



Possible solution to past CM examination question

Question 4 - April 2006

Highway Viaduct

by Dr KS Law

The information provided should be seen as an interpretation of the brief and a possible solution to a past question offered by an experienced engineer with knowledge of the examiners' expectations (i.e. it's an individual's interpretation of the brief leading to one of a number of possible solutions rather than the definitive "correct" or "model" answer).

Question 4. Highway viaduct through an existing car park

Client's requirements

1. A viaduct to carry a new two-lane highway through an existing multi-storey car park; see Figure Q4. The highway is to have a level and straight longitudinal profile along the length of the viaduct.
2. The viaduct is to be fully enclosed from the car park; there is to be no access to the viaduct directly from the car park.
3. The car park is of reinforced concrete frame construction supported on piled foundations. Although there is no record of the reinforcement details of the slabs, beams and columns, a site survey has revealed the following:
 - a). The floor slabs are 200mm thick;
 - b). The beams are 260mm wide x 700mm deep;
 - c). The columns are 700mm x 500mm (in cross section).
 No further information is known about the existing construction.
4. The new highway is to have a clearance envelope of 12.15m x 5.4m throughout the length of the car park, as shown in Figure Q4.
5. The car park is to remain open throughout the construction period. The reduction in space to accommodate the new viaduct is to be kept to a minimum during and after construction. The space at level 5 and above must not be reduced at any time during or after construction.
6. The entrance and exit to the car park must remain unchanged during and after construction. The working area for construction may be extended beyond the building line, if necessary.
7. Any new construction must have minimal maintenance costs.

Imposed Loading

- | | | |
|----|------------------------------------|---|
| 8. | Car park roof | 0.75kN/m ² |
| | Car park floors | 3.5kN/m ² |
| | Viaduct (vertical traffic loading) | 10.0kN/m ² A concentrated wheel load of 100kN distributed over a 0.3m x 0.3m contact area is to be applied where this is more onerous than the uniformly distributed load. |

Site Conditions

9. The site and surrounding streets are flat and level. The highway level at the approaches to the building is very similar to level 3 of the car park.
Basic wind speed is 46m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23m/s.
10. Typical ground conditions:

Ground level – 1.5m	Made ground.
1.5m – 8.0m	Loose Sand and Gravel. N values vary between 5 and 8.
8.0m – 12.0m	Medium dense to dense Sand and Gravel. N values vary between 35 and 50.
12.0m – 16.0m	Dense to very dense Sand and Gravel. N values vary between 50 and 70.
Below 16.0m	Rock. Allowable bearing pressure = 1500kN/m ² .

 Groundwater was encountered at 3.6m below ground level.

Omit from consideration

11. An overall stability check of the existing car park; vertical loads from the viaduct outside the building line and horizontal loads acting on the viaduct. Detailed design of the viaduct end supports and parapets. Detailed consideration of wind loading.

continued overleaf

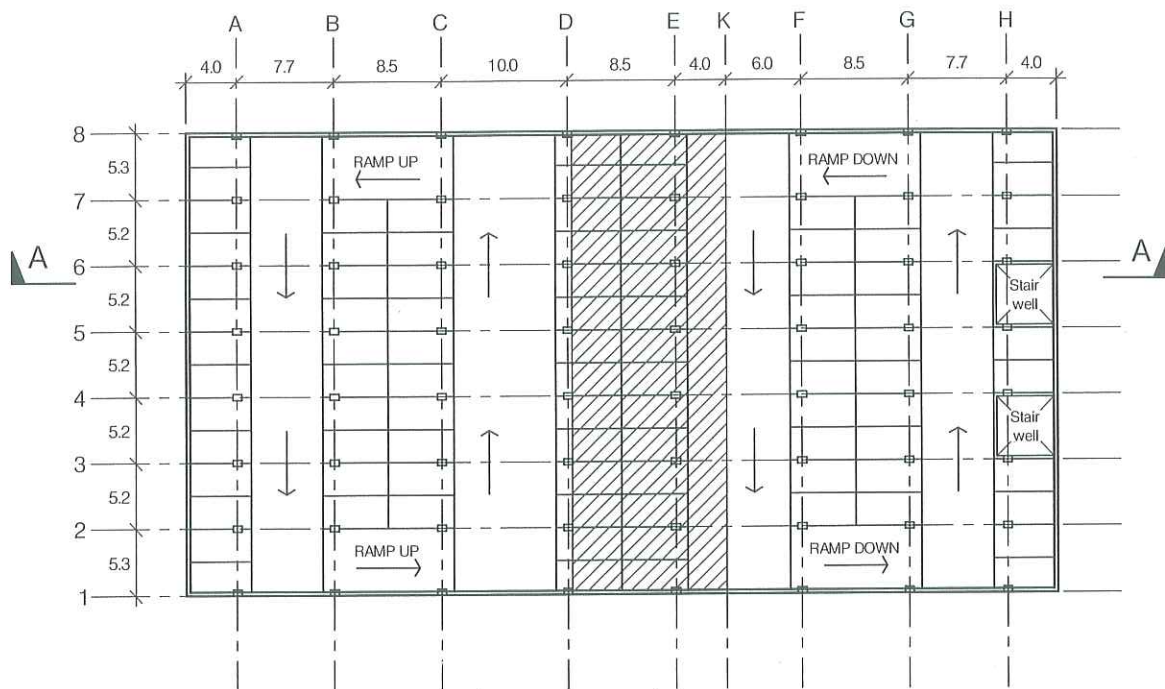
SECTION 1**(50 marks)**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed construction including the foundations. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. Tests carried out on the groundwater sampled immediately before construction of the foundations reveal high concentrations of chloride and sulphate salts. Write a letter to your client explaining how your design would be modified to accommodate these groundwater conditions. (10 marks)


SECTION 2**(50 marks)**

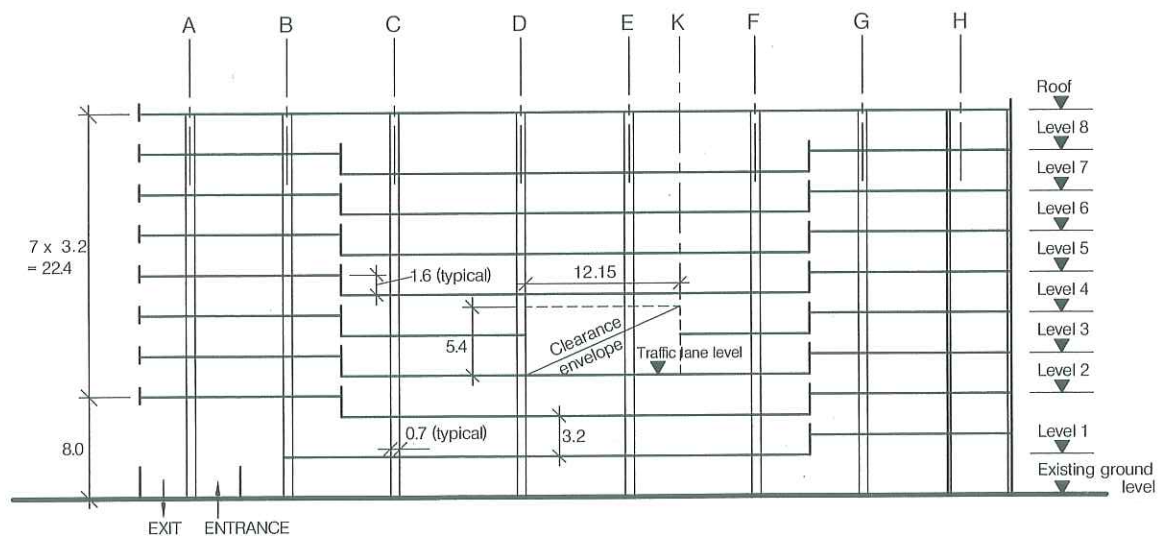
For the solution recommended in Section 1(a):

- c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)
- d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)
- e. Prepare a detailed method statement for the safe construction of the proposed structural works and an outline construction programme. (10 marks)



TYPICAL FLOOR LAYOUT PLAN

 Clearance envelope
(Levels 3 and 4)



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q4

❑ Introduction

A viaduct carrying a 2-lane highway through an existing multi-storey car park.
The viaduct is to be fully enclosed from the car park and there is to be no access to the viaduct from the car park

❑ Issues and their implications

- Clearance envelope
- Existing columns removed
- Integrity of existing structural elements
- New foundations

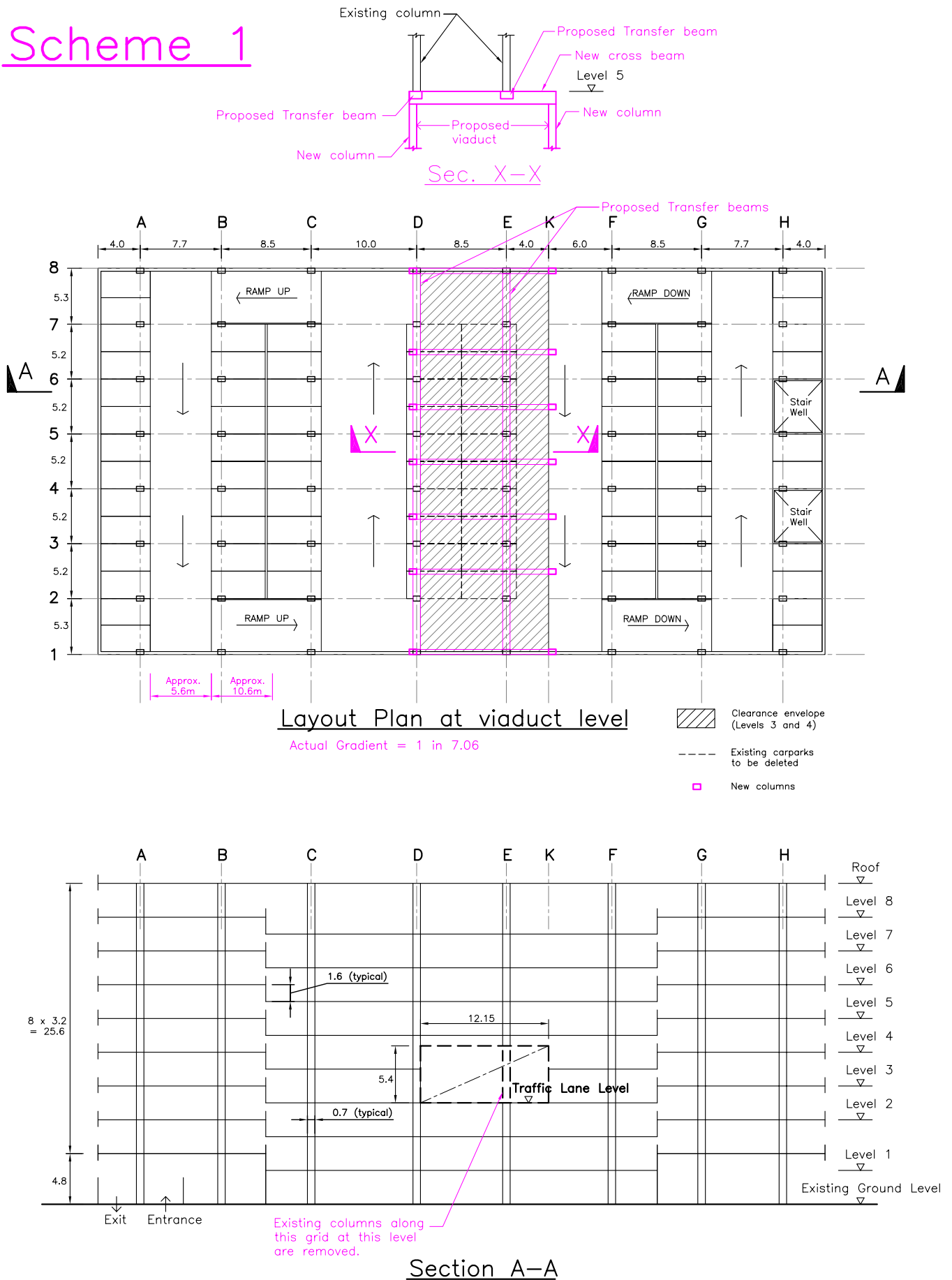
❑ Conceptual Design

- Transfer elements
- Temporary supports

❑ The letter

- Sulphur and chloride attacks

Scheme 1



Scheme 2

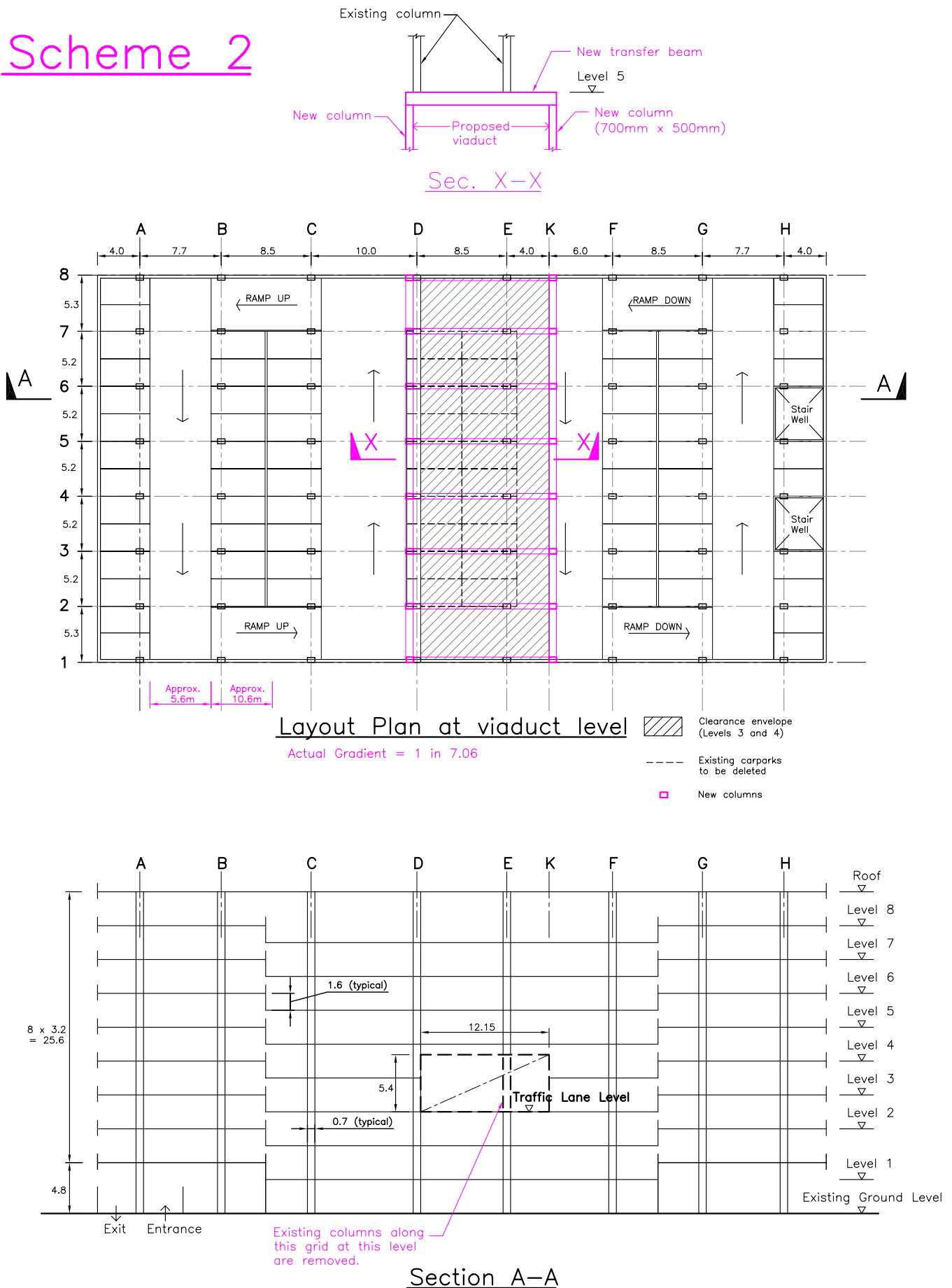


FIGURE Q4