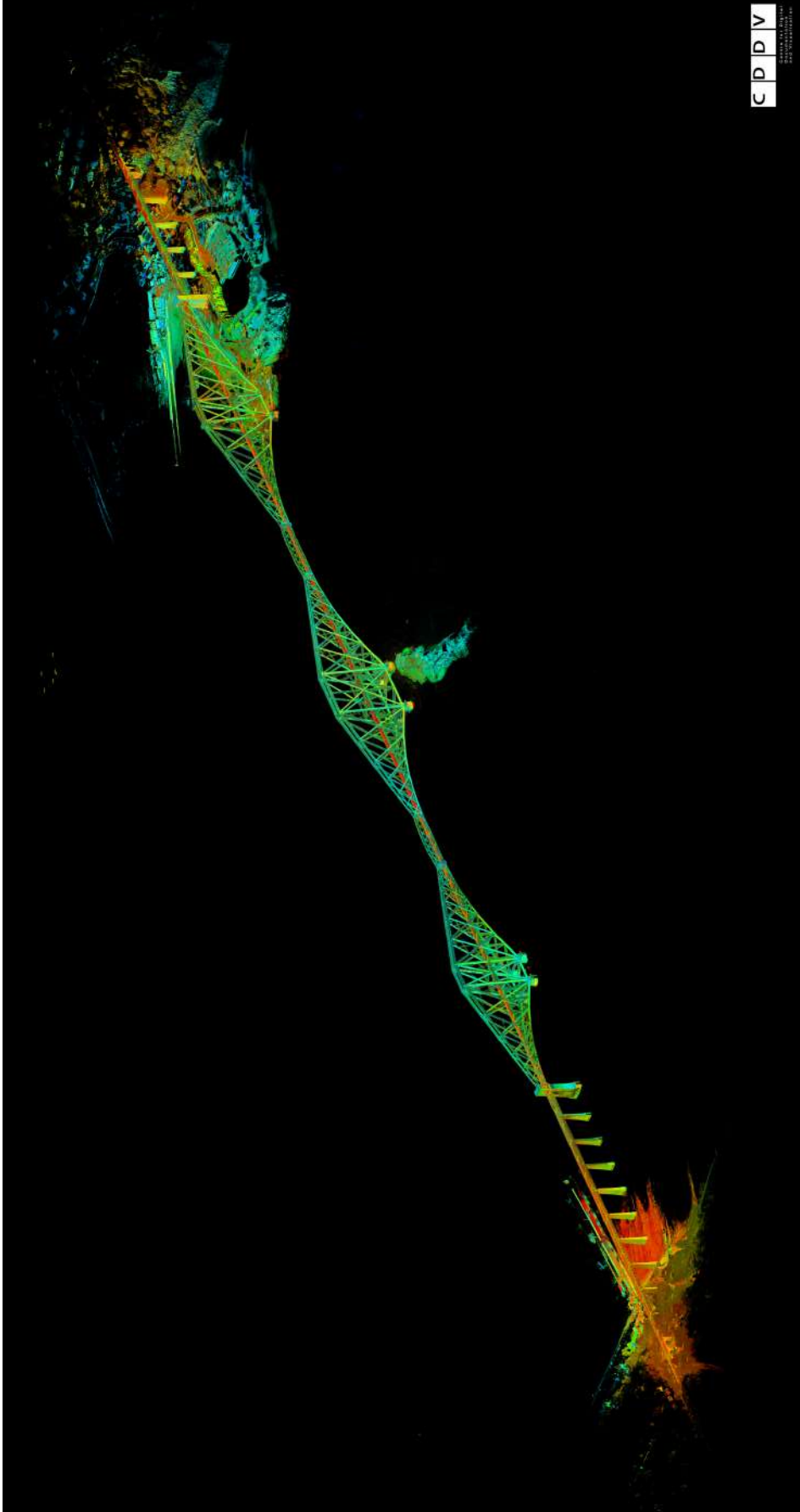


Image courtesy of CDDV, Point Cloud still from laser scanning of Forth Bridge showing scan locations, 2016



CDDV
CONSTRUCTION DATA VISUALIZATION

Image courtesy of CDDV, Point Cloud still from laser scanning of Forth Bridge, 2016

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A range of CAD resources which support understanding in design and engineering, raising awareness and knowledge of the Forth Bridges and their place in Scotland's history.

Resource Pack B : Bridge Components



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Centre for Digital
Documentation and
Visualisation



United Nations
Educational, Scientific and
Cultural Organization



The Forth Bridge
inscribed on the World
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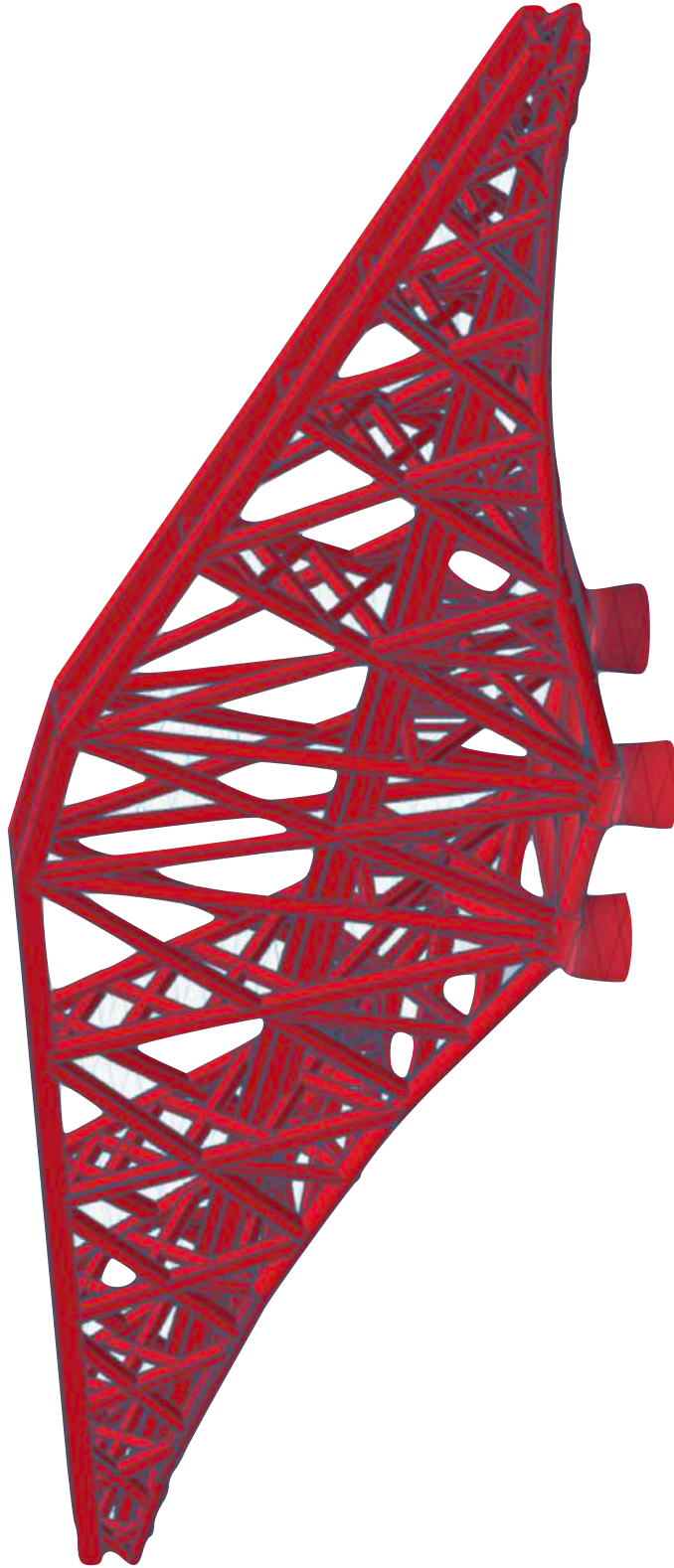
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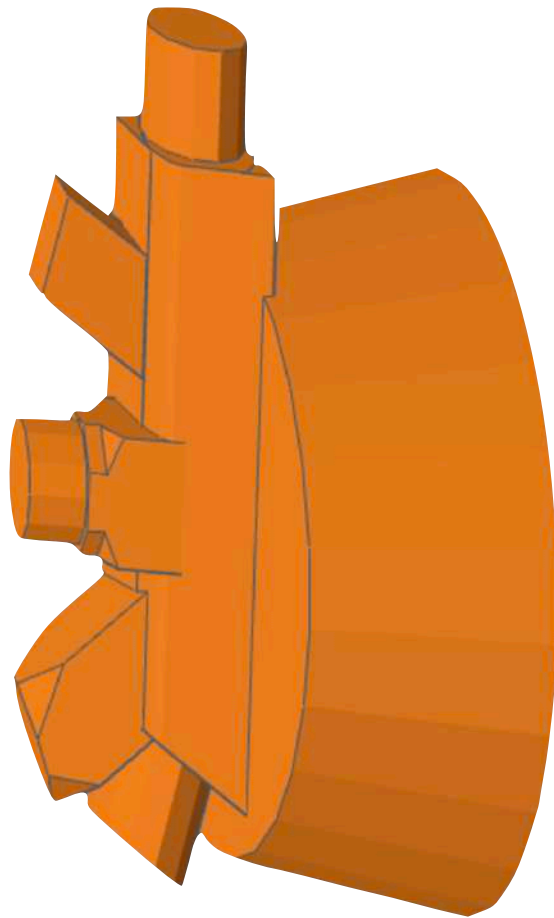
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Balanced Cantilever



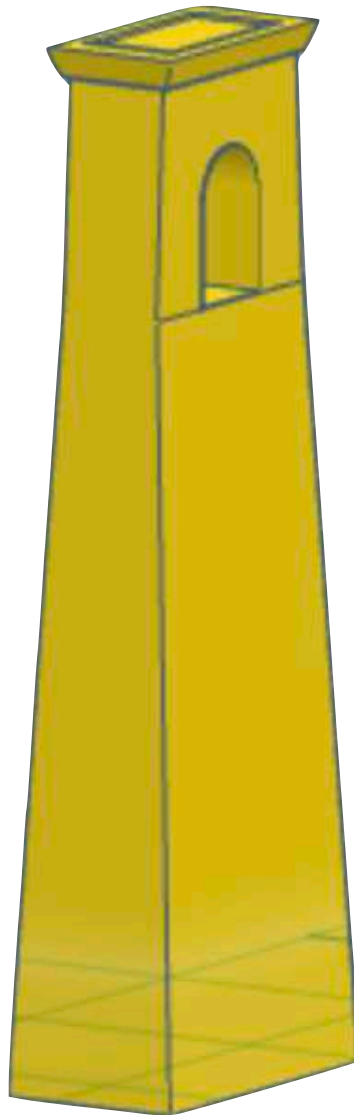
Go Forth and Design



Skewback



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Stone Tower



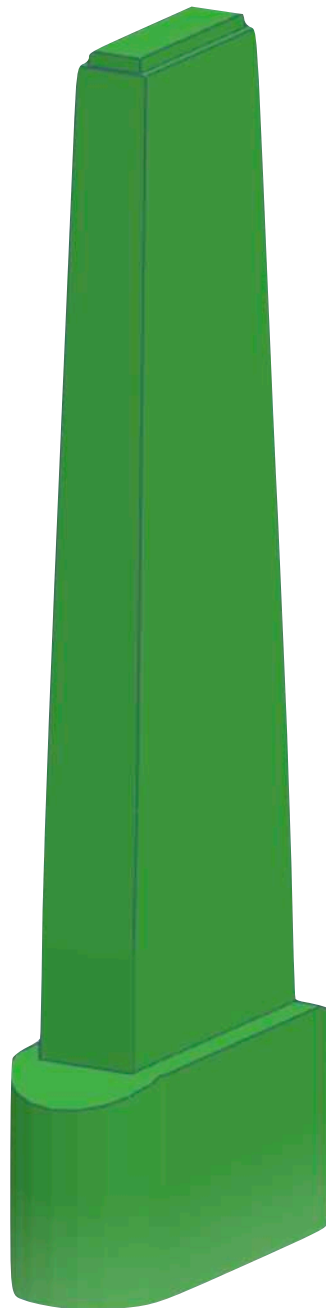
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Masonry Arches with Abutment



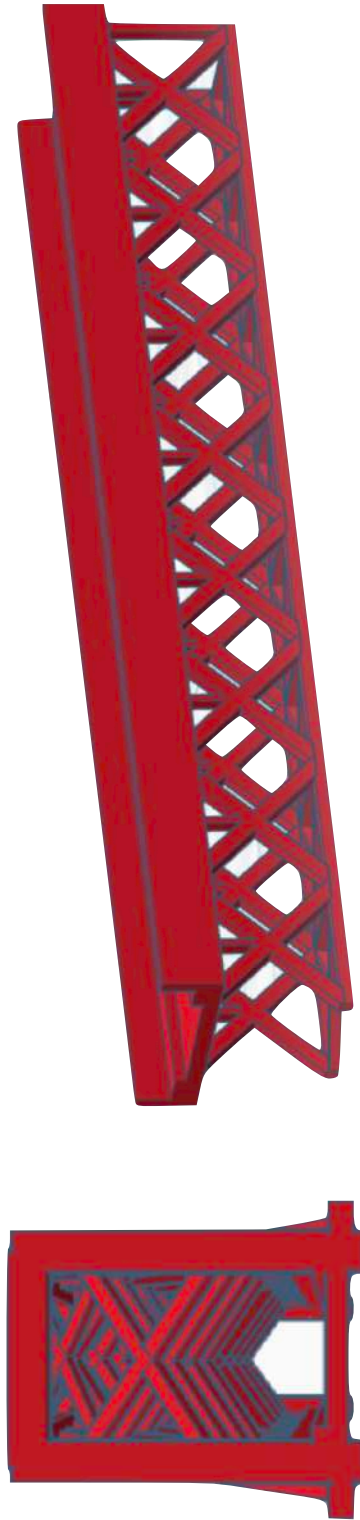
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Pier



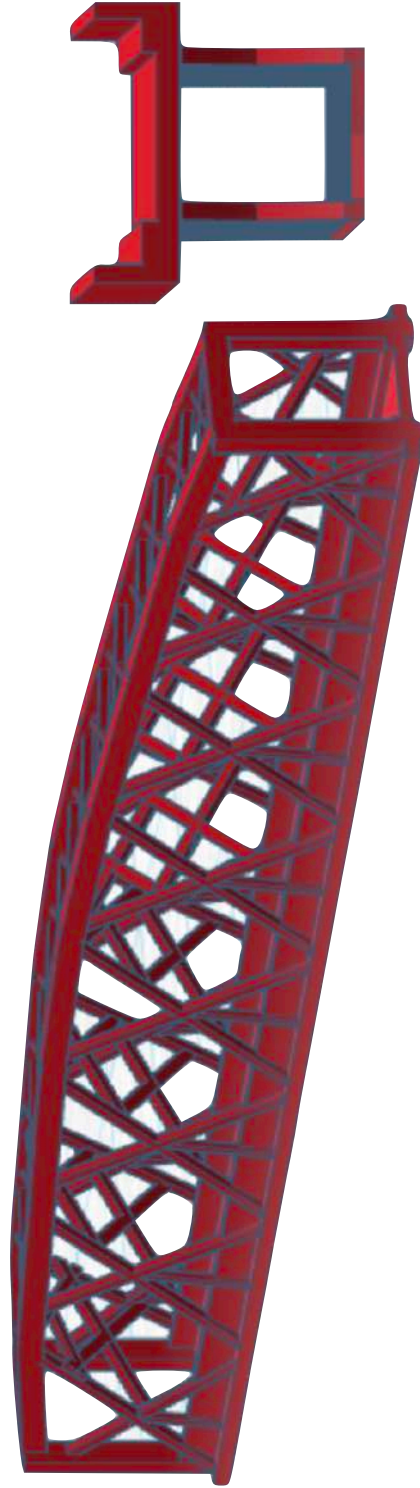
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Viaduct
Side and Front Elevations



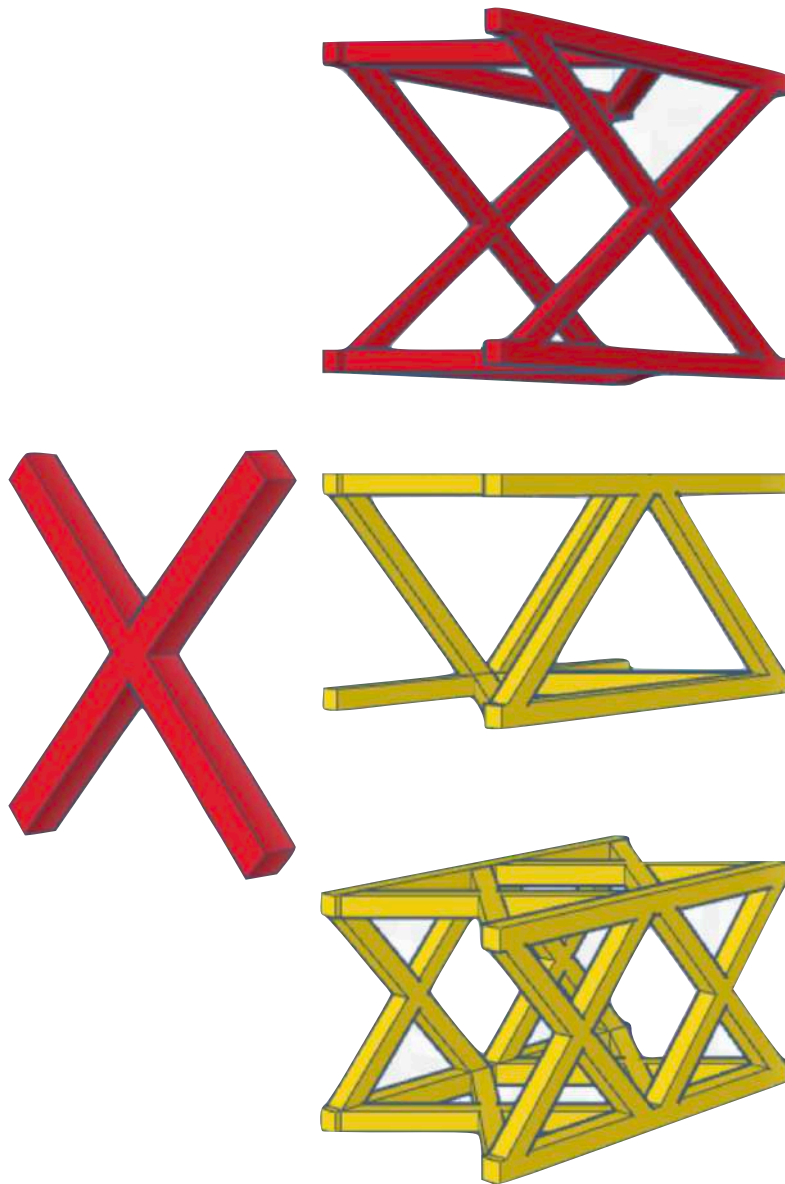
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Suspended Span
Front and Side Elevation



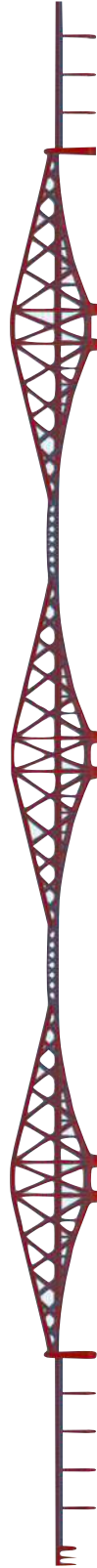
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Trusses



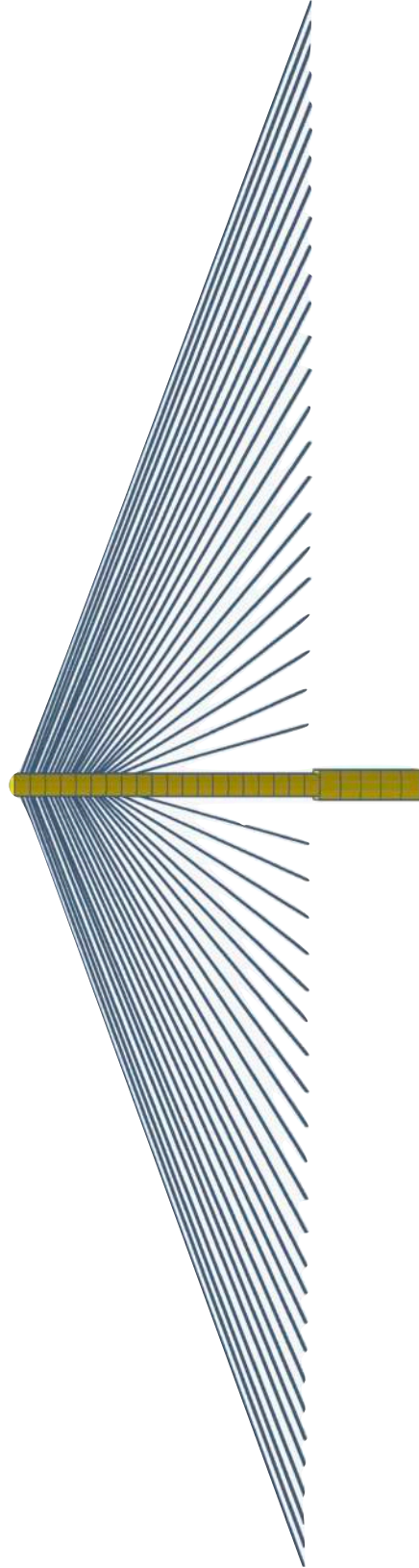
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Complete Cantilever Bridge



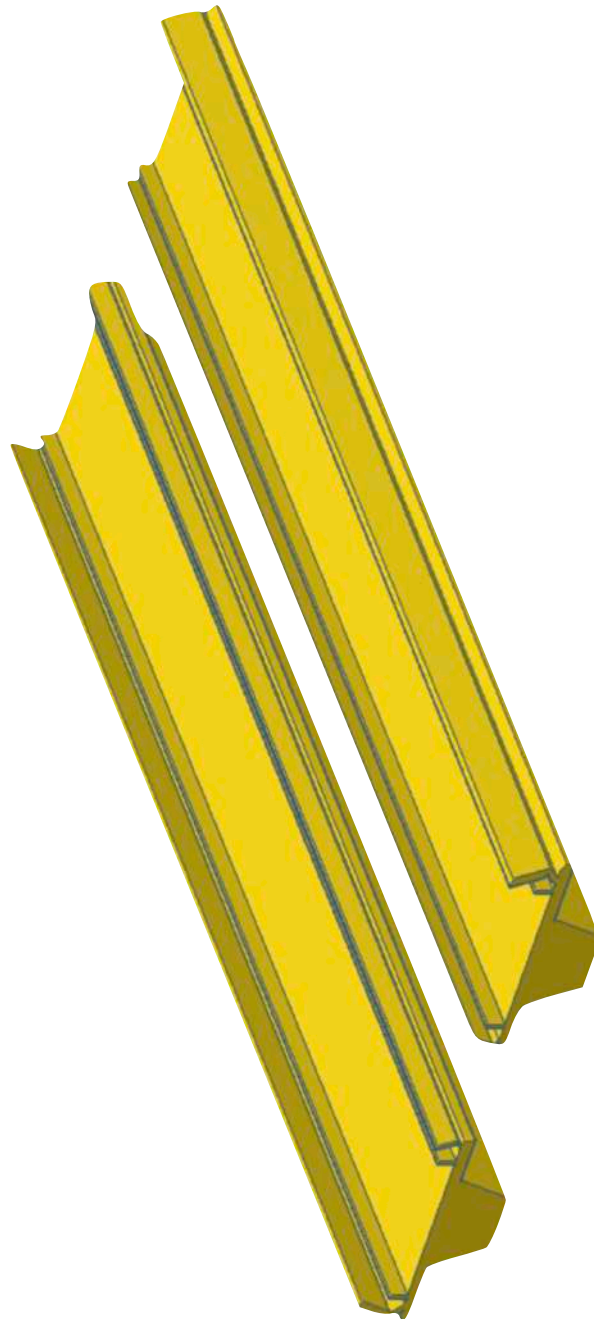
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Cables attached to Fan Tower



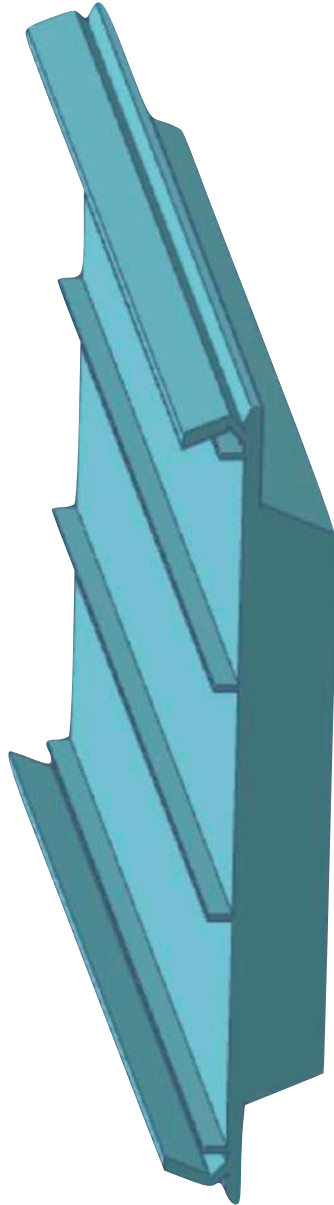
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Viaduct



Go Forth and Design



Deck



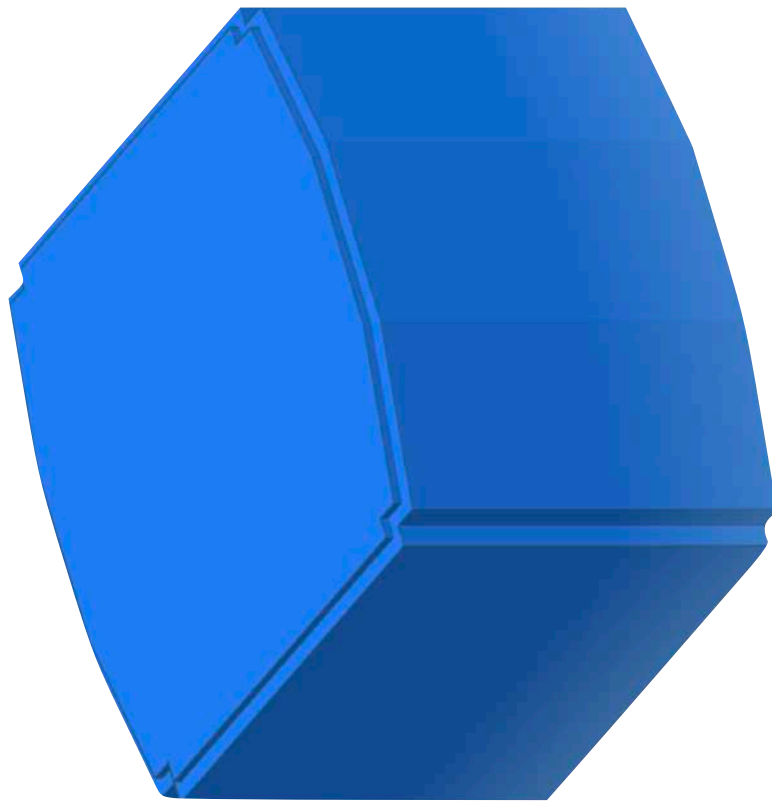
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Viaduct Pier



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Individual Section of Tower



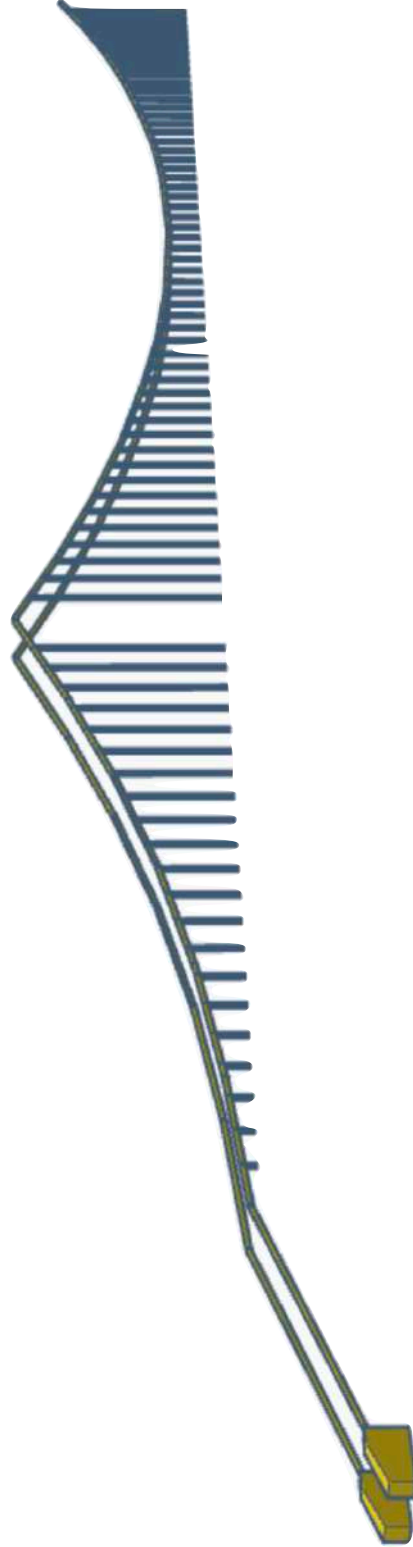
Go Forth and Design



Complete Cable Stayed Bridge



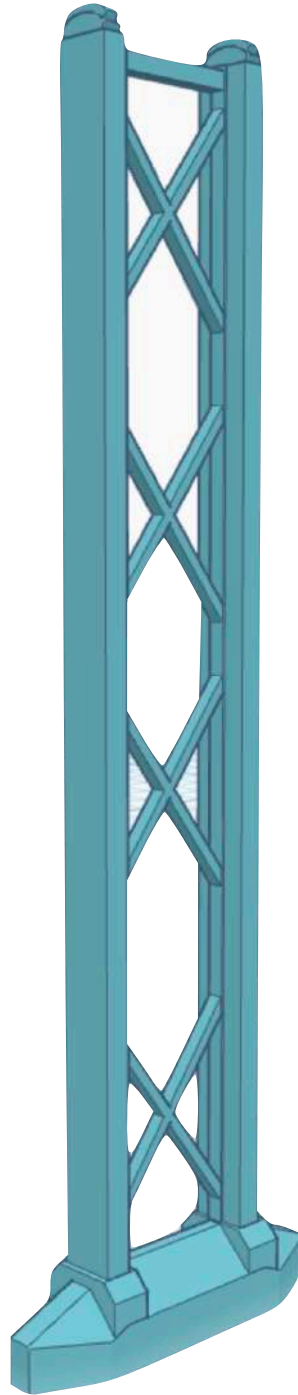
Go Forth and Design



Suspension Cables
with Hanger Ropes and Anchorage



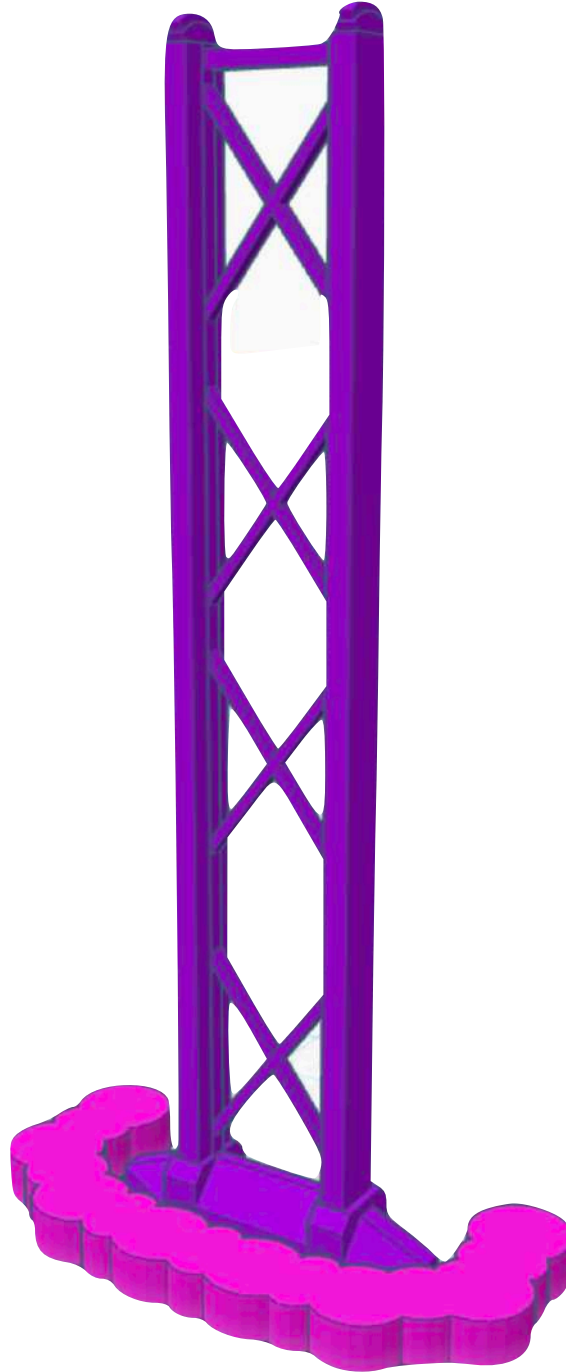
Go Forth and Design



Tower



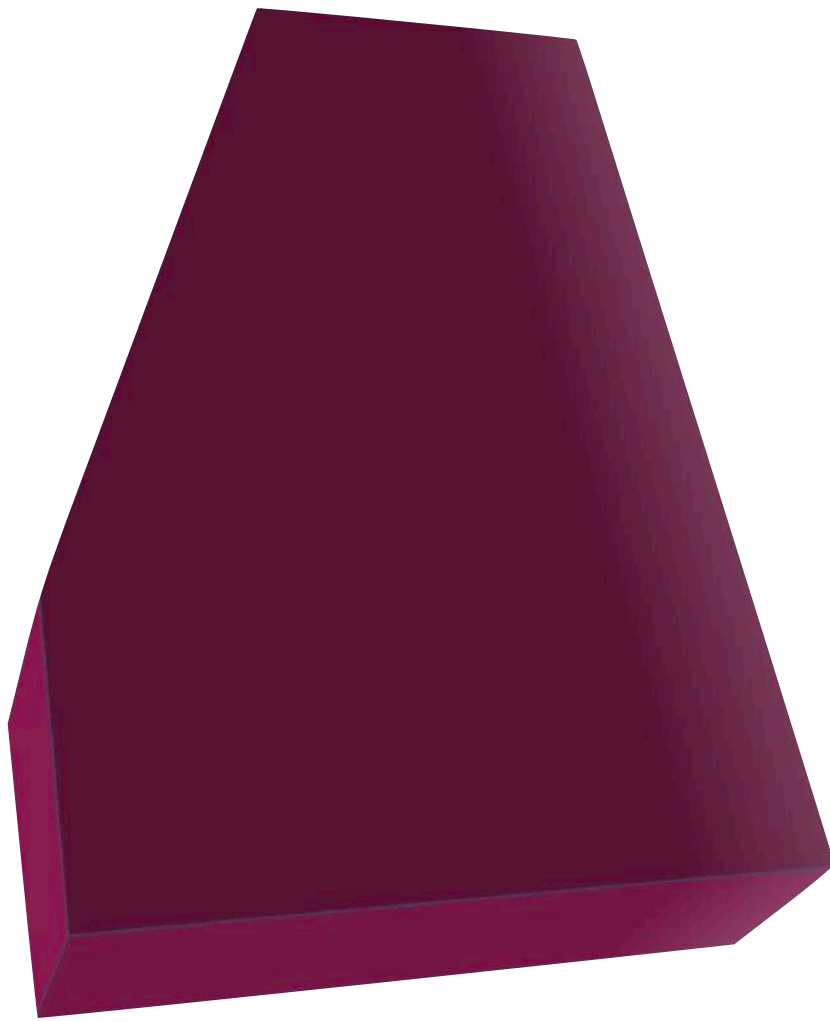
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Tower with Pontoon



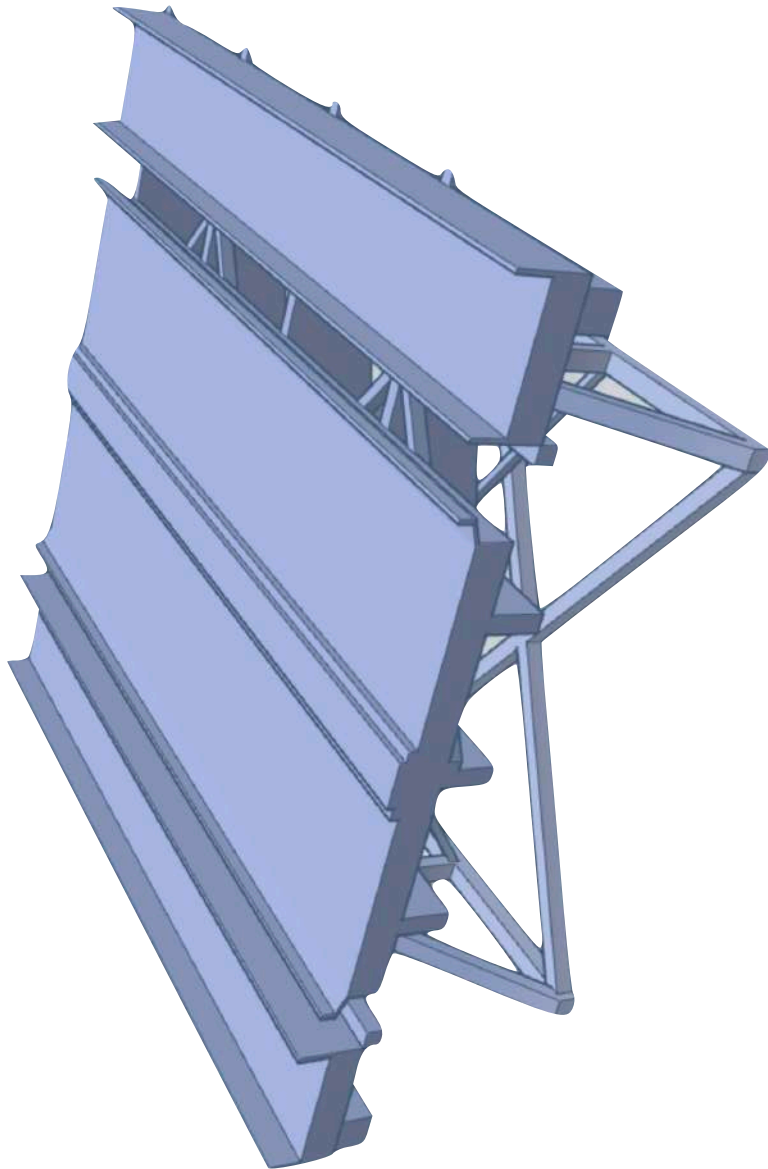
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Anchorage for Suspension Cables



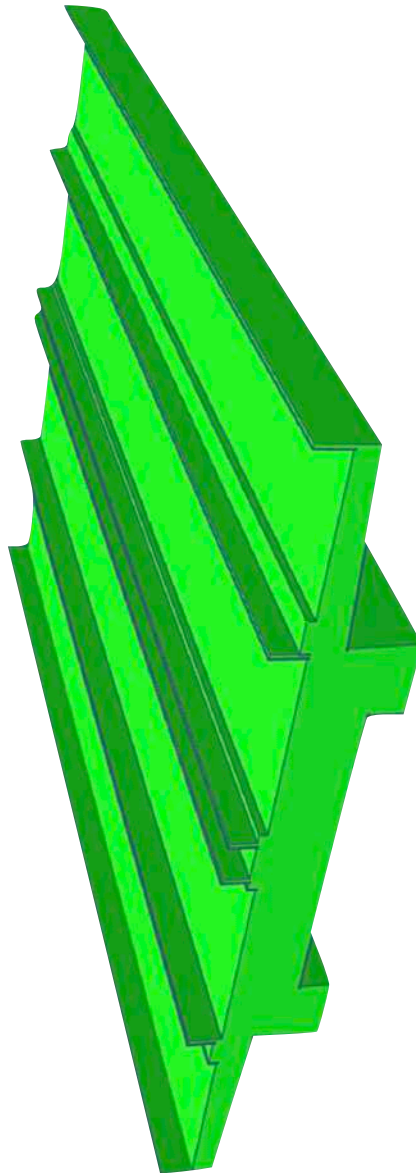
Go Forth and Design



Deck with Truss



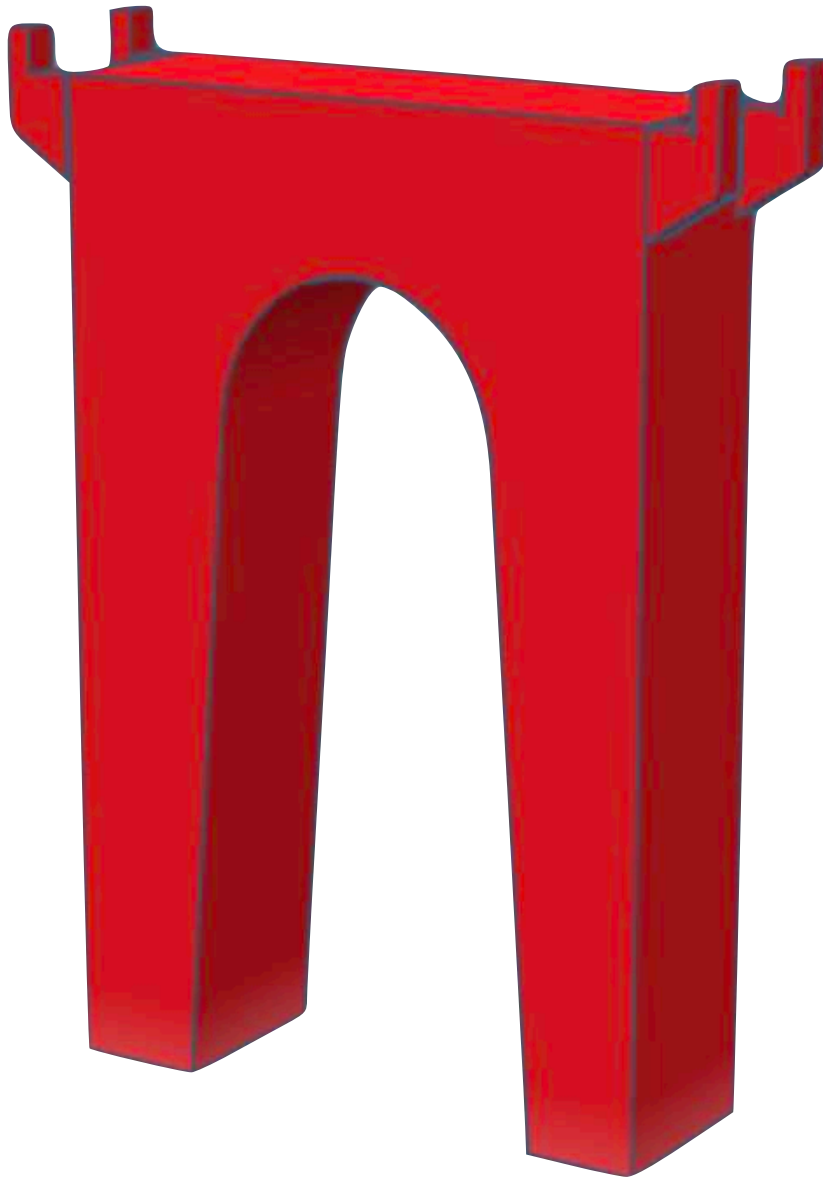
Go Forth and Design



Deck



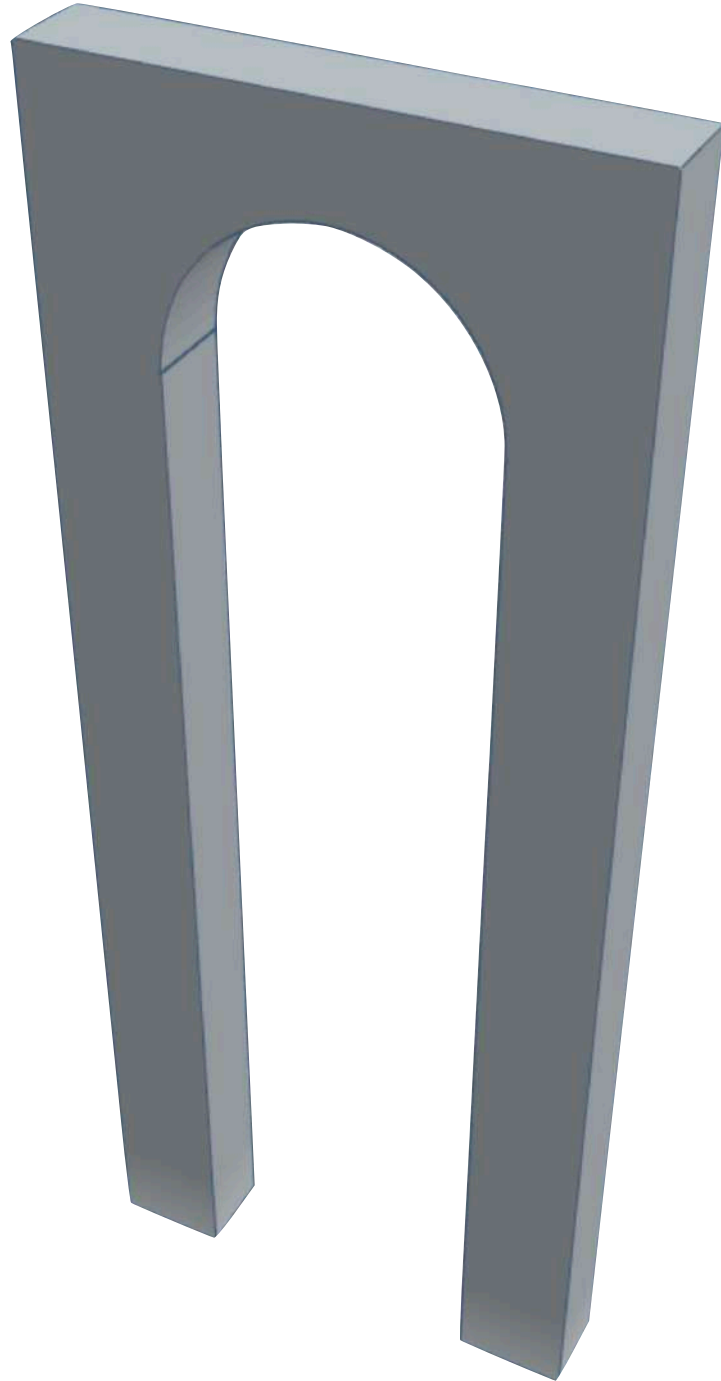
Go Forth and Design



Road Connection Pier



Go Forth and Design



Pier



Go Forth and Design



Complete Suspension Bridge

With Thanks to The National Records Of Scotland, The Forth Bridge Forum, Historic Environmental Scotland's Canmore Records and CDDV for the use of their images.