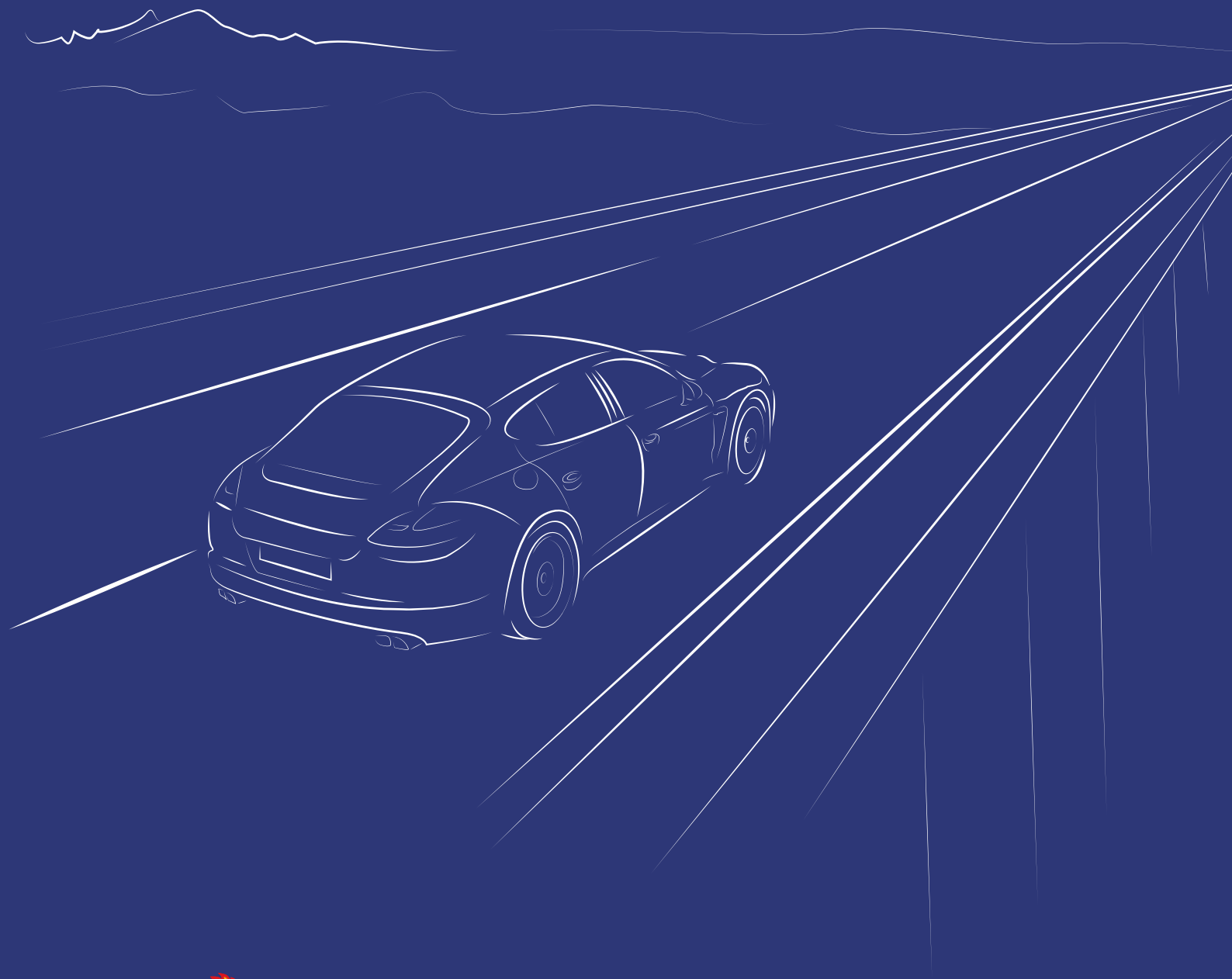
STUDENT DESIGN COMPETITION - BRIDGES 2014

For further information visit:

SteelConstruction.info/Student_awards



BCSA

TATA STEEL

SCI
Steel Knowledge

Foreword

The Tata Steel / BCSA Students Awards - Bridge Design has been organised by The Steel Construction Institute, and is one of three undergraduate prize award competitions; the other competitions cover the design of building structures and an architectural competition. The objective of the competition is to encourage excellence in steel bridge design.

The competition is restricted to undergraduates.

The project Brief this year is to design a road bridge over an area of railway sidings and main railway lines. As the bridge is to be a symbol of the regeneration of the area, the project sponsors anticipate an elegant solution. A wide range of structural forms are possible. This project is intended both to motivate and challenge the entrants. The competitors are expected to demonstrate sound engineering skills and structural design and to produce an elegant structural solution.

The Brief has been finalised in consultation with course tutors and those actively involved in designing, detailing and constructing steel bridges. The Brief was compiled by:

Mr B R Mawson	Capita Symonds	Chairman
Mr D G Brown	SCI	Secretary
Mr C Cocksedge	AECOM	
Mr D Dickson	Mabey Bridge Limited	
Mr C Dolling	BCSA	
Mr J D Place	Mott MacDonald Group Limited	

Tata Steel / BCSA and The Steel Construction Institute would like to express their gratitude for the continuing support of all those concerned.

The compilers of the Brief will judge the competition.

1 THE BRIEF

1.1 INTRODUCTION

As part of an urban regeneration scheme, a new single carriageway road bridge is proposed across an area of sidings and main railway lines. As the area around the railway is predominantly flat, the bridge will be a major landmark, seen from all directions.

The client is aware that modern highway bridges in steelwork are not utilitarian in form, but can be designed as elegant, cost-effective structures, enriching the local environment and acting as a visual statement. The client is seeking such a structure, to be ranked alongside the very best steel structures in the UK.

1.2 APPOINTMENT AS CONSULTANT

You have been retained as a consultant to carry out a feasibility study for the new bridge, and to report your findings to the client. Your brief is to prepare a report that is to have the following scope:

a) Consideration of at least **two distinct and viable** structural arrangements for the bridge;

b) A **clear recommendation** to the client on which scheme should be selected, with reasons for your choice;

c) A **detailed structural design** for the recommended scheme.

1.3 DETAILS OF THE PROJECT

a) Site

A plan of the site is shown in Figure 1.

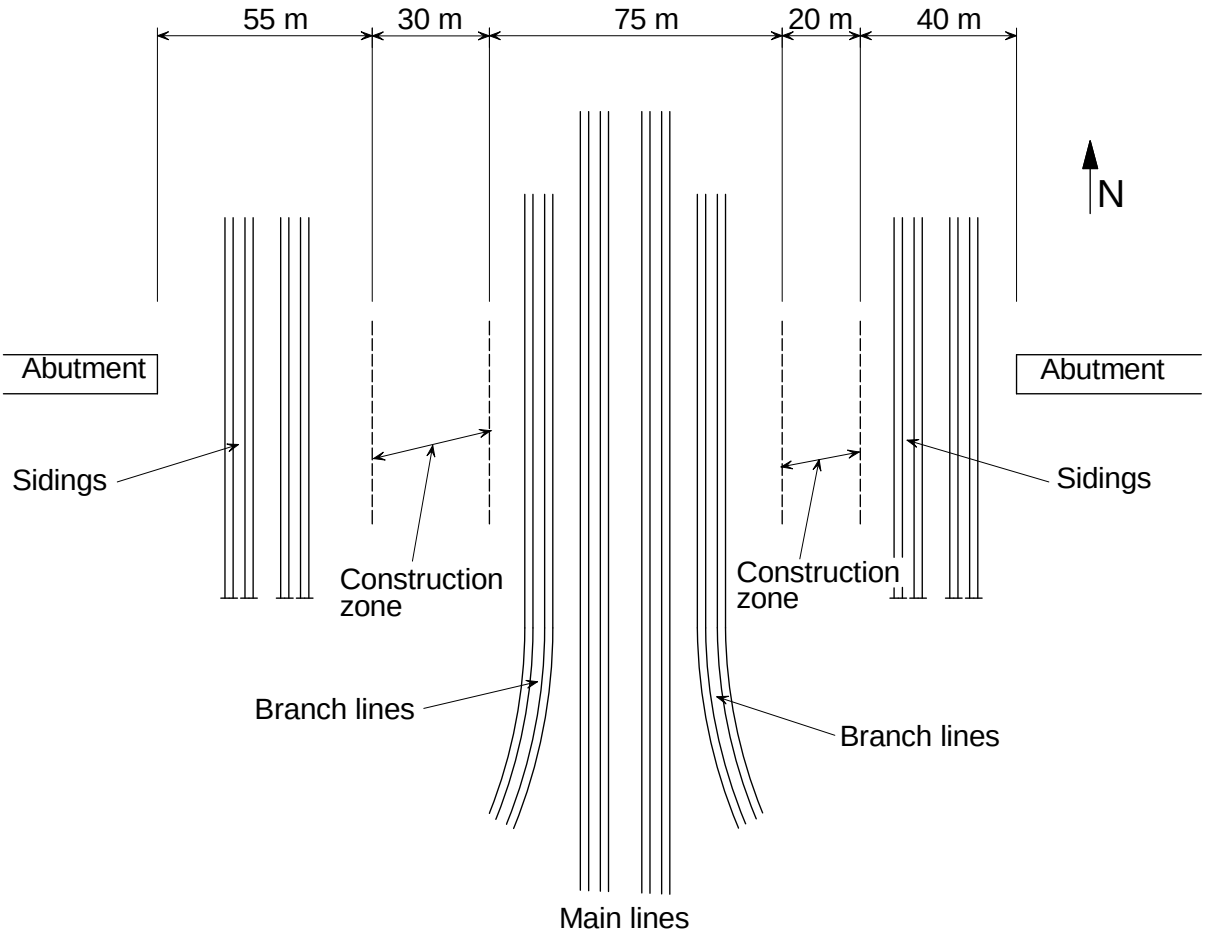


Figure 1 Site Plan

The key feature of the site is the large number of railway lines that the bridge must cross. The primary inter-city lines are approximately central to the crossing, with branch lines adjacent. In addition to the branch lines, there are a number of sidings on both sides of the main lines. The position of the lines shown in Figure 1 is fixed, so the structure must respect the restrictions imposed by the railway lines.

Construction zones are shown in Figure 1. Any permanent works must be within these zones. The extent of the zones allows sufficient lateral clearance to the tracks.

The scope of the design is limited to the bridge structure and supports over the tracks; the abutments and approach embankments at each end of the bridge are to be designed by others.

A cross section through the proposed bridge is shown in Figure 2. The superstructure must be a single deck. The two traffic lanes cannot be separated to accommodate any central cables or other structure. If cables are required, they must be located outside the cross-section shown.

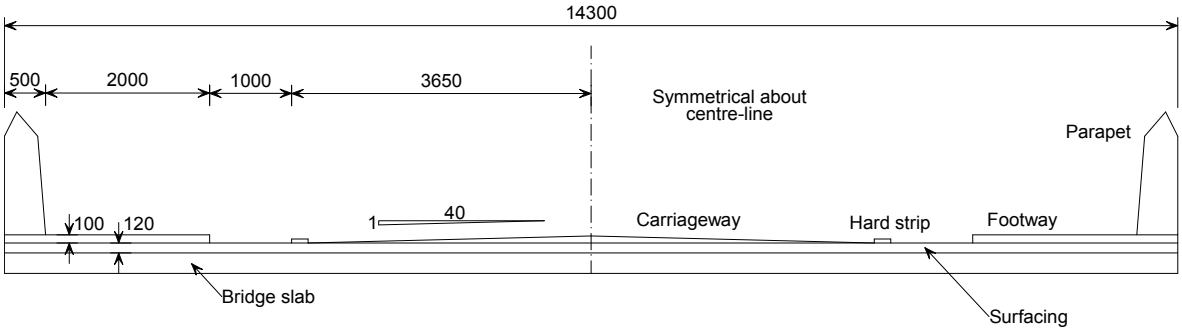


Figure 2 Cross-section of proposed bridge

b) General arrangement

A schematic elevation of the proposed bridge is shown in Figure 3. As shown in Figure 3, the clearance above the main lines and branch lines must be 5.5 m. A reduced clearance of 4.5 m is required over the sidings. Longitudinally, the bridge may be flat, or curved vertically.

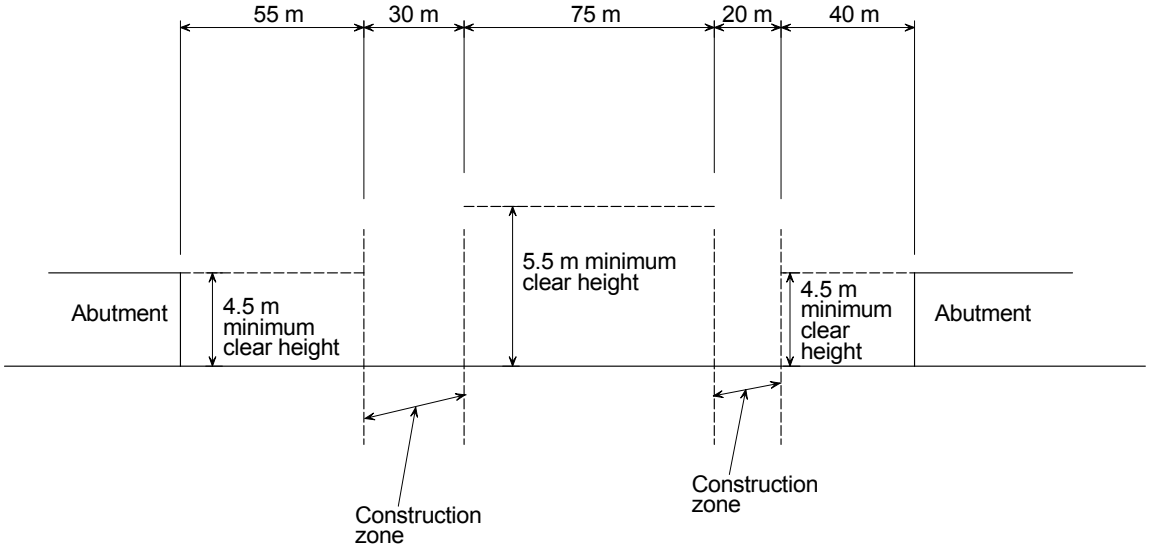


Figure 3 Longitudinal elevation of the proposed bridge

c) Construction constraints

Access to the construction site is from the South (see Figure 1) only. Access from both East and West is readily available, and there is land available adjacent to the site for any storage or preassembly.

Although the sidings can be shut for periods of time, both the branch lines and the main lines must generally remain in use. Clearly, these lines will have to be closed during certain periods to allow construction of the new bridge directly over the railway. However, the railway authority is insistent that both the number of closures (called ‘possessions’) and the duration of each closure are minimised. It is critically important that the construction method be carefully considered, and closures justified.

1.4 BASIS FOR THE DESIGN

a) Structural Behaviour

The primary bridge structure, including any pylons or towers, is to be of steel, which is to be designed making efficient use of material in accordance with basic structural theory. If guidance is required, reference may be made to the Eurocodes for bridge design (EN 1993-2 and EN 1994-2), or the simplified version of the Eurocodes for student projects, which may be found at http://discus.steel-sci.org

Checks for deflections, fatigue and dynamic response are not required..

b) Materials

i) Structural steel

The primary members of the proposed structure must be steel of the appropriate grade. Steel elements are to be Advance rolled sections, Celsius hollow sections or sections fabricated from plate (e.g. plate girders and box girders).

The materials used should be chosen from the following:

BS EN 10025-2:Grade S275 or S355
BS EN 10025-5:Grade S355
BS EN 10025-3:Grade S275, or S355
BS EN 10025-4:Grade S275, or S355
BS EN 10210:Grade S355

You will be expected to demonstrate an appreciation of the implications of the mechanical properties on the selection of steel grades in relation to strength, ductility, notch toughness (impact strength) and weldability. In choosing an appropriate sub-grade, students are advised that the minimum effective bridge temperature may be taken as -20^0C.

ii) Cables

If cables are used as structural members, the material strength of the wire in the cables should be taken as 1600 N/mm^2. Checks on cables at the Serviceability Limit State are not required.

iii) Foundations material

Foundations will be provided by others, and do not form part of the final design. However, foundations can be expensive, and must be included in the estimated cost of the works. Costs of foundations are indicated in Table 1 of this brief.

c) Loading

Permanent actions (dead loads and superimposed dead loads) should be determined from the sizes of the structural members and their specific weights (see the simplified version of the Eurocodes for student projects).

The variable actions should be taken as Load Model 1, comprising a UDL over all of the superstructure, plus a pair of axles, as described in *Bridge Design to the Eurocodes – Simplified rules for use in student projects*, available from the discussion site at http://discus.steel-sci.org

If a concrete slab were to be used for the composite deck, a 250 mm slab would be typical, as is shown in the simplified Eurocode document.

Although shear lag can be ignored for the design of steel deck plates, a maximum plate width of 28εt either side of the web of the main girder should be used, when the plate is in compression."

Wind load need not be considered in detail, but consideration must be given to any parts of the bridge, or stages of erection, that might become sensitive to wind effects. Overall stability effects should be checked under a nominal wind load of 2 kN/m^2 applied over the projected surface area in elevation, with no other variable action on the bridge.

The accommodation of temperature effects and articulation of bearings should be described, and the submission should explain how all the forces are carried to the foundations. This description should be a properly resolved system of forces, not merely an abstract flow diagram.

Partial safety factors on actions can be taken from the simplified version of the Eurocodes for student projects, available from http://discus.steel-sci.org Prestressing actions in cables (which would normally be necessary to ensure the intended geometry under permanent actions) may be neglected.

d) Substructures

For outline design of the bridge substructure (e.g. piers and foundations) and for estimating the cost of the proposals, the following should be assumed. However, note that major supporting structures (e.g. pylons and arch elements) should be considered as part of the superstructure and thus require design.

i) Piers:

Steel piers should be designed as simple compression members. Concrete piers should have at least 100 mm^2 of concrete provided for every 1 kN of ULS vertical reaction that is to be supported.

ii) Foundations:

A detailed design is not required for any foundations, but outline interface details and loads should be indicated on the drawings.

iii) The height width ratio:

The ratio of the height of the pier to the smaller cross sectional dimension should not exceed 16 for steel piers or 12 for concrete piers, unless a detailed analysis is presented to show that more slender piers could be used.

iv) Movement:

The effects of settlement may be neglected when considering the bridge and its foundations.

e) Other design requirements

The bearing system at the bridge support points should be selected and explained in words and sketches but need not be designed in detail.

Deck details at the end of the bridge and any intermediate joints, accommodating anticipated movements, should be shown. Annotated sketches will be satisfactory.

Durability issues of the structure (i.e. corrosion protection, numbers of joints, bearing replacement) should be considered and explained in the submission.

A detailed design of the bridge substructure, beyond that provided under d) above, is not necessary.

1.5 ADDITIONAL DESIGN RESOURCES

Guidance on the design and construction of steel bridges is available at www.steelconstruction.info/Bridges

All SCI resources are available at www.steelbiz.org

The design brief and the simplified Eurocodes for student projects are available at: http://discus.steel-sci.org.

1.6 CONSTRUCTION TIME RATES AND COSTS

The construction time for the proposed design should be considered in terms of the construction time rates detailed in Table 1. It should be assumed that the activities listed in Table 1 cannot be overlapped.

Both steel erection and the concreting of a composite deck in situ directly over the main lines and branch lines require closures of the railway. It can be assumed that no other operations require the railway to be closed. Note that if a composite deck is to be concreted in situ, it may be assumed that the area over the main lines and branch lines can be concreted in one 32 hour closure.

Construction costs for the various items involved in the building and erection of the bridge are also detailed in Table 1. It should be noted that the costs given are notional values, selected for the purpose of this exercise. There are also overhead costs involved in staffing and running the site; fast construction times will clearly minimise these. A nominal overhead cost of £3,000 per day must be added to the calculated construction costs.

Table 1 Time rates and costs

Activity	Time/Rate	Cost
Construction Work		
Concrete piers, abutments and anchorage blocks for cables if required.	5 m^3 /day	£650/m^3
Concrete deck (non-steel) [including formwork, reinforcing, placing, curing etc]	30 m^2 /day	£200 m^2
Waterproofing, surfacing and finishes	100 m^2/day	£70/m^2
Railway closures		£250,000 per closure
Erected Fabricated Steelwork in Grade S355		
(a) Plate girders	20 tonnes/day	£1900/tonne
(b) Rolled Sections	20 tonnes/day	£2000/tonne
(c) fabricated box sections or stiffened steel plate decks	20 tonnes/day	£4200/tonne
(d) Hollow sections	15 tonnes/day	£3800/tonne
(e) Saving for use of grade S275	nil	£25/tonne reduction
Cables		
Stay cables and arch hangers	1 cable/day	£5.0 per kN of breaking load per 100 m length
Cable and hanger end anchorages	included in above	£1.0 per kN of maximum breaking load of cable per end
Foundations for piers (abutments need not to be priced)		
	By others	For each foundation: £12,500 plus £8 per kN

Notes to Table 1:

1) The cost given for steelwork includes all costs of supply, fabrication, transportation and erection. In addition:

   a) For carbon manganese steel, the rates include all costs of providing protection against corrosion.

   b) For weather resistant steel, the cost includes a margin for the normal practice of providing extra thickness to allow for initial corrosion. This extra thickness need not, therefore, be taken into account when calculating the weight of steel for costing purposes.

   c) Concrete costs include all formwork, reinforcement fixing, placing, etc.

2) The time rate for one cable is that for a single length of cable between the bridge and the top of the support structure.

3) Construction rates include all ancillary activities – such as erecting formwork, laying reinforcements etc.

2 SUBMISSIONS

2.1 SUBMISSION CONTENT

The submission is to be a single copy of the report, calculations and drawings, for which you have been commissioned (see Section 1.2) and should not exceed a total length of 70 single sided A4 pages plus two drawings.

The submission should include the following:

a) Report

A **maximum** of 35 pages of text, either printed with a minimum font size of 11 pt or neatly hand written. which must cover

i) For each of the initial schemes:

The considerations leading to the outline design of each initial scheme, including both the superstructure and substructure. Load transfer paths should be identified and described. Internal forces must be properly resolved.

A brief description of the proposed methods of construction. These need not be quantified or described in detail but they must, in principle, be feasible. Construction problems and safety hazards that might be encountered during construction should be discussed, together with the steps that might be taken to overcome them. Each of the schemes considered must be costed using the information provided in Table 1.

Future maintenance requirements should be considered and described.

ii) A clear recommendation to the client on which scheme should be adopted. In making this recommendation all aspects of the design, construction and maintenance should be taken into account.

iii) For the recommended scheme:

A report on the final detailed design of the bridge superstructure;

Confirmation of (or modification to) the outline design of the substructure described in (i) above;

A description of the method of construction of the bridge. The proposed sequence should be described with comment on design checks made on the most critical conditions to ensure that the structure is stable at all times.

iv) An artist's impression, sketch or image (which may be used freely by the sponsors), which conveys the essence of the recommended scheme. The graphic must be A3 landscape and should not disclose the identity of the competitor.

v) In addition to the graphic described in iv), entries must include a JPEG image of the structure, on a CD, which the competition sponsors may freely use in any way whatsoever.

b) Calculations

A **maximum** of 35 pages of calculations, which must cover:

Outline calculations for the initial schemes, to show the viability of the proposals and to enable a reasonable estimate of the costs to be made.

Sufficient detailed calculations for the design of the superstructure of the recommended scheme to demonstrate its structural strength and stability. These should include consideration of the main structural elements, principal connections and loads on the bearings. The structural efficiency of the primary members should be indicated.

The transfer of all forces (vertical, longitudinal, lateral) to the foundations should be shown diagrammatically, with a sketch of properly resolved forces and reactions.

Sufficient calculations to justify the principles of the methods of construction for the recommended scheme. These need not be in detail, but must comply with the constraints described in this brief.

c) Drawings

One print of each of the two A1 drawings. The drawings must show:

Drawing 1 Plans, elevations and cross-sections of the proposed steel structure, at appropriate scales. It should show relevant member forms and sizes, foundation loads and abutment arrangements and give general specification clauses.

Drawing 2 Typical details - e.g. steel connections, bearings, etc at an appropriate scale.

d) Other submission requirements

i) All calculations must be submitted on copies of the calculation sheet shown on page 14. A calculation sheet may be downloaded from the discussion area of the SCI's website at http://discus.steel-sci.org.

ii) If a computer analysis is used, then the main members should be checked by hand calculations and these calculations must be submitted with the report. Where appropriate, computer input and summary results (for the final run only) should be included.

iii) Computer drawings using a CAD system are acceptable.

iv) No sheets or drawings of any entry should contain the identity of the competitor or of the university represented. Total anonymity must be maintained in all submissions.

2.2 SUBMISSIONS AT THE UNIVERSITY

All students intending to submit an entry for this competition should inform the academic tutor in charge of the project at their university, who should submit a Notice of Intent form (page 16) by **Friday 24 January 2014**.

Completed submissions should be handed to the tutor in sufficient time to allow for the selection of the best entry from the university.

2.3 SENDING SUBMISSIONS TO THE SCI

The chosen submission from each university must be received **at the SCI by 4:00 pm on Tuesday 17 June 2014**. Late submissions will not be accepted.

3 CRITERIA FOR JUDGING

3.1 LOCAL

The competition will operate at two levels. All submissions made at each university will first be judged locally by the academic tutor(s) involved with the project at that university. The winning submission at each university will then be entered for the national competition. A certificate will be issued to all those reaching the national final.

Only one entry from each university will be considered to go forward for final judging at national level.

3.2 NATIONAL

All winning local submissions will be judged at national level using the following criteria:

(a) The exploration of alternative structural forms and the discussion leading to the selection of the recommended scheme.

(b) The demonstration of sound engineering in design.

(c) The stability, integrity and aesthetics of the chosen scheme.

(d) The economics, structural efficiency and buildability of the chosen scheme.

(e) The inclusion of a safe construction sequence.

(f) The imaginative and innovative use of structural steelwork.

(g) The clarity and conciseness of the report and the drawings describing the proposed structural schemes.

(h) The environmental and sustainability credentials of the proposed solution.

(i) Compliance with the Brief.

The interpretation of these criteria by the Judges will be final. Entrants should note that the design development, structural engineering design and buildability will receive a high weighting during judging. Submissions should clearly describe the structural concept and arrangements.

Only those aspects set out in the brief will be judged. Aspects specified in the brief but omitted from the submission will lead to a reduction in the overall marking. Features outside the scope of the brief will not be judged.

4 THE AWARDS

4.1 UNIVERSITY LEVEL

A certificate will be issued to all those reaching the national final.

4.2 NATIONAL LEVEL

The winners of the competition will receive certificates and prizes up to a total of £2,500. The exact division of the prize money will be decided by the Judges and will depend on the standard of the submissions received. Generally, the judging panel will seek to award up to three prizes. The winners' universities will also receive certificates.

4.3 ELIGIBILITY

The competition is open only to undergraduates. Individual entries, or team entries from a small group of students, will be accepted. Although the competition is aimed at final year students, entries from any other appropriate stages will also be considered at the discretion of the course tutors.

No family member of staff from the sponsoring body or the judges, nor any partner, associate or employee from their companies or practices, shall be eligible to enter the competition or to assist a competitor. Assistance is available through the competitions website, http://discus.steel-sci.org

Tata Steel / BCSA Student Awards Bridge Design 2013/2014 **CALCULATION SHEET**	Job No.	Sheet *of*	Rev
	Job Title		
	Subject *Roadbridge*		
	Client	Made by	Date
		Checked by	Date

How to Enter

1. To enter the competition the academic tutor(s) at your university should firstly complete the enclosed **Notice of Intent** form and return it to the competition organiser at the address given below by **Friday 24 January 2014**. This will enable the SCI to provide supplementary information should this be necessary.
2. Any questions that competitors wish to ask should be submitted via the Undergraduate Prize Awards discussions area of the SCI's website at http://discus.steel-sci.org. All competitors should review the questions and responses posted to the site; automatic notification can be set up via the user profile.
3. The completed **Entry Form and Authorship Declaration** (contained in this booklet) should reach the competition organiser at the address given below by **Friday 9 May 2014**. On receipt of this, the SCI will issue each competitor with an entry reference number, which should be marked clearly on all items forming the design entry and on the outside of the package in which the entry is submitted. **No other form of identification or distinguishing mark should appear on any part of the submission.**
4. A successful competitor must be able to satisfy the judges that he or she is the bona fide author of the design that he or she has submitted.
5. Competitors should retain the originals of the designs and drawings submitted. The organisers cannot be held responsible for loss or damage to submissions which may occur either in transit or during exhibition, storage or packing.
6. Design entries must be received by **4.00 pm on Tuesday 17 June 2014**.
7. The designs awarded first, second and third places will be announced in early July 2014 (date to be confirmed)**.**
8. Any entry shall be excluded from the competition if:
    i) the competitor does not meet the eligibility requirements detailed in Section 4.4;
    ii) the entry is received after the competition closing date, **4.00 pm on Tuesday 17 June 2014**;
    iii) the competitor shall in any way disclose his or her identity or that of their university;
    iv) the competitor attempts to influence either directly or indirectly the decision of the judges;
    v) in the opinion of the judges, the design does not substantially meet the requirements of the brief.

Only one copy of each competitor's design is to be sent in a single package, carriage paid to:

The Competition Organiser
Tata Steel / BCSA Student Awards Bridge Design
The Steel Construction Institute
Silwood Park, Ascot
Berkshire, SL5 7QN

Tel: 01344 636525
Fax: 01344 636570

Notice of Intent

(to be submitted by **Friday 24 January 2014**)

TATA STEEL / BCSA STUDENT AWARDS BRIDGE DESIGN: 2013/2014

If you wish to enter the competition, the academic tutor(s) at your university should complete this form and return it to the address given below in a sealed envelope.

Name of academic tutor(s) .....

.....

email(s) .....

Telephone No .....

University .....

Address .....

.....

.....

.....

This year, we expect approximately ..... students will participate in the competition or use this brief as a design exercise.

Signature(s) .....

.....

Please return to:

The Competition Organiser
Tata Steel / BCSA Student Awards Bridge Design
The Steel Construction Institute
Silwood Park
Ascot
Berkshire
SL5 7QN

Tel: 01344 636525
Fax: 01344 636570

Entry Form and Authorship Declaration

(to be submitted by **Friday 9 May 2014**)

TATA STEEL / BCSA STUDENT AWARDS BRIDGE DESIGN 2013/2014

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
BLOCK CAPITALS PLEASE.

University .....

Name of academic tutor(s) .....

Email address .....

The following student(s) have been selected to represent my university in the above competition.

Student's name ..... Year .....
E-mail .....
Tel. no. .....
Address .....
.....

Student's name ..... Year .....
E-mail .....
Tel. no. .....
Address .....
.....

Student's name ..... Year .....
E-mail .....
Tel. no. .....
Address .....
.....

Student's name ..... Year .....
E-mail .....
Tel. no. .....
Address .....
.....

1. *I/We have complied with and accepted the regulations and conditions 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 design.
3. *I/We declare that the design is *my/our work and that the drawings have been prepared by *myself/ourselves.

*Delete as applicable

Signature, student(s) ..... Date . . . . . .

..... Date . . . . . .

Signature, academic tutor(s) ..... Date . . . . . .

(see continuation overleaf)

This form is to be completed by the competitor(s) and the academic tutor(s), placed in a sealed envelope and returned to the address given below. ***An entry reference number will then be given, which should be marked clearly on all items forming the design entry and on the outside of the package in which the entry is submitted.***

Please return to:
The Competition Organiser
Tata Steel / BCSA Student Awards Bridge Design
The Steel Construction Institute
Silwood Park, Ascot
Berkshire, SL5 7QN

Tel: 01344 636525
Fax: 01344 636570