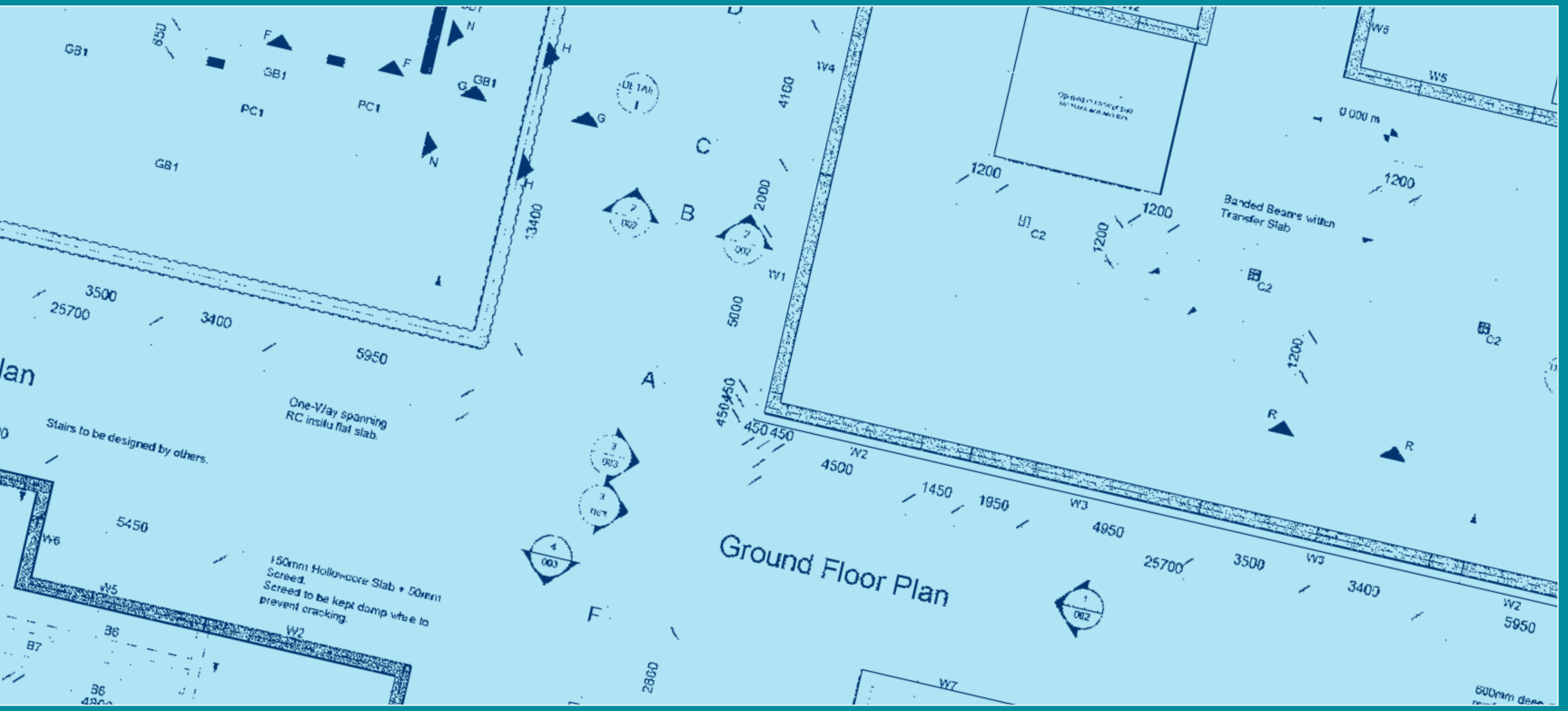
Structural Concrete 2027



The Concrete Centre Student Structural Competition

Contents

mpa The Concrete Centre

The Concrete Centre provides material, design and construction guidance. Its aim is to enable all those involved in the design, use and performance of concrete to realise the potential of the material as a long lasting and sustainable choice. The Concrete Centre provides published guidance, seminars, courses, online resources and industry research to the design and academic communities. For more information on The Concrete Centre visit **www.concretecentre.com**.

The Concrete Centre is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries.

CARES

CARES is the leading independent international constructional steels product certification body delivering confidence in the performance, provenance and quality of safety-critical reinforcement products entering the construction supply chain. With a proud track record of providing assurance to users, designers, consultants and specifiers spanning four decades, CARES' data-led inspection and certification services provide valuable transparency into the provenance and sustainability characteristics of constructional steels moving across complex global supply chains.

Clients and specifiers can specify CARES-approved reinforcement suppliers with confidence that the product will comply with the relevant product standard without the need for costly, on-site testing.

For further information please go to the CARES website:
www.carescertification.com

1. Introduction

Structural Concrete 2027 sets a demanding challenge for all students studying structural design as part of UK University BEng, MEng and MSc degree courses in Civil and/or Structural Engineering.

This demanding student design competition aims to encourage interest and raise competence in designing with concrete. The competition offers a stimulating and fun challenge to students, while supporting the curricula of civil and structural engineering departments of UK universities. The main benefit for a student is in being able to present their work to prospective employers, some of whom are involved in setting and judging the competition. The national winners will be presented with their prizes at an event in London where their award winning entries will be shown. There will also be a sustainability award for the student who demonstrates the best understanding of this subject in their submission.

These awards reflect a significant commitment from the judges who, together with The Concrete Centre, have carefully developed this year's competition. Initiative, creativity, aesthetic appreciation and accuracy are called for, and will be assessed by the judges. Above all, this competition has been designed to stretch the technical competence of the students taking part.

Because it is so flexible, Structural Concrete 2027 can easily be incorporated into existing university curricula, with content that reflects an independent project, a group project or a module assessment run over the first, second or both semesters of the academic year.

DOWNLOAD ENTRY FORM

This year's challenge…

The 2027 project is to design a laboratory building which is to be built on a prominent site on the outskirts of a large UK town. The client, a company engaged in research, development and production of advanced materials for the construction industry, has commissioned an initial structural design from a firm of consulting engineers. Entrants must respond as if they are part of the consultant's team.

2. Project brief: TriCA Laboratories

Our client TriCA requires a new laboratory facility. In addition to the main laboratory and office space, the building is to include a reception and display area, seminar and meeting rooms, and an atrium space for staff recreation and canteen facilities. TriCA has commissioned an initial structural design from a firm of consulting engineers. You are to be the engineer involved.

TriCA is a company which specialises in the development and manufacture of advanced technology materials for the construction industry. Due to the continuing success of the company, a new laboratory facility is to be constructed. In addition to the main laboratory and office space, the building is to include a reception and display area, seminar and meeting rooms, and an atrium space for staff recreation and canteen facilities. TriCA, as client, has commissioned an initial structural design from a firm of consulting engineers. You are to be the engineer involved.

The new building is to be hexagonal in plan and situated on a prominent site at the junction between two highways on the outskirts of a large UK town as shown in **Figure 1**. The building will have a high visibility to traffic approaching from the north, and the client wishes the building to convey the identity of the company, and its current success, to those passing.

The building is to be constructed over an existing brick culvert 4.0m wide and 2.0m deep, passing through the middle of the site. The invert to the culvert is at a depth of 1.8m. The culvert was constructed over 75 years ago. A survey has found the brick construction to be in good condition, but no disturbance to soil is to be permitted within 1.0m of the culvert, i.e. within a zone 6.0m wide.

The building is to be five storeys in height and hexagonal in plan, with a full height central atrium, as shown in **Figure 2**. The ground floor footprint is to be a regular hexagon, see **Figure 3**, which is to have a main entrance, reception and product display area, meeting and seminar rooms, a staff canteen and recreation area within the central atrium together with associated kitchen facilities, and a goods inward/storage area. Levels 2, 3 and 4 comprise laboratory and office space, with office accommodation located towards the north side and laboratory accommodation located towards the south. A typical floor layout is shown in **Figure 4**. The zoning of office and laboratory space is to be flexible, and indeed the desire for flexibility has been a factor in the choice of a hexagonal building footprint. At level 2 and above, floors cantilever out 4.5m above the main entrance. Level 5 will be used for plant, and the floor layout will be similar to that of floors 2, 3 & 4.

Floor to floor height is to be 5.0m for level 1 to 2 as shown in **Figure 2**. A 0.7m deep service zone is to be provided beneath level 2, 3, 4 and 5 floors, and all floors are to have clear headroom of 2.8m. The atrium is to be 15m in diameter, with a minimum 1.7m wide circulation zone around the circumference. Principal access to upper floors is by staircase or feature lift within the central atrium. The staircases are expected to match the profile of the atrium. A service zone containing goods lift, emergency stairs and a services void is to be located along the southern face of the building. The zone will have dimensions of 11m by 2.5m, and may be located anywhere along the 20m wide wall.

External walls are to be fully glazed on the three facades which have a northerly exposure, see **Figure 5**. The remaining three facades with a southern component of exposure will be clad in brick/masonry. A lightweight pitched glazed roof is to be supplied to cover the atrium, and the remainder of the roof is to be flat.

Columns and walls may be located anywhere on the external elevation of the three south facing walls where masonry cladding is to be used. On glazed facades the clear spacing between columns must not be less than 6.0m. Internal columns may be located only a) along lines which radiate from the outside of the circulation zone to the six corners of the building and b) adjacent to the circulation zone around the central atrium. Columns adjacent to the circulation zone may be located either within the 15m diameter of the atrium, or just outside the circulation zone. Shaded areas on **Figure 5** denote permissible locations for internal columns. Note that the circulation zone must maintain a minimum width of 1.7m throughout the full circumference of the atrium.

Delivery access to the kitchen and to the laboratories is to be provided to the south east and south west respectively of the new building. Parking for approximately 30 vehicles is to be available along the southern edge of the site. These areas have a combined area of approximately 900m^2, which will be available to the contractor during the construction period.

The client would welcome proposals from you as the structural engineer for incorporation of design features which demonstrate the capabilities of the ultra high strength and fibre reinforced concretes which the company manufactures. The staircases in the atrium are considered an important design feature which could be exploited for this purpose. In compliance with the requirements of BS 5395-1, the pitch of the staircase is not to exceed 24 degrees slope, and a clear width of 1.2m is required. An intermediate landing 2.0m in length will be required at mid-height of each flight of stairs. The client imposes no constraints on the form of the stairs beyond these dimensions.

More information on concrete staircase construction can be found in Concrete Quarterly 248 (summer 2014), download from **www.concretecentre.com/cq**

3. Design data

Verification of structural viability should be carried out in accordance with current Eurocodes and British Standards. Either the first or second generation Eurocodes may be used, together with their National Annexes. No mixing of first and second generation Eurocodes is permitted. Entrants should clearly state the documents used in support of calculations. Materials specifications should be defined to current standards. Fire resistance of two hours is required.

3.1 Loadings

Dead loads of structural elements: as found.

Cladding: an average value of 2.4kN/m² of elevation for the masonry cladding on the southern section of the building and 1.0kN/m² of elevation for the glazed cladding on the three north facing facades and on the atrium canopy may be taken.

Imposed loadings:

- Flat roof: over roof area 1.5kN/m²
- Plant area, level 5 7.5kN/m²
- Ground floor, level 1 4.0kN/m²
- All other floors, circulation areas, stairs 5.0kN/m²

These loadings include an allowance for raised floors, internal partition walls, ceilings and services. All values are characteristic values.

3.2 The site

3.2.1 Exposure conditions

The site is flat and situated on the outskirts of a large town.

The fundamental basic wind velocity should be taken as 22m/sec. Snow loading may be neglected.

3.2.2 Ground conditions

Description	Depths below ground level	Soil data
Sand and clay	Ground level to 16m	c=40kN/m²
Rock	Below 16m	Allowable bearing pressure 2500kN/m²

Ground water level should be taken as 1.0m below ground level.

Francis Crick Institute, London.

Figure 1

General arrangement of site

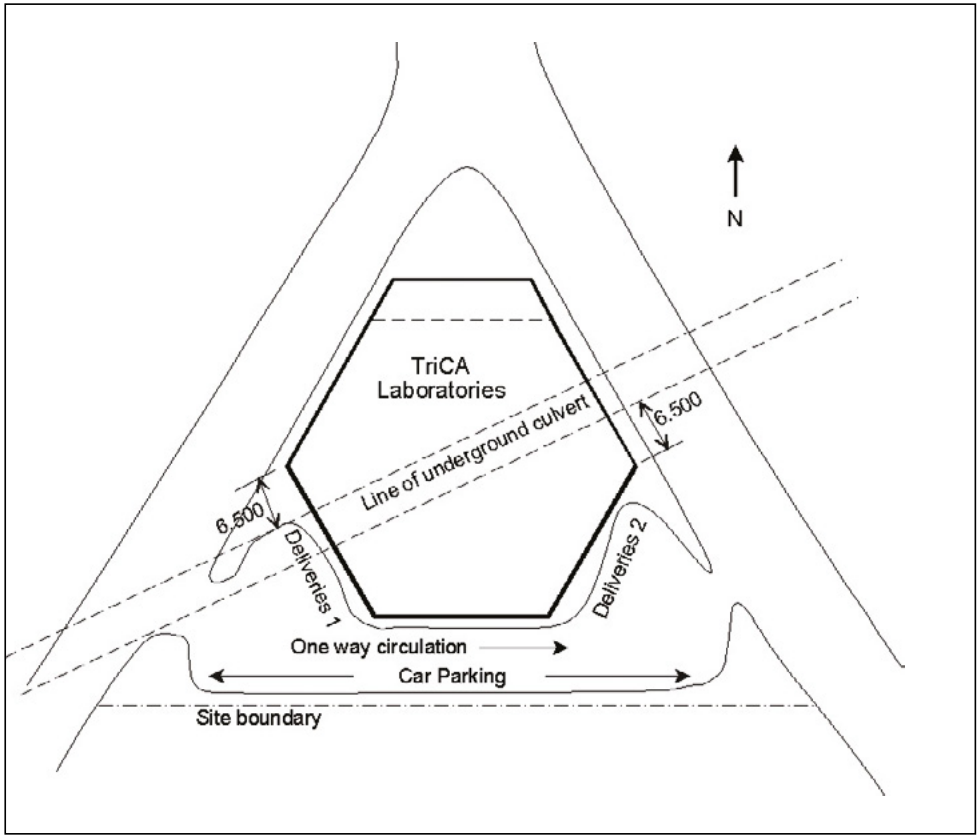


Figure 2

Section M-M through building

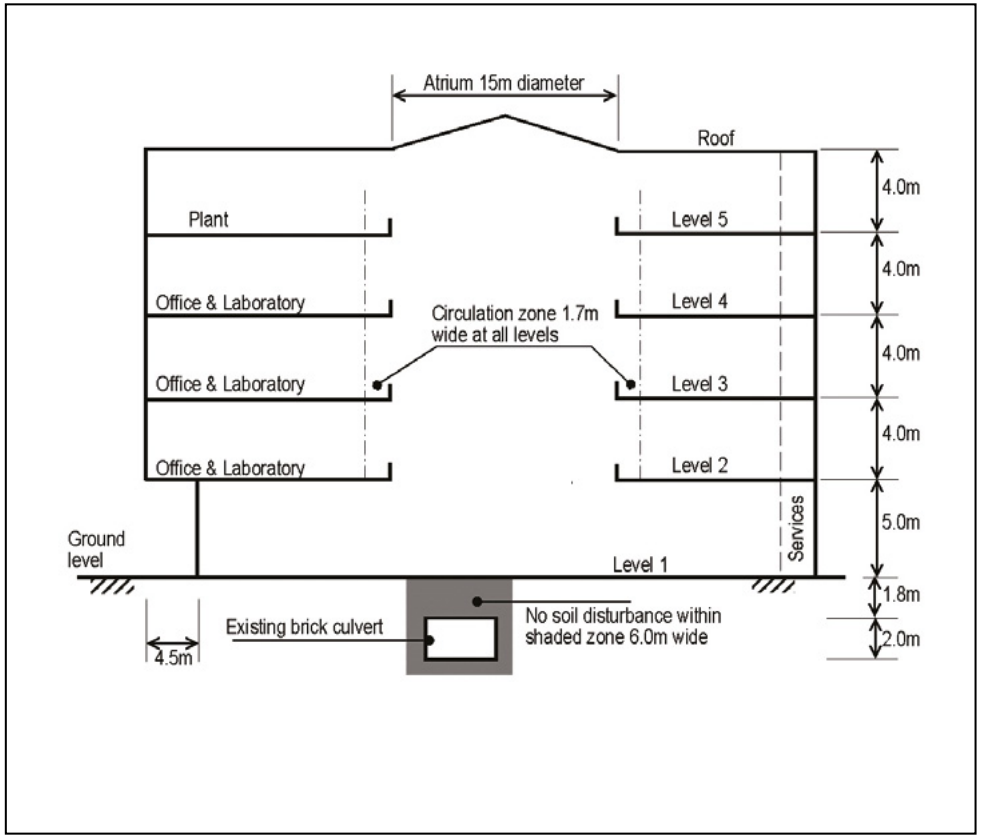


Figure 3

Ground floor plan

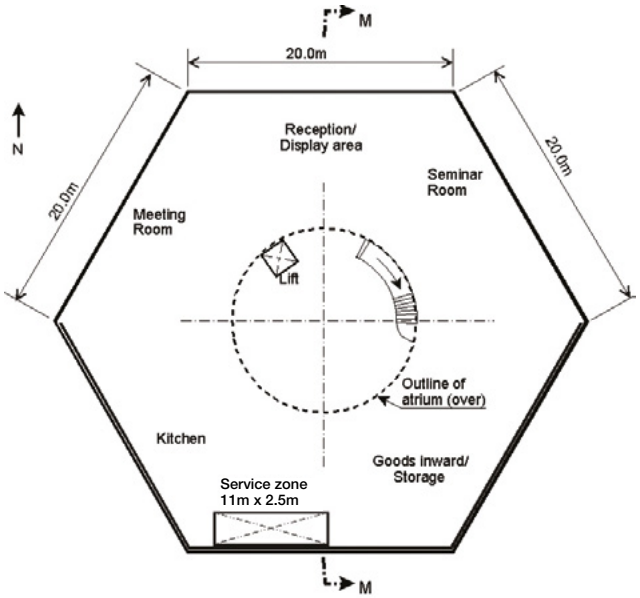


Figure 4

Typical upper floor plan

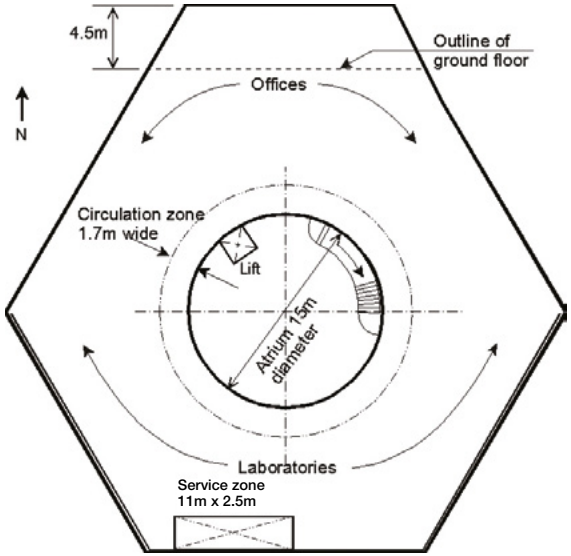
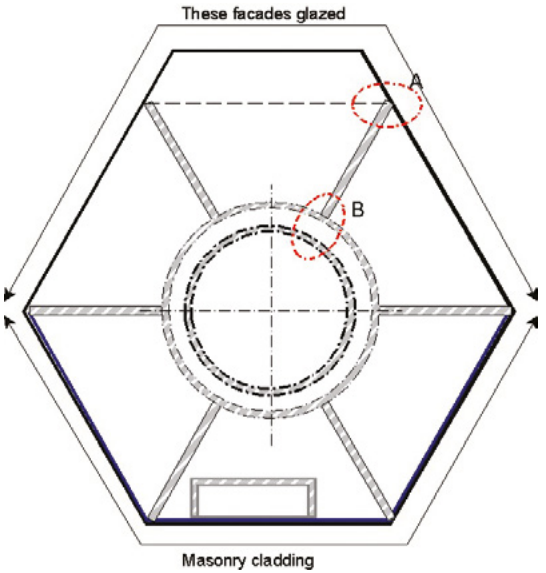


Figure 5

Permissible internal column locations and construction details required.

(The red dotted lines show the two details that need to be drawn (see 4.3(ii)). The hatched areas are where the columns can be placed.) See the project brief information on page 4 for more details.



4. Submission requirements

The submission is to comprise four components:

i. A conceptual design report

ii. Appendix 1 containing calculations for the selected scheme

iii. Appendix 2 containing the drawings for the selected scheme

iv. Appendix 3 containing a sustainability appraisal.

The submission must not exceed 60 single sided A4 pages and three A3 size drawings.

4.1 Conceptual design report

A maximum of 30 pages, of either 1.5 line spaced text in a maximum 11pt font, or neatly hand written in black ink, which should include:

i. An appraisal of two distinct and viable structural concrete solutions for the main building, together with their associated column/wall layouts. The appraisals should comprise sketches with supporting notes outlining the intended load transfer mechanisms, framing and stability functions, and some brief notes on construction methodology.

ii. An evaluation of the merits and disadvantages of the two solutions. The evaluation should identify significant differences such as cost or buildability between the two alternatives, and make a recommendation in favour of one solution.

iii. A description of the foundation scheme adopted for the preferred solution, with a rationale for the selection. A fully detailed design for the foundation scheme is not required.

iv. The form selected for the stairs, together with an outline specification for the materials to be used in its construction.

v. An outline specification for the concrete and reinforcing materials.

vi. A method statement for a safe construction procedure for the building.

vii. A statement of how robustness to avoid disproportionate collapse is to be satisfied.

viii. After completion of your design, the client points out that certain items of laboratory equipment to be installed in the building are extremely sensitive to vibrations when in use. Write a letter to the client explaining the best location for such equipment and the effects it could have on your design.

Note: the lightweight glazed atrium canopy is not to be designed.

4.2 Verification of structural viability

The verification of structural viability of the selected scheme should be demonstrated in Appendices to the conceptual design report to make up the balance of the report. (The maximum total length of the design report, sustainability appraisal and Appendix is 60 single-sided A4 pages).

The Appendices should contain sufficient design calculations by hand to establish the form and size of all structural elements for the chosen scheme, including the stairs. Entrants should decide how best to convey this information within the space constraints imposed. Calculations for individual elements should enable a checker to clearly understand their contribution to the strength and stability of the whole structure, and the load paths assumed. Hence, if computer output is presented, validation by (approximate) hand calculations is also required. Consideration should be given to performance at both Serviceability and Ultimate Limit States.

4.3 Drawings

A total of three A3 drawings should be included. Drawings may be prepared using appropriate CAD software, or by hand. In either case, notes and dimensions should not be smaller than the equivalent of an 9pt font. These drawings need not be counted in the 60-page limit.

Two of the A3 drawings should be used to present general arrangements, sections and elevations of the building to show the layout, disposition and dimensions of structural elements for estimation purposes. Drawings should be to an appropriate scale and must be dimensioned. Reinforcement details should not be shown on these two drawings.

The third drawing should show:

i) Annotated sketches of the layout, disposition and dimensions of stair construction, together with sketches and notes as appropriate to describe the completed construction.

ii) Outline reinforcement details within the zones marked as A and B on Figure 5.

A - at the top of a Level 1 column on the north face of the building.

B - the connection between the Level 1 floor and an internal column adjacent to the circulation area.

The sketches should be approximately to scale but need not be fully dimensioned.

4.4 Sustainability plan

The Client requires the building to have a long life and to be economical to maintain and service. It also needs to be resilient to flooding and climate change impacts.

The Client has therefore requested a sustainability report from the design team. Prepare a section on the structural aspects to be included in the report, including any mitigating measures taken in the specification of the structure. It should also include sustainability aspects such as fire safety and fabric protection, material efficiency and resilience.

5. Assessment criteria

5.1 University

The competition will operate on two levels. Firstly, all submissions made at each university will be judged by the academic tutor(s) involved with the project. The winning submission from each university should then be entered for the national level of the competition by the tutor or a member of the team.

Only one entry from each university can go forward for final judging at a national level and the entry form must be signed by the appropriate tutor.

5.2 National

The winning entry from each participating university will be judged at national level using the following generic assessment criteria:

- Compliance with the project brief
- Safety, function, stability and robustness
- Buildability, constructability and maintainability
- Speed of construction and cost effectiveness
- Imagination, flair, aesthetic appreciation and innovation

The interpretation of the above criteria by the award judging panel will be final and feedback will not be provided.

6. Awards

6.1 University level

The winning entry from each university will receive a prize of £250. The winning entry will go forward to compete at national level.

6.2 National level

The winner(s) of the national competition will receive a certificate(s) and a prize of £1,250. Runner(s) up will also receive a certificate(s) and a prize of £750. The judges may decide on joint prizes in which case the above prize money will be divided up by the judging panel at its discretion.

A special commendation, certificate and prize of £250 will be available for the best Sustainability Report.

The prize-winners' universities will also receive certificates.

6.3 Presentation

The winners will be announced in a webinar to be held in August 2027. The prizes and certificates will then be presented to the winner(s), runner(s) up and winner(s) of the special commendation at an awards ceremony in London. This will be part of a seminar for practising engineers who will be able to review the winning entries. The prizewinners will be notified of further details.

6.4 Eligibility

Structural Concrete 2027 is open only to students studying for a degree at a UK university. Entries can be single, joint, or from teams of up to four students. Although the competition is aimed at students in their final years of study, entries from any other appropriate undergraduate and/or postgraduate stages will also be considered at the discretion of the academic tutor(s).

7. Rules

I. To enter the competition the university academic tutor(s) should register the university's intention to participate by either filling in the online form at **www.concretecentre.com/competition** or emailing The Concrete Centre at **competitions@concretecentre.com**. Registration will enable The Concrete Centre to provide supplementary information and/or assistance if needed.

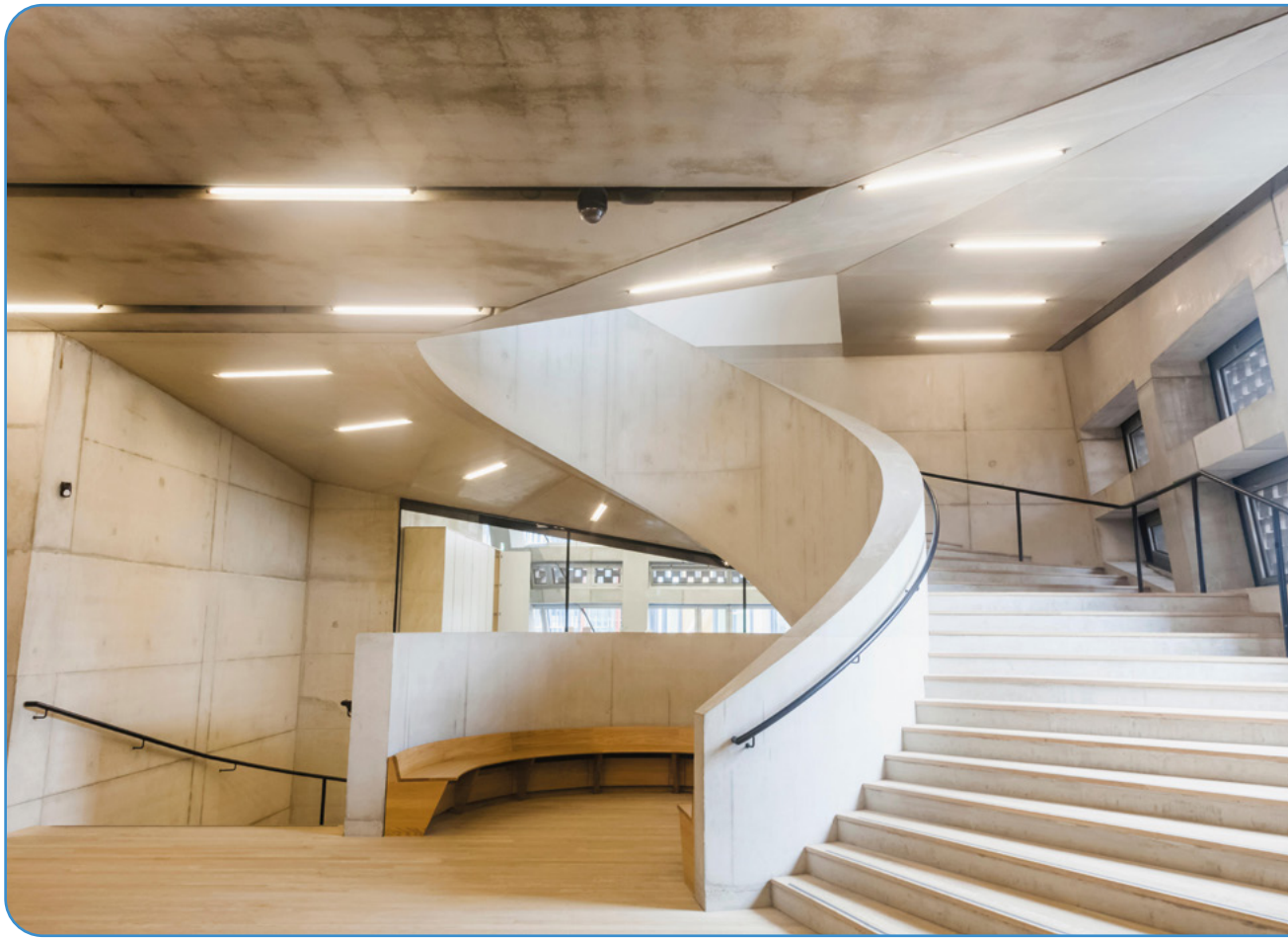
II. The completed entry form naming the local winner should reach The Concrete Centre by either submitting online or email by Friday 18 June 2027. On receipt, The Concrete Centre will issue each competitor with an entry reference number.

III. Complete design entries must be received by email or into The Concrete Centre Dropbox (details will be provided to those submitting an entry), by the final deadline of 4pm on Friday 16 July 2027. The entry reference number should be clearly marked on all items forming the design entry. **No other form of identification or distinguishing mark should appear on any part of the submission.**

IV. A successful competitor may be required to satisfy the judges that he or she is the bona fide author of the design that he or she has submitted.

V. Any entry shall be excluded from the competition if:

- The competitor does not meet the eligibility requirements detailed in Section 5.4
- The entry is received after the competition closing date in rule III above
- The competitor discloses his or her identity, or that of the university, in the submission
- The competitor attempts to influence either directly or indirectly the decision of the award judging panel.



Tate Modern, London, where a pale concrete containing 50% GGBS was specified.

Entry Form

Structural Concrete Student Design Competition 2027

To be submitted by no later than Friday 18th June 2027. This form is to be completed only for the entry which has been marked and selected by the academic tutor(s) for submission to the national competition. Only one entry will be permitted from each university.

University	
Name and email address of Academic Tutor(s)	

1. *I/We have complied with and accepted the rules which apply to this competition
2. *I/We agree to accept the decision of the judges as final, and agree to permit free publication and exhibition of *my/our work
3. *I/we declare that the design is *my/our work and that the drawings have been prepared by *myself/ourselves.
4. *I/we agree that any part of this work may be reproduced in publicity or other materials by The Concrete Centre as required.

*Delete as applicable

Signature student(s): .....

Signature academic tutor(s) .....

This form is to be completed by the competitor(s) and academic tutor(s) and submitted online or via email to competitions@concretecentre.com. An entry reference number will then be given, which should be marked clearly on all items forming the design entry. **No other form of identification or distinguishing mark should appear on any part of the submission**.

Please return to:
competitions@concretecentre.com

The following student or student team (maximum of four students per team) will represent the university:

Student Name			
Home Address			
Email			
Phone		Year	

Student Name			
Home Address			
Email			
Phone		Year	

Student Name			
Home Address			
Email			
Phone		Year	

Student Name			
Home Address			
Email			
Phone		Year	

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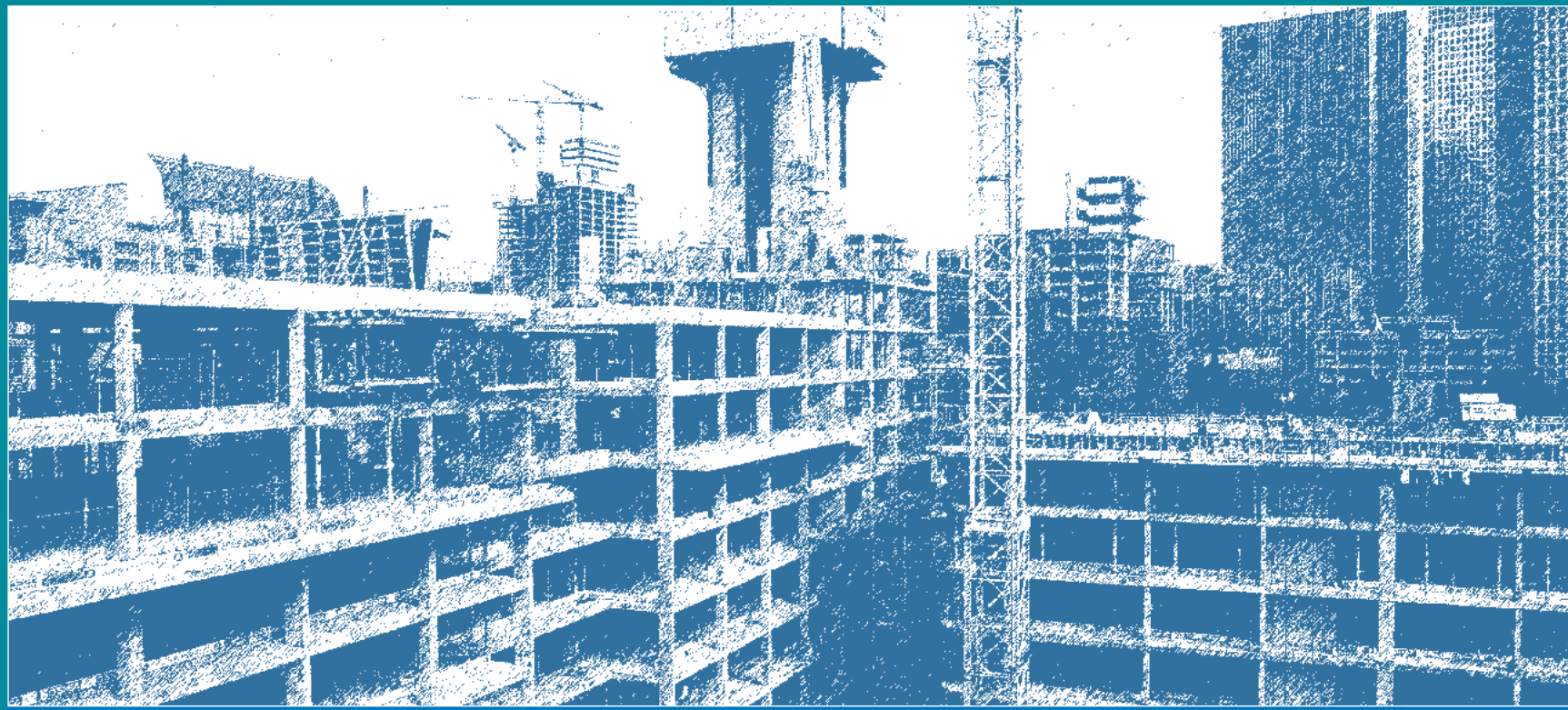
www.mineralproducts.org



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