Challenge Overview

Our challenge will task teams of three students to design, present, and create a model of a housing complex suited to house 200 people. Students will be given anywhere from 6 hours or more (depending on ambassador preference) to complete their challenge. Before the hands-on challenge portion of the programme begins, the STEM ambassador team that will facilitate the programme will give an interactive introductory presentation that introduces students to structural engineering and the housing crisis. The ambassador team will comprise of a one to three ambassador to student ratio, which will be necessary for the hands-on portion of the programme. After the introductory presentation, ambassadors will break students into teams of three to begin the hands-on portion, with one ambassador accompanying each team of three students.

Once the challenge begins, students will first choose one of three roles that they will fulfil in their groups: the project manager, primary architect, and structural engineer. Each team will have an individual STEM ambassador who will assist the group throughout the entirety of the challenge, answering student questions and helping to resolve conflicts the team may face. First, the students will work on the design phase of the programme, which will take teams roughly one and a half to two and a half hours to complete. The teams will choose from one of three housing complex designs: one large apartment building, two to three multi-storey townhouses, or about a dozen two-family homes. After they choose their land plot, teams will work together to design the exterior and footprint of their building or buildings. When the students create the footprint and exterior, they will begin individual work based on the roles they chose. The architect will develop floor plans for each of the floors in their buildings. Architects will fit appropriate flats within each footprint for each floor. The structural engineer will take the building exterior and footprint and identify which materials their team can use to build the structure(s), and what quantity of those materials they will need. The project manager will create a timetable for building their structure(s) and additional

amenities like the electrical and heating and air conditioning systems by creating a schedule with associated time constraints for each amenity. The project manager will also create a budget with the materials the structural engineer chooses to utilise. The design phase is the most time and labour intensive portion of the challenge, and will require the most ambassador assistance. Because of this time constraint, we recommend the aforementioned one to one ambassador to team ratio. Common tasks that ambassadors will face throughout this portion of the challenge will include assisting in floor plan design, assisting in structural engineer material quantity calculations, and assisting in timetable optimization. After the design phase, students will transition into the bid phase.

In the bid phase, the teams will create a poster presentation of their programme design and present it to their ambassadors. This portion of the challenge promotes public speaking and communication skills, both valued in structural engineering projects. This phase will take roughly half an hour for teams to complete. Students will present their individual findings and deliverables from the design phase (e.g. the architect will present and explain her finalised floor plans), and will answer any questions the ambassador may ask. Ambassadors will provide constructive feedback on student designs in this phase and ultimately accept the student bid after they decide the team has created a sufficient product. As each team design will be different, ambassadors will use their best judgement to determine when the team's design is ready based on student effort, deliverable quality, and student creativity. After the ambassadors accept the team's bid, the team will transition into the build phase.

In the build phase, the team will use associated low budget materials to create a model for their structures that represent the structural designs they created in the design phase and presented in the bid phase. Depending on team designs, this portion of the programme will take students an estimated one to one and a half hours to complete. Students will only build the exterior skeleton for their buildings, and do not have to create individual floor designs. Students will not focus completely on making a precise scale model for their finished products as creating accurate scalars are above the level of most key stage four

student, and rather will focus on creating structures that are structurally stable and reflect the concepts they devised in the design phase. Students who designed multiple buildings with the same designs (most likely the students who chose to do the one dozen two-family homes) will not need to create multiple of the same model, and should instead focus on creating well-built models for each unique design. In this phase, the ambassadors will work with the teams to optimise their structural models by showing students efficient ways to utilise their materials and assist students should they struggle to make their building structurally stable.

After the challenge concludes, all of the teams will present their finished builds and discuss in an ambassador-led open discussion what challenges their teams faced, what successes they had, and areas where they can improve. Finally, ambassadors will lead a discussion with all of the teams to connect the challenge with real-world engineering problems that students may face should they choose to pursue a career in the field. Ambassadors will also offer careers advice to students about different courses that they can take for their A levels, as well as educational paths they can take as either academics or apprentices to pursue careers in structural engineering.

Build Your Own City - Ambassador Guidebook

As the ambassador, you are your programme's facilitator. Your role is to introduce students to the challenge, answer any questions they have throughout the challenge, and work to resolve conflicts struggling groups may have. While you may not be a formal educator, remember that your attitude and level of engagement in the programme directly influences what your students learn from it. Your objectives for this programme are to:

- Engage students in the programme and answer challenge related questions
- Create an environment to the best of your ability where all students can thrive, regardless of personal traits
- Answer student questions and resolve conflicts that arise
- Inform students about career opportunities in STEM
- Gather feedback on the programme to improve upon its future implementation

Programme Rules and Expectations

The programme rules and expectations section explains the main programme rules, and student expectations of the challenge. This section provides a list of the technical aspects of the challenge. This includes key technical aspects such as time or resource constraints and group sizes. The section also contains participant expectations like deliverables and behavioural expectations. Remember, student behaviour and engagement is the most important aspect of this programme. Students who are well-behaved and engaged are far more likely to succeed in the technical aspects. For references to student task expectations, please refer to the student brief manuals for each role and each challenge phase. These guides outline the student objectives in detail, as well as the methods by which they should approach their objectives.

Technical constraints

- Students must be in teams of no more than three students
- Each student must fulfil at least one role on the team, and there may only be one of each role on each team
- Students will have approximately 60 minutes to design their structure, 15 minutes to create and present their bid, and 60 minutes to build their finished deliverables (time constraints are up to ambassador discretion, these are just recommended guidelines)
- Student budgets may not exceed £15 million (financial constraints are up to ambassador discretion, these are just recommended guidelines)

Behavioural expectations

- Students are expected to treat all ambassadors and other participants with respect
- Students are expected to treat all materials with respect
- Students must listen to ambassador instructions and guidance (within reason)
- When conflict arises in a group, students are expected to work collaboratively with their teammates and ambassador in the best interest of the group as a whole

Students who fail to meet technical constraints and deadlines may be met with point deduction at the ambassador's discretion. Students who fail to meet behavioural expectations may face consequences such as point deduction, disqualification, or other penalties at the ambassador's discretion.

Ambassador Expectations and Requirements

Ambassador participation is integral to programme success. As the ambassador, you are expected to abide by all ambassador expectations and requirements in order to ensure that teams can accomplish their tasks efficiently and effectively.

Expectations

- Be on time and prepared to teach each lesson. This includes having necessary materials and reviewing all content beforehand.
- Treat all students with equal respect, regardless of age, sex, gender identity, ethnicity, nationality, and socioeconomic background.
- Utilize additional resources as you see fit. This includes referencing listed supplementary structural engineering literature and gender inclusivity content.
- Adjust content to best suit your needs as an ambassador and the students' needs as participants. This includes editing the introductory PowerPoint or other supplementary content as you see fit, adjusting time constraints for challenge parameters, or reworking group sizes and role expectations as you see fit.
- Utilize survey material for both yourself and participants to evaluate and improve the programme.

In addition to behavioural expectations, all ambassadors are must have a set of technical requirements. These requirements are as follows:

Requirements

- Have basic understanding of the structural engineer, primary architect, and project manager roles in a structural engineering project
- Have a basic understanding of the housing crisis facing the greater London area
- Be able to present and elaborate on supplementary PowerPoint presentation
- Able to address the needs of student teams and work well with other ambassadors
- Understanding of maths trigonometry and budget creation to assist students in their design phases

Ambassador roles throughout the programme

Design phase

Work with your designated group of students to help them accomplish their team and individual tasks. The team tasks for this phase are:

- Identify square footage needed for buildings
- Create building designs

In addition to helping the team as a whole, you will work to help the individual students with their respective roles. The individual tasks for this phase for reach role are:

- Architect
  - Create a floorplan for each floor of the building/buildings
- Project Manager
  - Create a timetable and budget for the construction
- Structural Engineer
  - Create a structural design for the building or buildings

Bid phase

Approve or critique your team's design. As a team, the students need to

- Create a poster and presentation for their project design

Ask them to explain their design approach and reasoning behind their design. Ask them to explain what worked and what they could have improved. In particular, each student must

- Architect
  - Explain their floorplan and why they chose that design
- Project manager
  - Explain their budget and how they created their timetable
- Structural Engineer
  - Explain their structural design and why they chose their materials

Build Phase

In this phase, students will be constructing models of their designs using available materials. Students do not have individual roles in this portion of the challenge. Rather, they need to demonstrate strong team dynamics by working together to create their final product. Your primary role in this portion of the challenge is to aide students in

their structure creation by helping them to appropriately measure and cut their materials, as well as offer advice when needed. Students do not need to build their models to perfect scale, but should rather focus on constructing models that reflect their building design and characteristics (shape, building materials, and creative aspects).

Design Phase

In the design phase, you will primarily work to assist students throughout the design of their building structure, materials, budget, and timeline. You will work both individually with students in specific roles, as well as with teams as a whole, to ensure that teams can accomplish their goals on time and effectively. Below is a chart listing both individual role and team objectives for the design phase.

Architect	Structural Engineer	Project Manager	Team
Design Building Aesthetics	Work with materials	Create building timeline	Create poster deliverable
Design Floorplan	Develop superstructure design	Create budget	Present bid

While the students have individual tasks that they must perform, they will work with each other to accomplish both their individual tasks and their team objectives. The next page includes a complete timeline of how each team should be progressing through their challenge. For example, while the project manager works with the architect to develop a building(s) design, the structural engineer will be working with structural materials to identify the properties of each one. Then, the structural engineer will work with the project manager to create a budget based on the design of the building(s) that the architect created using the material the structural engineer identified. Meanwhile, the architect will develop the individual floorplans for each floor of the building(s). For a comprehensive breakdown of each objective, refer to the student manuals for each respective role.

<table>
<tr><th colspan="7">Ambassador Programme</th></tr>
<tr><th rowspan="2">Roles</th><th colspan="4">Design Phase</th><th colspan="2">Bid</th><th>Build Phase</th></tr>
<tr><th>Concepts</th><th>Decision</th><th colspan="2">Development</th><th>Analyse</th><th>Combine</th><th>Present</th><th>Construct</th></tr>
<tr><td>Architect</td><td rowspan="3">Design structure based on land plot</td><td rowspan="3">Share the concepts and decide on one</td><td>Design room plans</td><td>Design floor plan</td><td>Finalise floor plan</td><td rowspan="3">Combine their work in one presentation and create team goal statement</td><td rowspan="3">Present to ambassador</td><td rowspan="3">Build model based on building design</td></tr>
<tr><td>Project Manager</td><td>Design timetable</td><td rowspan="2">Create budget</td><td>Finalise budget
Finalise timetable</td></tr>
<tr><td>Structural Engineer</td><td>Determine structure materials</td><td>Finalise structure</td></tr>
</table>

Conflict Resolution

As the ambassador, you will be tasked with helping the students resolve conflicts that they may encounter throughout the programme. Below are some common conflicts that students and teams face, and advice for how to address those conflicts should they arise.

Common Conflicts

Conflict: Two students in a team have a conflict over which role they prefer
Resolution: Work with the students and the other group members to find a role choice that best suits each student. If a compromise between role assignments cannot be found, potentially exchange role objectives between the two conflicting members (e.g. the architect may swap their building exterior design with the project manager's timetable design in order to find compromise between the two students)

Conflict: One student in a team is not engaged in meeting their objectives causing other team members to cover the extra work.
Resolution: Work with the student to identify why they do not want to do their portion of the work (uninterested, apathetic, bored, etc.) and find a way to reengage the student. For example, if the architect does not want to design the façade of their building for the structural engineer, offer suggestions to the student or work with them to make a more creative design.

Conflict: Students are struggling at a certain point in their challenge, or do not know how to get started with an objective.
Resolution: Help the students identify what aspect of the challenge confuses them and help them to find a direction on their own. Try to avoid giving them the answer and instead offer them hints as stepping stones.

For all of the conflict that you face, use your best judgment and common sense to resolve the problem. No two students are alike, and thus no conflict will have a

definitive best solution. Remember that a frustrated student leads to a disengaged team. Try to see the conflict through the student's perspective and do your best to involve the student in the programme.

Discussion Questions

What worked well for your team during the design, bid, and build stages of the programme?

What did your team struggle with during the design, bid, and build stages of the programme?

What new things have you learned about engineering?

Why did your team choose to build the structure(s) the way you did?

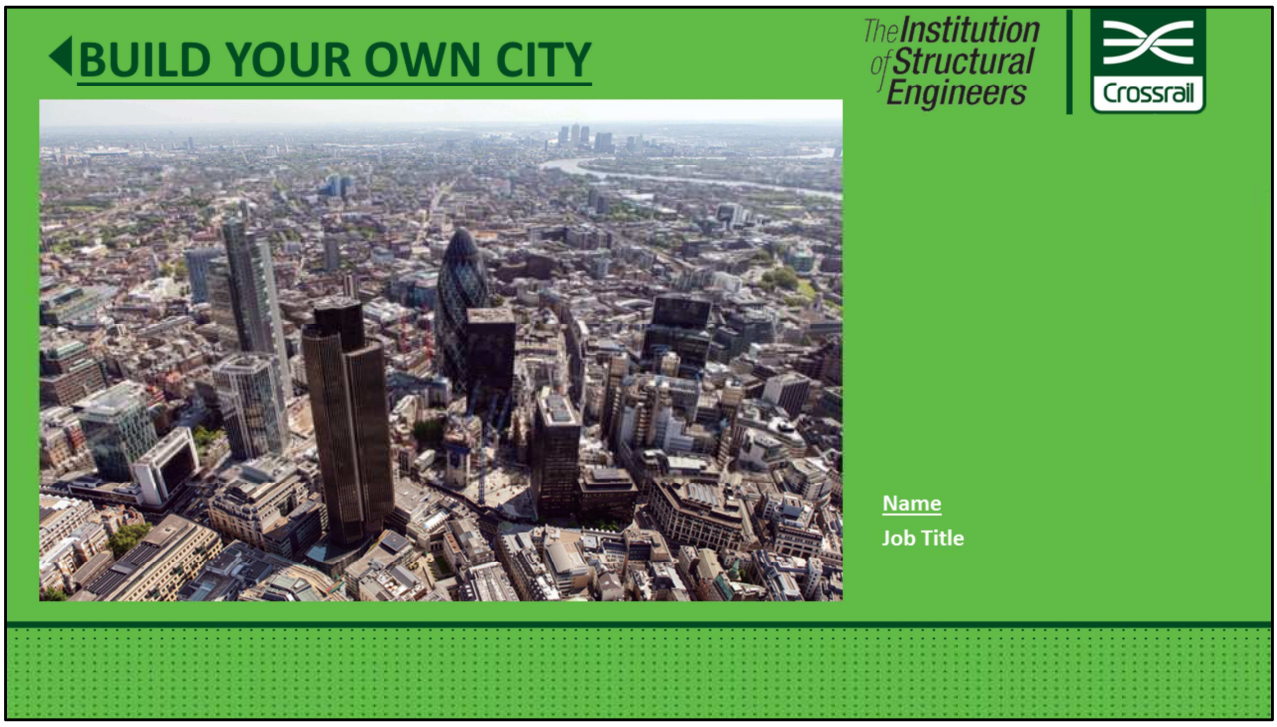
Can you see any relationships between the challenges and your schoolwork?

What did you particularly like about the programme?

What did you particularly dislike about the programme?

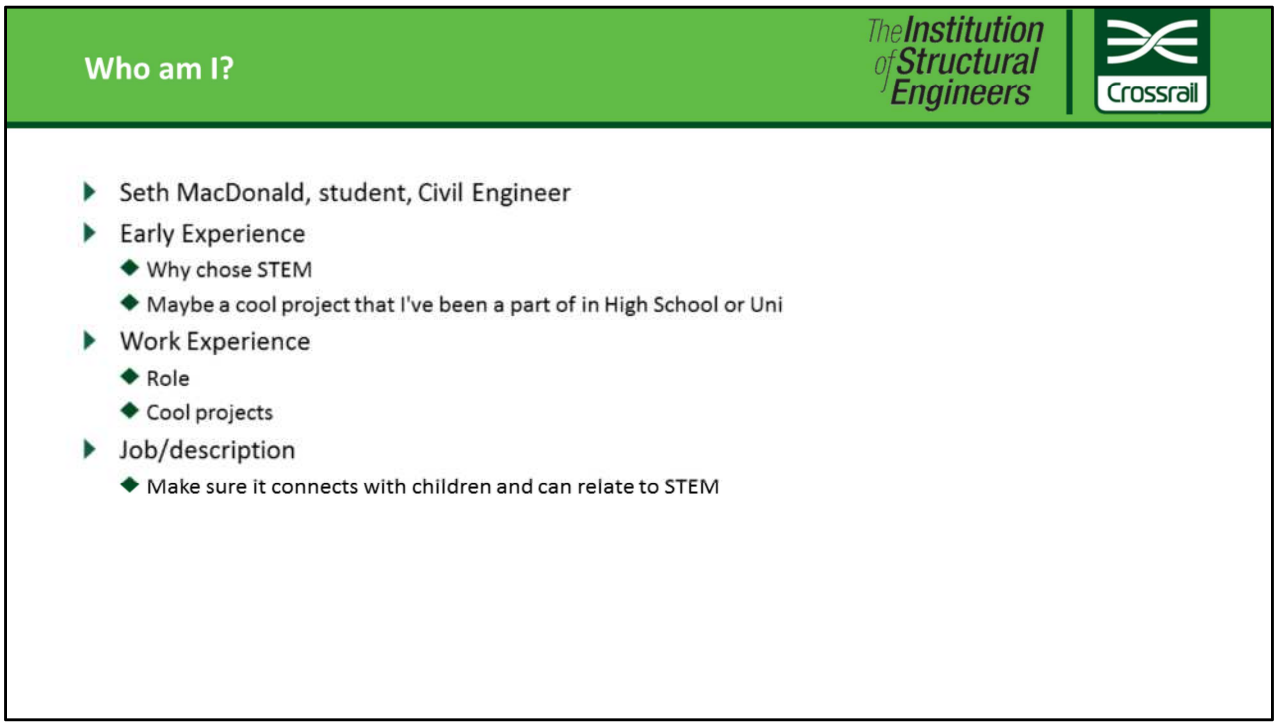
What aspects of the programme were the most challenging?

What aspects of the programme were the easiest?



Complete your name and job title

"Hello and welcome, my name is [*enter name*] and today I'm here to lead a hands-on challenge and talk about engineering. Today we're going to be talking about construction and all of the different roles that work together to organise a huge project like this."



Customise this slide to fit your personal details

Your introduction and profession

What is your job title?

What do you do for work/who do you work with?

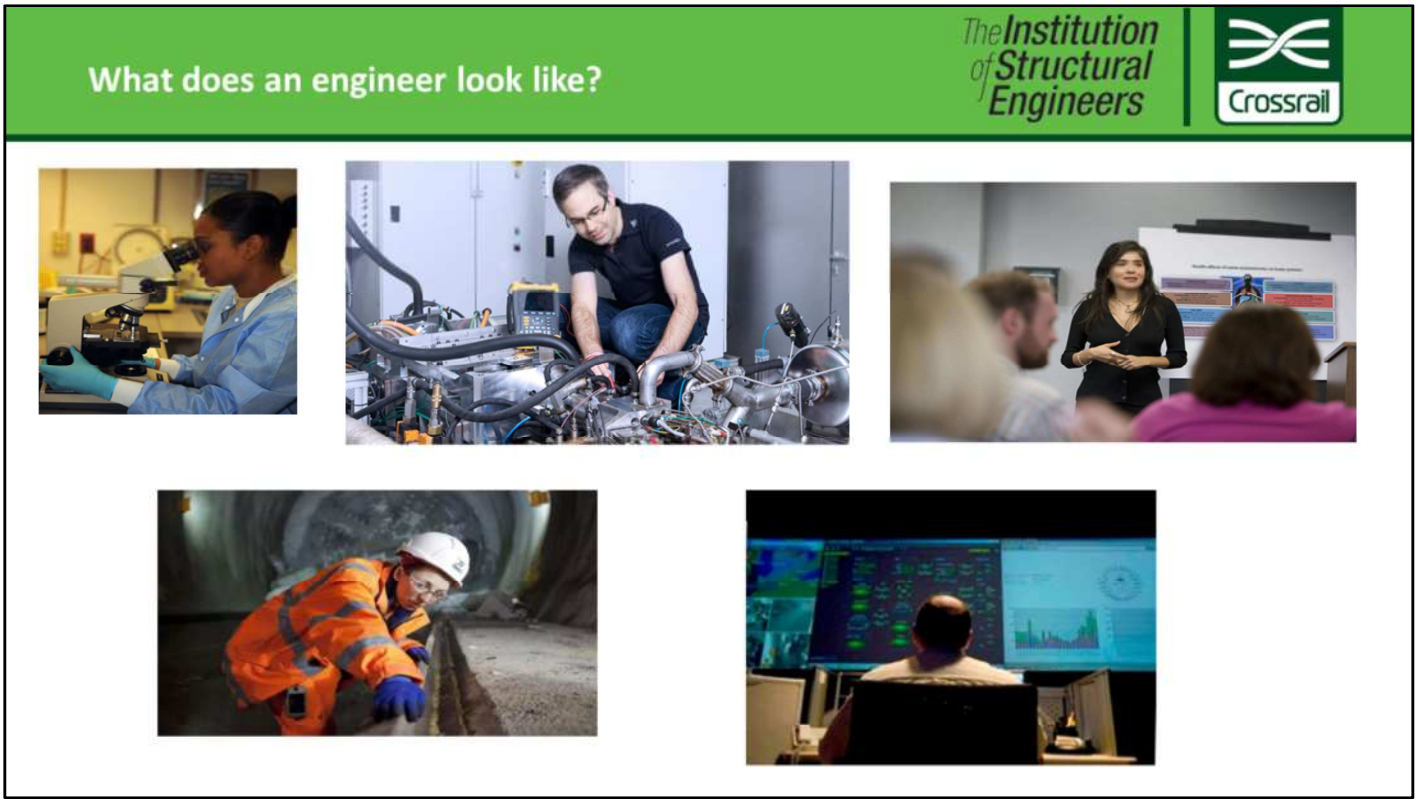
What is your educational and professional background?

You are a real person, just like them! Share a challenge you've overcome to get where you are now or ask them if they share any of your favorite hobbies

Position: "I work for Crossrail as a Student Consultant in the Young Crossrail Programme helping to create new activities for students, like you."

<u>Education/Job Experience</u>: “I’m a current student from the United States. I’m studying Civil Engineering. My job experience includes summer work at a small company near home making 3D computer models of buildings.”

This slide has many objectives. Some of them may stand out to you as more important than others. Remember that you have a strict time constrain; try to include as much information as you can, but mind the time limit.



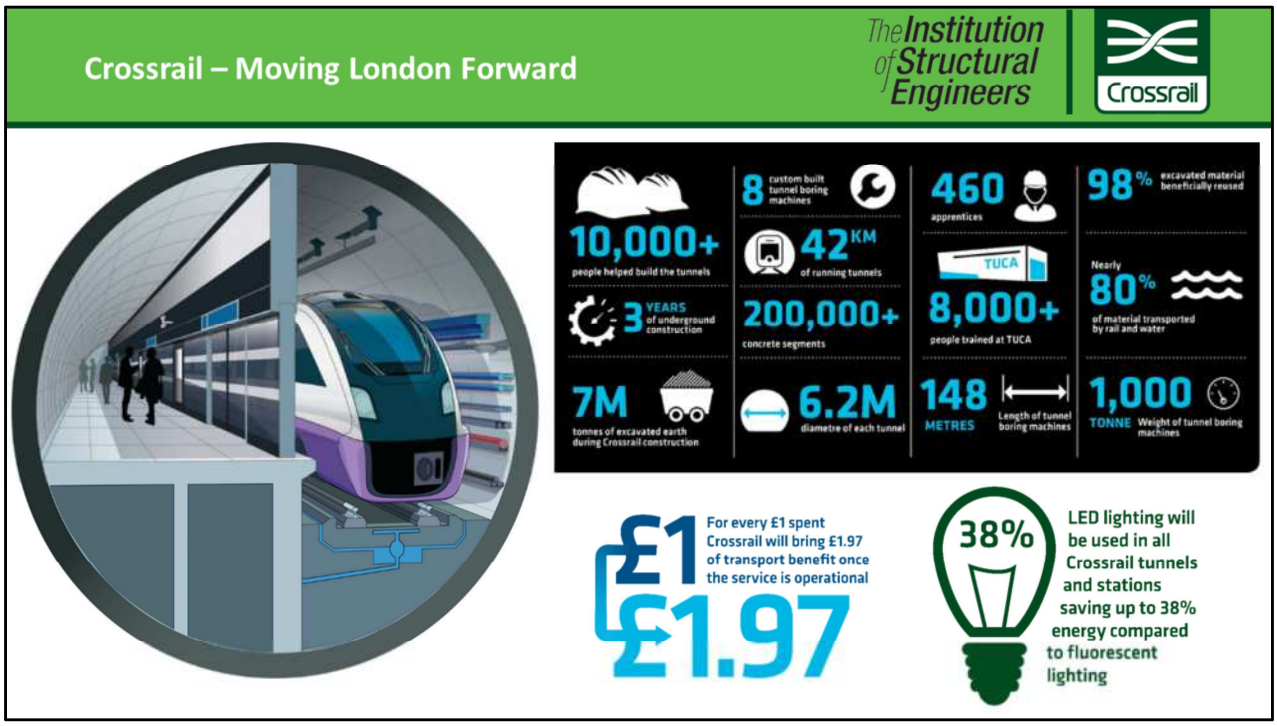
To begin this slide, you might ask the students the prompting question at the top, **"What does an engineer look like?"**
Give some time for the students to answer and encourage a discussion.
If the students are reluctant to answer at first, you might ask some questions about the appearance of engineers
(e.g. What do they dress like when they go to work? Are they old, or young?, etc.)

After you are satisfied with the discussion, or the student starts to become disengaged, **flip through each photo individually asking, "Is this an engineer?"**
All of the photos are of engineers in some form or another; remember to have the students come up with the answers on their own.
You may even poll the students by a show of their hands for either believing the person is an engineer or not an engineer.

The photos above flip in this order:

Yes, this woman is a biomedical engineer; she could be working on a cure for cancer!
Yes, this man is an operations engineer; he is making sure that his data center is operating at it's highest potential!
Yes, this woman is an engineer, too; she is leading a meeting of her peers!
Yes, this man is an transport engineer; he is designing a generator to produce electricity for electric cars!

Sorry! Trick question, this woman is an engineering apprentice; working her way to becoming an engineer!

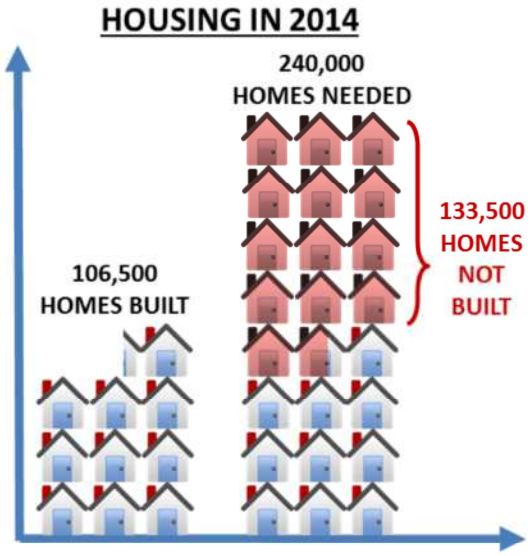


"One example of what engineers can accomplish while working together is the Crossrail project. Crossrail is delivering a new railway for London and the Southeast that will we called the Elizabeth line when it's finished in 2018. The Elizabeth line will bring 1.5 million more people into the city each day. Most notably, the Crossrail project bored 42 kilometers (26 miles) of new tunnels through central London to make this new Elizabeth line possible! The engineers at Crossrail have even thought about sustainability: LED lighting in stations will save energy costs and for every pound spent, the economic benefit of the project will bring in almost double that cost in new business totaling 43 billion pounds! It's amazing what engineers can do when they work together."

Housing Crisis

The Institution of Structural Engineers | Crossrail

- Populations are growing, more affordable homes are needed
- On average, house prices are now almost seven times people's incomes.
- 28,900 homes were repossessed across the UK in 2013
- There are now more than nine million renters in private rented accommodation, including almost 1.3 million families with children.
- The number of homeless households has risen to more than 50,000 a year.



"Crossrail are working hard to relieve the pressure of an overcrowded city by improving transport. They even have community relations officers working around the clock to help accommodate residents who have had to be moved from their homes to build Crossrail. Crossrail have made huge steps to make London less crowed, but more work needs to be done for affordable housing!…"

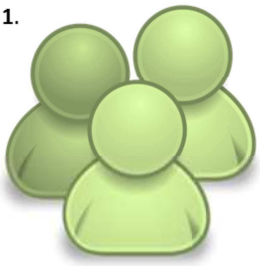
"London is facing a crisis of a growing population with not enough affordable homes to house this influx of citizens. Housing is increasingly difficult for young people and families to afford, we need to find a better way to house these families."

"One problem that engineers could help solve by working together is the housing crisis in London; in fact, this is the problem that all of you will be attempting to solve today!"

BUILD YOUR OWN CITY

- **GOAL |** Design a housing solution for 200 people – 20 families of three, 20 families of five, and 40 individuals
  - **TASKS | 1.** Split into groups of three
    2. Decide who is going to be the Architect, Project Manager, and Structural Engineer
    3. Decide as a team which location you are going to build your house(s)

1.



2.

3.

"The goal of today's challenge is to design housing for 200 people – 20 families of three, 20 families of five, and 40 individuals**. Please split into groups of three.** We will work through the second two tasks together."

Architects

KHALIDA AHMED – ARCHITECT

http://www.stephenlawrence.org.uk/case-studies/khalida-ahmed

"I am passionate about residential architecture because when designing a home you are thinking about the family who are going to live there for the next 50 years and that personal consideration with the building is what is important to me."

ASHER BOURNE – ARCHITECT

http://www.stephenlawrence.org.uk/case-studies/asher-bourne

"I wanted to study architecture to ensure my creative output has a direct effect on people, to help them in their everyday lives… I wish to see more of the world and experience the amazing architecture dotted around the globe. I want to work in a practice that makes a difference, one with an informed view of the world and an ambition to improve it."

To help you all pick your roles, we have curated a few case studies for each profession

"Khalida and Asher are two examples of Architects; read what they have to say about why they choose that profession."

Project Managers

The Institution of Structural Engineers

Crossrail

ANDY ALDER – CROSSRAIL PROJECT MANAGER FOR WESTERN TUNNELS

Andy Alder wants to change the world; one engineering project at a time. The 6'4" rugby player and kayaker was destined for building big tunnels.

LINDA MILLER - PROJECT MANAGER, CONNAUGHT TUNNEL

With a CV that boasts serving as a paratrooper and helicopter pilot in the US army, an engineer on a new Cape Canaveral launch complex and now working as Project Manager on the Crossrail project; Linda has been there, done it and probably made the t-shirt along the way.

"Andy and Linda are both Crossrail Project Mangers; read about their careers!"

Structural Engineers

The Institution of Structural Engineers

Crossrail

ALEX MITCHELL – SITE ENGINEER, CONNAUGHT TUNNEL

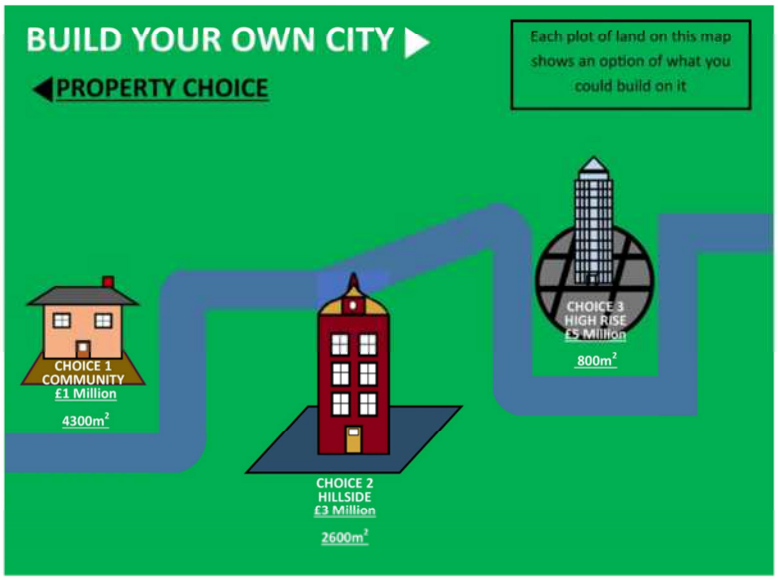
Fresh out of university, Alex, landed her dream job on Crossrail's Connaught Tunnel.

DAVID WILDE AND PAUL OSBORNE – CONNAUGHT TUNNEL

With a background in structural design the prospect of working as part of a project to revitalise a 150 year old Victorian-built tunnel on the Crossrail route was one too good to pass up.

"Alex, David and Paul are all structural engineers for Crossrail; read about their careers!"

MAP



"Your team will choose one location on this map to design your housing on; think carefully about cost. If you want your housing to be affordable, the more the land costs, the less you can spend on the building itself."

This is when you will hand out the team design brief…

Team Design Brief

Your team will be working together to create a housing development to give 200 people homes in your new city! You will use the following guidelines to design a building or multiple buildings to house 200 people on your site.

These 200 people comprise 20 families of five people, 20 families of three people, and 40 individuals.

If you have chosen the **city site**, you will be designing one multi-level housing complex with a variety of flats on each floor to accommodate the needs of the residents. The building footprint for this site is 800 m^2.

If you have chosen the **hillside site**, you will be designing two or more multi-level buildings (no higher than four floors) with a mix of flats on each floor to accommodate the needs of the residents. The building footprint for this site is 2600 m^2.

If you have chosen the **community site**, you will be designing about a dozen two level buildings to house families. The largest footprint for these buildings must be less than 210 m^2 and the total building footprint for the site is 4300 m^2.
Your first objective as a team is to design a building exterior. Your building or buildings can be a variety of shapes, from simple cubes to hexagons to circular. Use your creativity to create a design that works best for your team.

After you've determined the rough shape of the building, you need to determine about how much floor space your occupants will need to live in 1 person, 2 person, family of 3, or family of 5 living spaces. The guidelines below will allow you to determine the necessary space of each of these combinations.

Each home/flat will follow these guidelines for space:
Living room - 20 m^2
Large bedroom (maybe for 2 children) - 15 m^2
Bedroom - 10 m^2
Kitchen - 12 m^2
Bathroom - 10 m^2
Extra space/hallway - 10 m^2

For example:

1 x Living room - 20 m^2
1 x Large bedroom - 15 m^2
2 x Bedroom - 2 x 10 m^2

1 x Kitchen - 12 m^2

1 x Bathroom - 10 m^2

1 x Extra space/hallway - 10 m^2

Total = 87 m^2 for a home for a family of three

After you've decided how large each home will be (single, family of three, family of five), you will need to decide how big the buildings you will build will be and exactly how many floors there will be.

Remember, not every floor needs to have the same layout, and not every building needs to take up the same square footing. Houses that will house a family of 5 will have more common areas than houses with 2 individuals and family of 3, so plan your buildings accordingly.

For example –

10 families of three x 100 m^2
10 families of five x 150 m^2
+ 20 individuals x 50 m^2
= 3,500 m^2 of total living space

CITY: If my land plot is **450 m^2**, I divide:
(3500 m^2/450 m^2) = 7.8 floors so **I need 8 floors**

HILSIDE: If my land plot is **2000 m^2**, I divide:
(3500 m^2/2000 m^2) = 1.75 floors so I need 2 floors

Since I have plenty of room for my buildings, I will design my buildings to have gardens. I need to have **at least 2 buildings;** if I pick my footprints to be 500 m^2 each, then the total footprint for both buildings is 500 m^2 + 500 m^2 = 1000 m^2 and 3500 m^2/1000 m^2 = 3.5 floors, which means **4 floors in each building**.

COMMUNITY: If my land plot is 4000 m^2, I have more space than I need! If the **largest footprint is 200 m^2 and each house must be 2 floors**, then I can put one family of five and one individual on the first floor (150 m^2 + 50 m^2 = 200 m^2) and two individuals (2x50 m^2 = 100 m^2) and one family of three on the second floor (100 m^2 + 100 m^2 = 200 m^2). This means that, if each house has two floors of 200 m^2, then each house has a total footprint of 400 m^2. If 3500 m^2/400 m^2 = 8.75, that means **I need 9 houses** to accommodate all my residents. Remember to **account for a street** to access each house.

After the number of homes and floors in each of these homes is decided, it's time to read your individual briefs and get started!

Architect's Design Brief

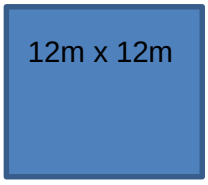
As the architect, you are your project's primary designer. Your role is to design a floor plan and exterior structure for your structural engineer and project manager. While cost is not your primary concern, remember that it does play a role in what your structural engineer and project manager can accomplish.

Your objective for this phase of the programme is to:

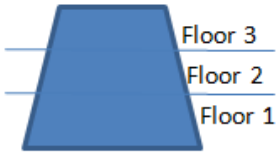
- Determine the floorplans for your building or buildings

Use the building designs that your team developed to identify how many people you will fit on each floor, and create a floorplan for each floor that will fit the design of your building. For example, if the footprint of your building is 12 by 12 meters (144m^2), then use that blank space as a template for constructing your floor layout.

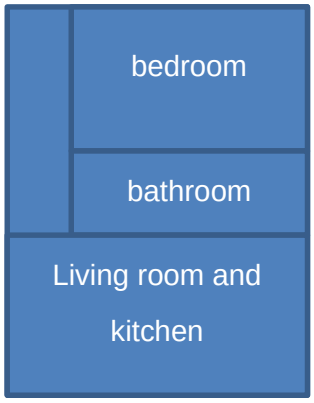
Footprint:



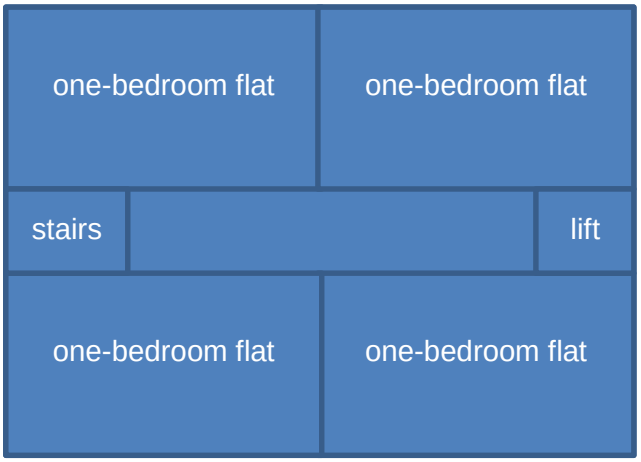
Remember that buildings with slopes and irregular shapes will have different footprints on different floors
If you have trouble utilising maths to calculate these differences, turn to your ambassador for help.
One very simple set of presentation deliverables may look like the example below.
Exterior design:



One bedroom flat:



Floor 1 floorplan



Remember to take creative approaches! Do you have extra space for an outdoor garden? Do you want to use communal bathrooms on smaller floors to maximize space? Ask your ambassador if you have any questions about different creative approaches

Good luck!

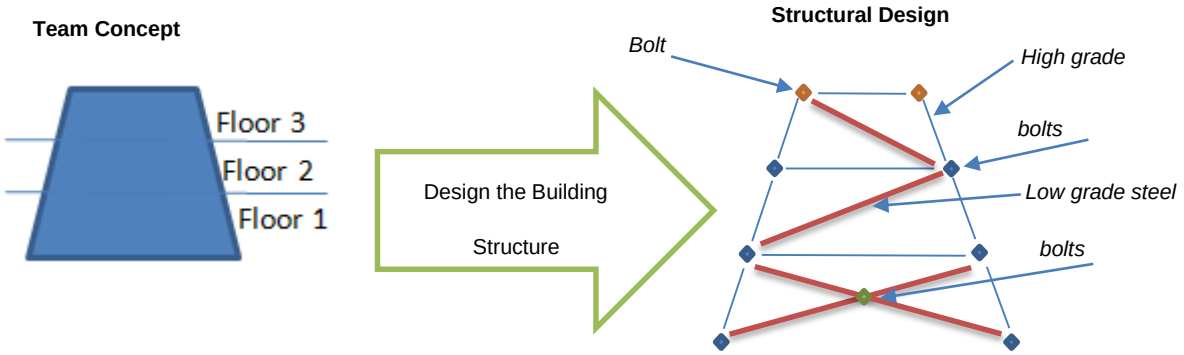
Structural Engineer Design Brief

As the Structural Engineer, you are your project's primary engineer. Your role is to choose structurally stable but cheap materials and design the building structure. While creating a budget is not your primary concern. Your objectives for this phase of the programme are to:

- Design the structure of your building or buildings with the given materials
- Work with project manager to create budget

Create structural design

In this phase of the programme, you will use the allotted materials and your team's building designs to create a structural design for your building. Below is a basic example of the concept translated into a structural design.



Remember that you can use multiple materials in your building design (e.g. high grade structural steel for main support beams and low grade steel for supports). Also, remember that you will need to account for how joints will be attached in your design. The above design illustrates a simple structural design for the accompanied sample team concept. The high grade structural steel supports the exterior and floors of the building, while the low grade steel and bolts act as supporting structures.

Here is a list of building restrictions to keep in mind during your building structural design:

- Low grade steel cannot be used as a main support beam
- Structural wood cannot be used on buildings taller than 2 stories
- Brick cannot be used on buildings larger than 4 stories
- If attaching two walls of structural wood, 10 nails must be placed for each meter of attachment (e.g. if the walls are 2 meters high, 20 nails must be used to attach them)
- Wood glue may only be used to attach roofs to structural wood framed buildings

- 1 bolt must be used to attach two pieces of high or low grade structural steel. 1 additional bolt must be added for each piece of steel beyond the first two

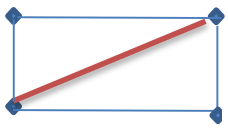
Use these guidelines and your list of materials to create your structural designs. Keep track of all materials you use. If you need any help with the maths for your structural design, remember to ask your ambassador for help.

After designing your structural design, work with your project manager to develop a budget for the building. While you do not need to keep track of your cost, keep track of the materials you use and how much. A basic example of a spreadsheet can be seen below.

Material	Amount
High grade steel	100m
Low grade steel	20m
Bolts	5

Give your list of materials to your project manager so that they can calculate the final budget. Finally, keep in mind the dimensions with which you are building. Each story is roughly 3 meters high. Also, if you choose to build side supports, remember to calculate their distances using trigonometry.

Example of Trigonometry



$3^2+10^2=109$

$\sqrt{109}=10.4$

10.4 is the length of the support beam

If you need help with any of the maths, remember to ask an ambassador for help!

Good luck!

Manager's Design Brief

As the project manager, you are the project's primary manager. Your role is to create a construction timetable and budget for your team's project. Your objectives for this phase of the programme are to:

- Create a timetable for your construction project
- Create a budget for your structural engineer's design

Develop a timetable

Now that you have created your building design with your team, your individual task is to construct a timetable for how you will build your structure. Your timetable will include the estimated time needed for the foundation, building skeletons, roofing, interior walls, flooring, electrical, plumbing, and heating and air conditioning. Below is a basic timetable sample to give you an idea for how to create your own.

	Day 1	Day 2	Day 3	Day 4	Day 5`	Day 6	Day 7	Day 8	Day 9	Day 10
Task 1										
Task 2										
Task 3										
Task 4										

Below is a complete list of the challenges you will need to address with the allotted time needed to complete them and associated restrictions.

Task	Time Needed to Complete	Other Restrictions
Foundation	20 Days	None
Skeleton	40 Days	After foundation Workers get 5 day rest for every 10 days of work
Roof	5 Days	After skeleton
Interior Walls	10 Days	After heating and air conditioning and plumbing
Flooring	40 Days	After heating and air conditioning and plumbing

Electrical	30 Days	After roofing 5 Days of inspection every 10 days of work
Plumbing	10 Days	None
Heating and Air Conditioning	20 Days	Cannot be installed when Electrical is being worked on

If you have any questions or concerns during your timetable design, remember to ask your ambassadors for help.

Create a budget

In this phase of the programme, you will work with the structural engineer to create a budget for your model. Remember, the structural engineer is the primary constructor, and your job is to offer financial advice and create a budget based on their plans. Remember to include both the total costs and total quantities of each of your materials in your budget. This is a basic example of a budget sheet.

Material (Cost)	Quantity	Total Cost for Material
High grade steel (£45/m)	10m	£450
Low grade steel (£30/m)	5m	£150
Steel roof (£5/m^2)	10m^2	£50
Total Cost for All		£650

When developing your budget, be conscious about how you choose to spend your money. Points will be awarded for good budgeting and aesthetics, so work with your structural engineer and architect to maximize appearance while minimizing costs. If you have any questions about how your budget is being created, ask your ambassador for help.

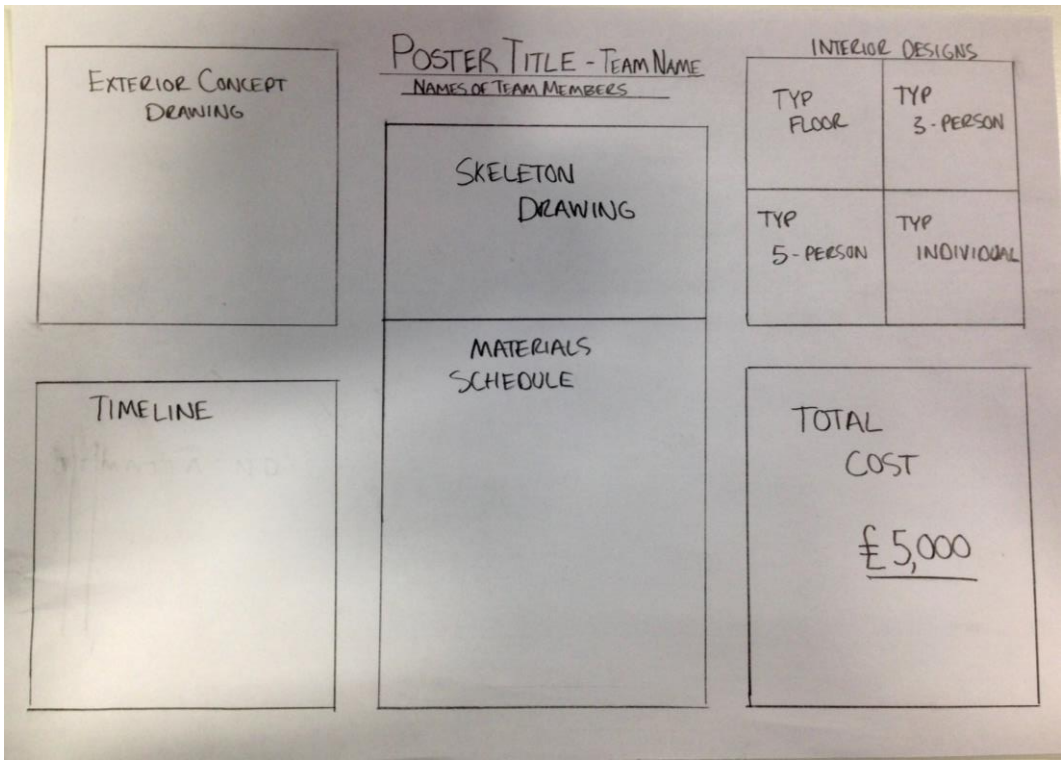
Good luck!

Team Bid Brief

In this phase of the challenge, your team will be working together to **create a poster and a presentation** to explain your design product. Your team will have **45 minutes** to complete these tasks before the presentation begins! Each team member has already finished his/her deliverable(s) for this presentation, but you must work together as a team to arrange your ideas on a poster and practice how you will present your ideas. You should **first plan how you will use the space on the poster**, fitting each of the following things on your poster, organized by each team member's deliverables:

Architect	Exterior concept drawing
	Interior floor plans (typical floor, typical five person flat, typical three person flat, typical individual flat)
Structural Engineer	Skeleton drawing
	Materials schedule
Project Manager	Timeline
	Total cost

Before you begin to cut and paste your individual parts onto this poster, it might be a good idea to do a concept drawing, like the one below, which shows the **poster layout** before you develop it:



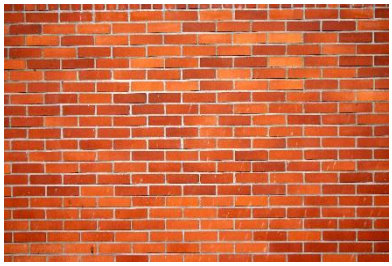
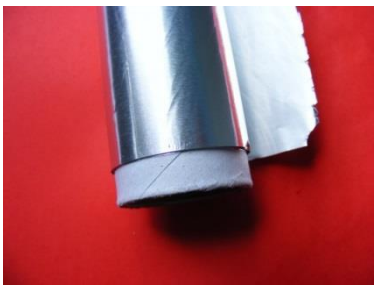
After you have finished the poster based on your original layout, you need to decide how you will explain the components of your poster. During your presentation, you will need to take your ambassador through **how and why each of you made the decisions that you did** when designing your building. Try to explain your design as specifically as you can while still remaining brief!

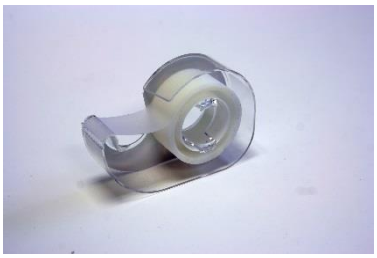
Good Luck!

Team Build Brief

In this phase of the challenge, your team will be working together to **physically build a model** of your housing complex! You will be given **an hour and a half to complete** this task. Try your best to use the materials listed below and build your model based on your structural engineer's design. You will be given enough materials to complete your model, but remember that things may change!

Actual material	Model material	Characteristics
High grade Steel – £45/m 	Art Straws 	• Strong and very structurally stable • Great for creating building skeletons • Can support glass walls and roofs well
Low grade Steel – £30/m 	Drinking straws 	• Great for secondary support • Not strong enough to hold skeleton on own • Great for support between stories

Structural Wood - £30/m^2 	Lolly sticks 	• Inexpensive, great for use in large quantities • Not strong enough to support several stories • Needs gypsum board for finish
Brick Wall - £50/m^2 	Cardboard 	• More expensive than wood • Better for medium sized buildings • Does not need gypsum board for finish
Steel roof/wall- £5/m^2 	Aluminium foil 	• Works well with larger buildings
Gypsum board - £2/m^2 	Paper 	• Finish for structural wood

Steel bolts - £5 each 	Pipe cleaners 	• Holds joints of structural steel together • Need one bolt to attach two pieces of steel • Need additional bolt for each piece of steel
Nails - £5 for 100 		• Holds wood together • Less expensive than bolts • Need 10 nails per meter of wood
Wood glue - £1 per bottle 	Glue 	• Can only be used to attach walls and roofs • One bottle per use

Good Luck!

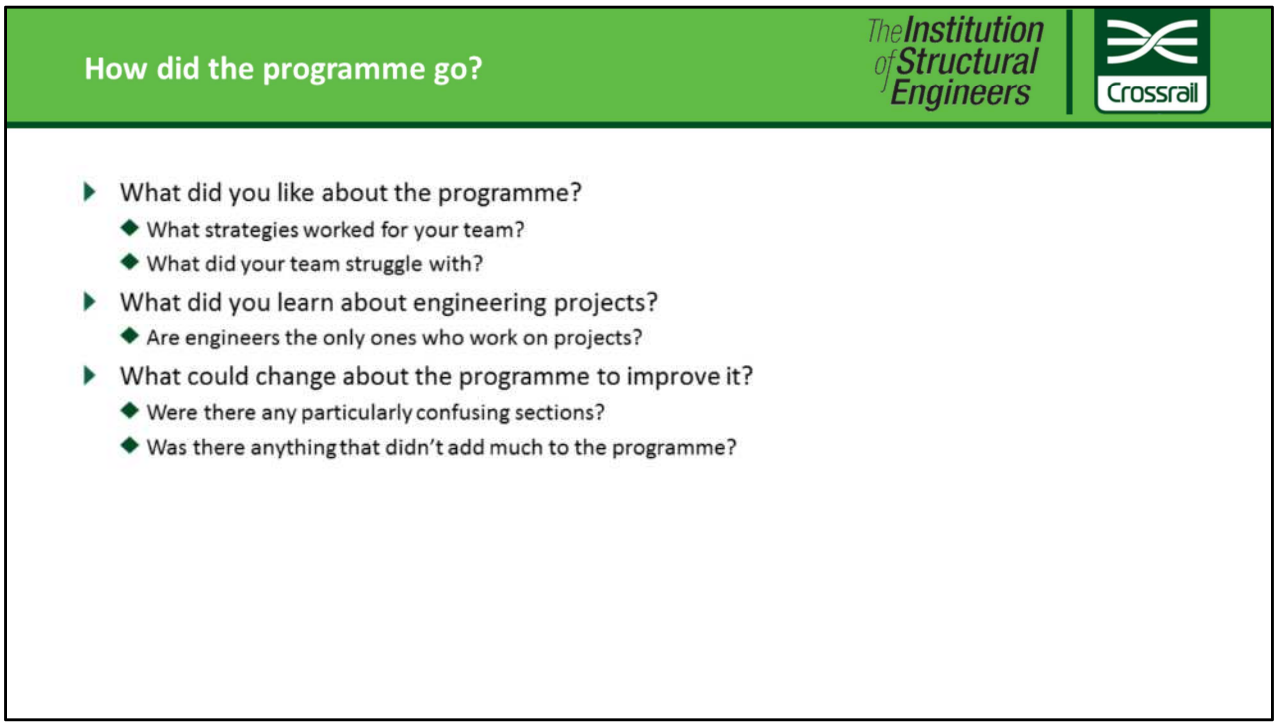
CLOSING DISCUSSION

The Institution of Structural Engineers

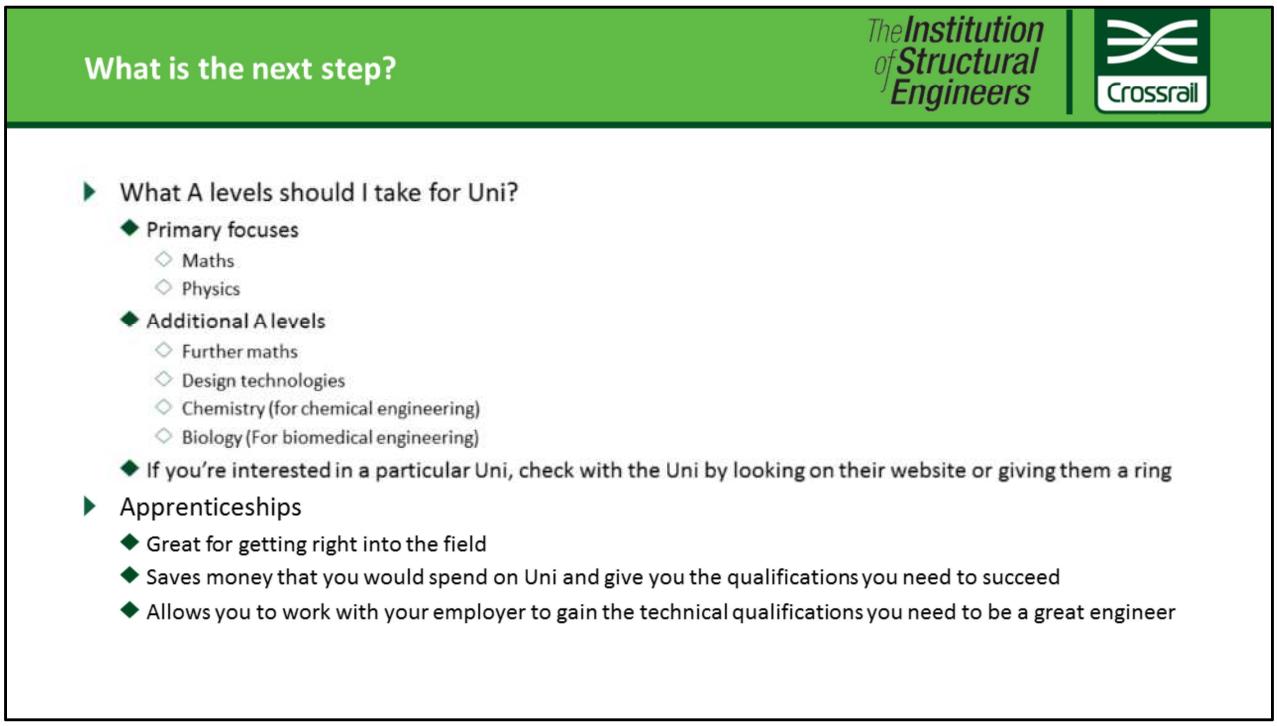
Crossrail

Name

Job Title



For this slide, keep the conversation discussion based. You don't need to stick to a script, and you can remove or add questions based on how you chose to facilitate the programme. Just be sure to keep the conversation constructive and engage the students as much as possible.



Use this as a discussion tool for introducing participants into the two different paths. Since they are Key Stage 4 students, they are looking at the A levels that they should be taking. Quickly review the above A levels and tell them why they are important.

Maths and physics are important because they form the foundation for many engineering programmes. Even non-engineers focus on these aspects (e.g. the project manager has to use maths to balance a budget and an architect has to have an idea of physics to ensure that buildings are structurally stable in design).

Talk about which A levels you took and how they helped you in Uni as well, and make sure to mention specific A levels if you are involved in a particular kind of engineering that required specific A levels (e.g. biomedical engineers should take biology)

For apprenticeships, make sure you stress that it is an alternative route and not an easier route or a route for students who are not “achievers.” Some people hold perceptions that you should go to Uni to be successful, and apprenticeships are the exact opposite of that. They are for engineers who PREFER hands-on approaches to academic settings, and have several benefits that Universities do not offer. Apprenticeships are just as valid as Universities for successful engineering careers.

Any questions for us?

- What did we do to get into the field?
- What motivated us to get into STEM?
- Any other questions?

Thank you for participating!

Open the floor for questions. Not all groups will have questions, and that's okay. Use this time to field the group of participants for any inquires they may have, and thank them for their participation at the conclusion of this session.