Stainless Steel In Bridge Design

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Introduction

- **Why use stainless steels for structural applications?**
- **Cost study**

Why use stainless steels?

- **Range of alloys to give required durability**
- **Wide range of finishes**
- **Good mechanical properties**
- **Readily weldable**

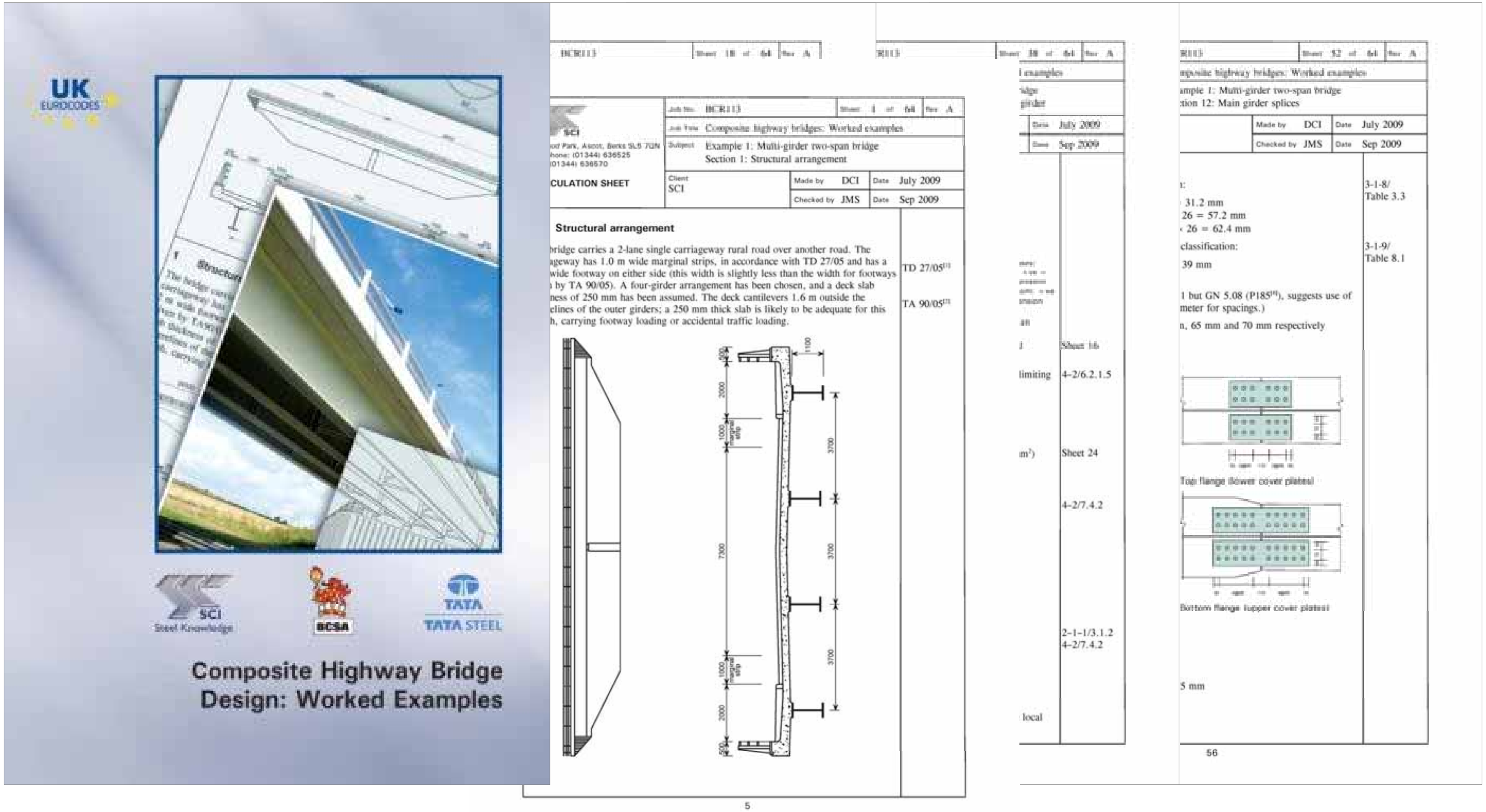
Cost Perception

- **Perceived as expensive material**
- **Rarely considered as an option**
- **Tends to limit use to special structures**

Cost study composite bridge

- **High level assessment**
- **Typical steel composite highway bridge**
- **Design to Eurocode 3**
- **Optimise for stainless steel**
- **Construction cost estimates**

Reference Design



SCI Publication 357 – Composite Highway Bridge Design: Worked Example

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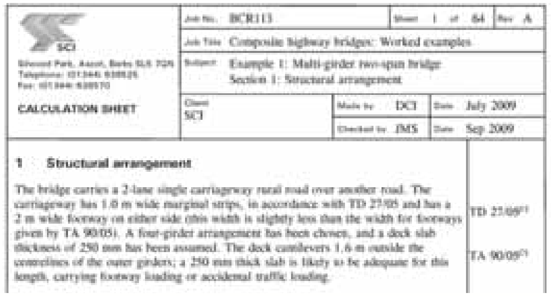
Reference Design



CALCULATION SHEET	Job No. BCR113	Sheet 1 of 64	Rev A
	Job Title Composite highway bridges: Worked examples		
	Subject Example 1: Multi-girder two-span bridge Section 1: Structural arrangement		
	Client SCI	Made by DCI	Date July 2009
		Checked by JMS	Date Sep 2009

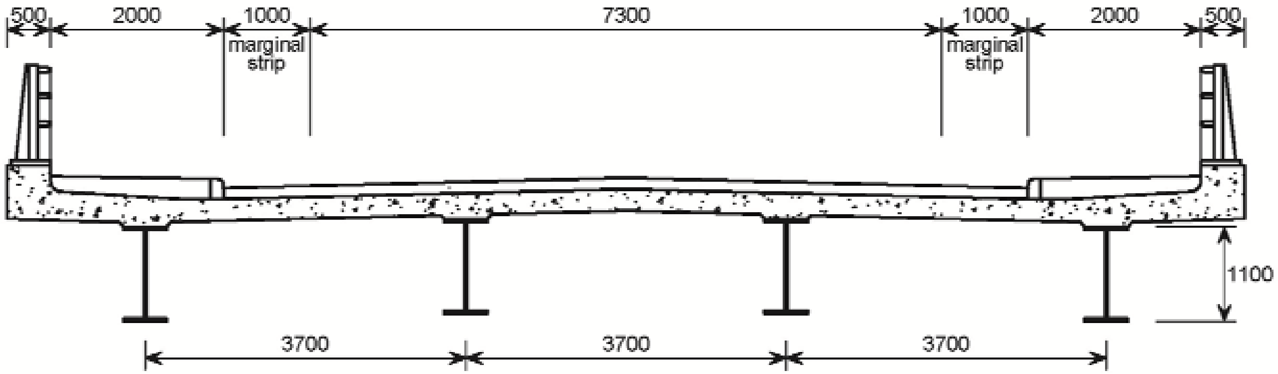
1 Structural arrangement

The bridge carries a 2-lane single carriageway rural road over another road. The carriageway has 1.0 m wide marginal strips, in accordance with TD 27/05 and has a 2 m wide footway on either side (this width is slightly less than the width for footways given by TA 90/05). A four-girder arrangement has been chosen, and a deck slab thickness of 250 mm has been assumed. The deck cantilevers 1.6 m outside the centrelines of the outer girders; a 250 mm thick slab is likely to be adequate for this length, carrying footway loading or accidental traffic loading.

TD 27/05[1]

TA 90/05[2]

Elevation



Cross section

SCI Publication 357 – Composite Highway Bridge Design: Worked Example

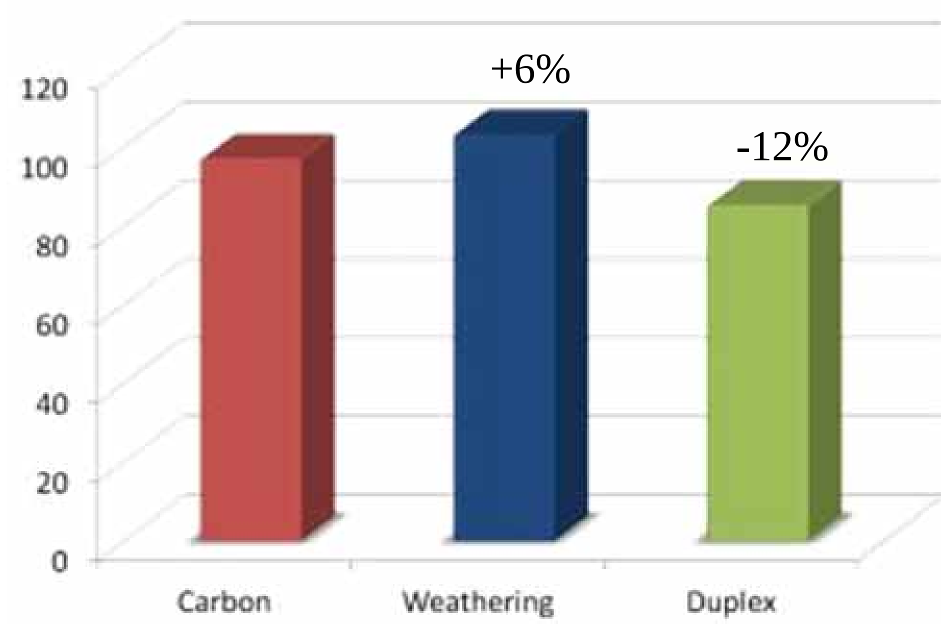
Material Grades

- **Carbon Steel:** **S355**
- **Weathering:** **S355W**

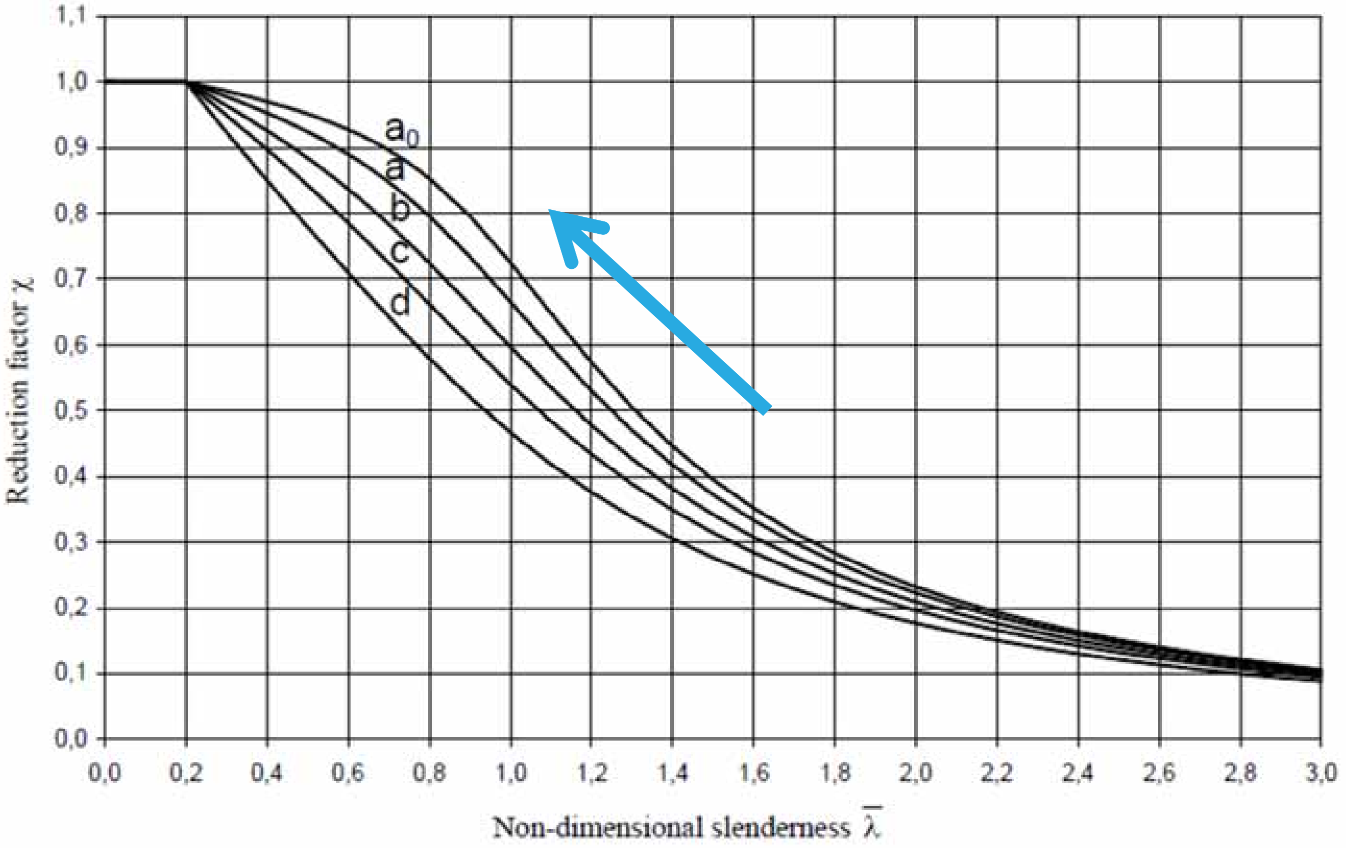
	EN	ASTM	Outokumpu
Austenitic:	**1.4404**	**316L**	**4401**
Duplex:	**1.4462**	**S32205**	**2205**
Lean Duplex:	**1.4162**	**S32101**	**LDX 2101®**

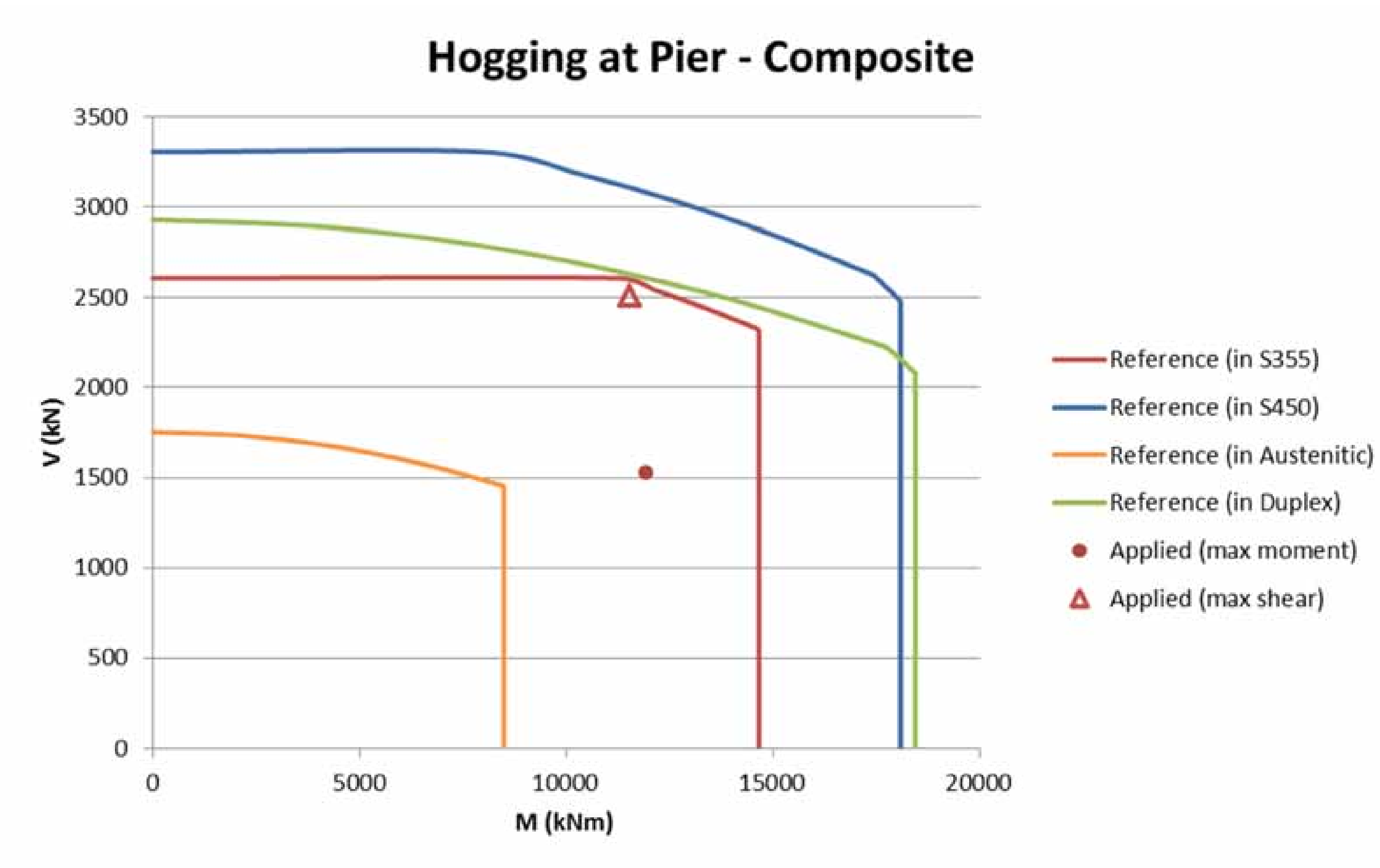
Initial steel tonnage results – no optimisation

- 30% stronger, but 12% less steel
- EC rules for stainless are more conservative
- Buckling limits the design



Buckling Curves





Hogging at Pier - Composite
V (kN)
M (kNm)
3500
3000
2500
2000
1500
1000
500
0
0
5000
10000
15000
20000
Reference (in S355)
Reference (in S450)
Reference (in Austenitic)
Reference (in Duplex)
Applied (max moment)
Applied (max shear)

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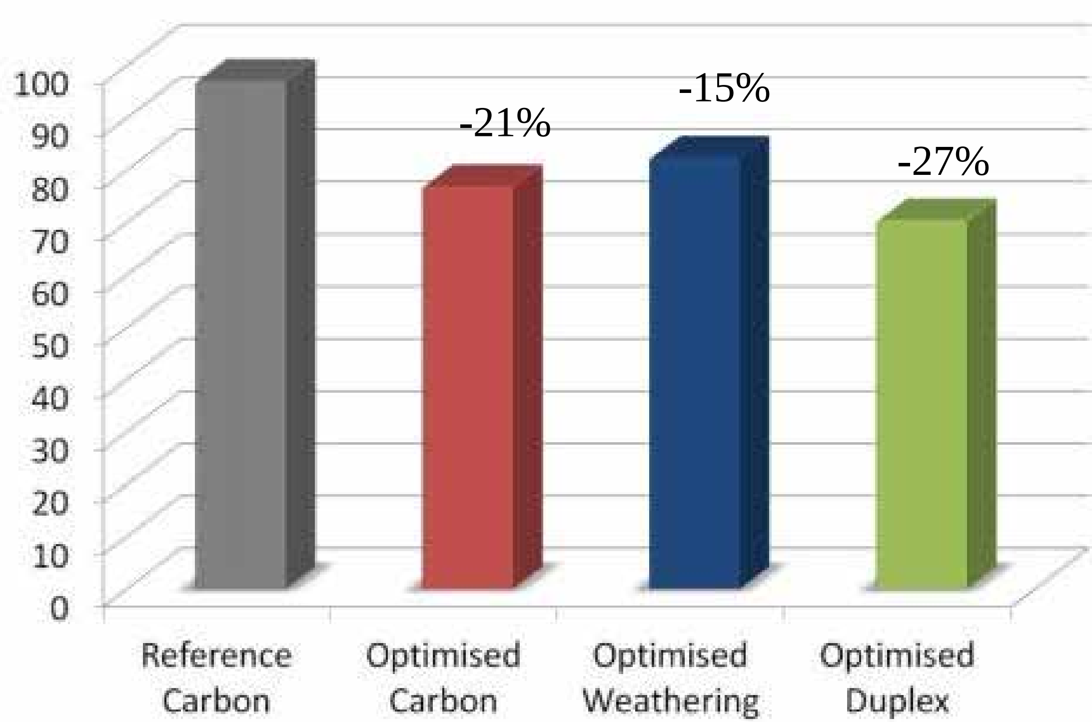
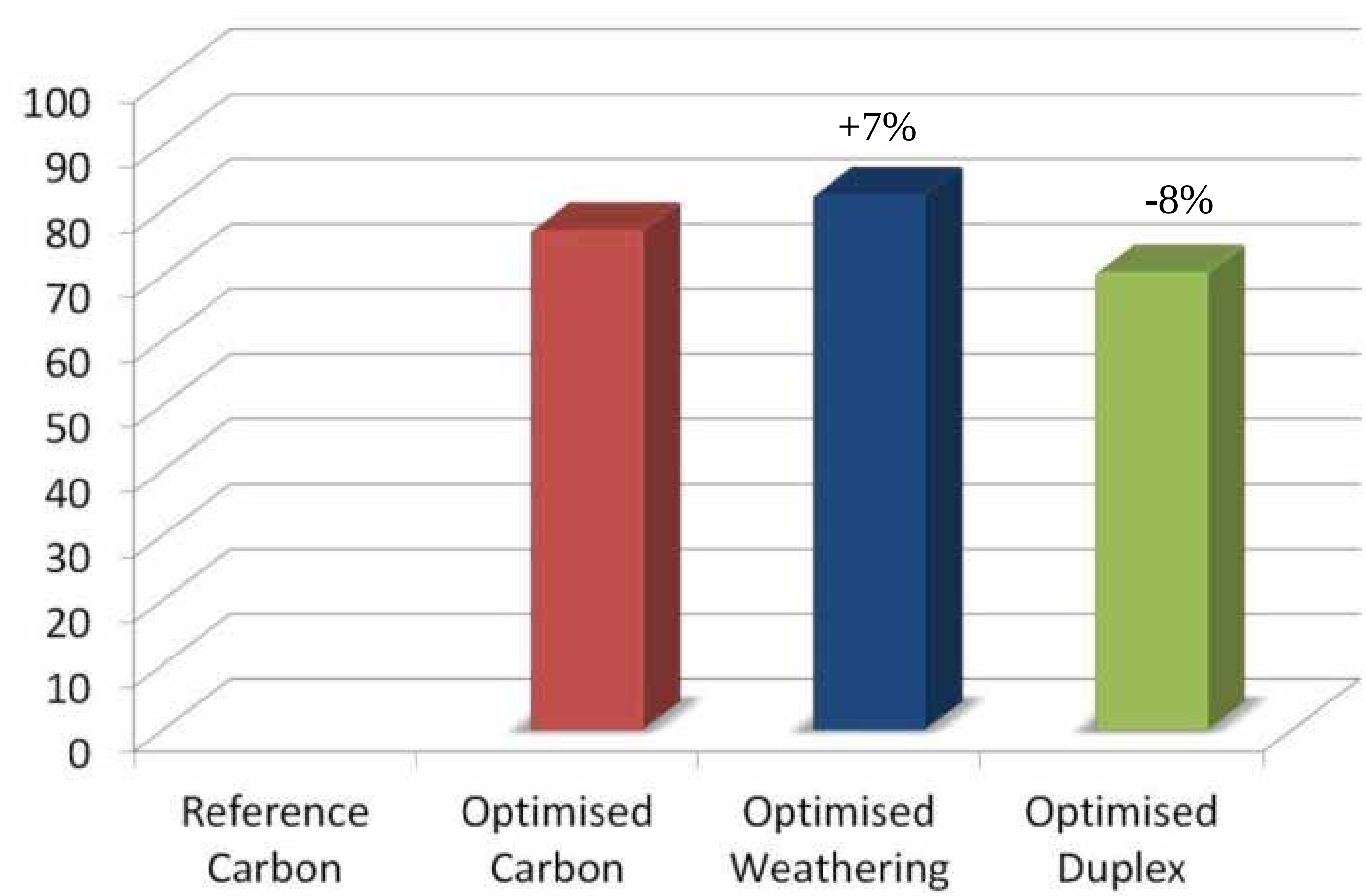
Optimisation - tonnage

- **Design rules**
- **Design methods**
  - Modal buckling analysis
  - Compact sections
- **Construction methods**
  - Bracing
  - More section changes
- **Others not investigated**
  - Tapered plates
  - Profiled beams
  - Corrugated webs



Optimised steel tonnages



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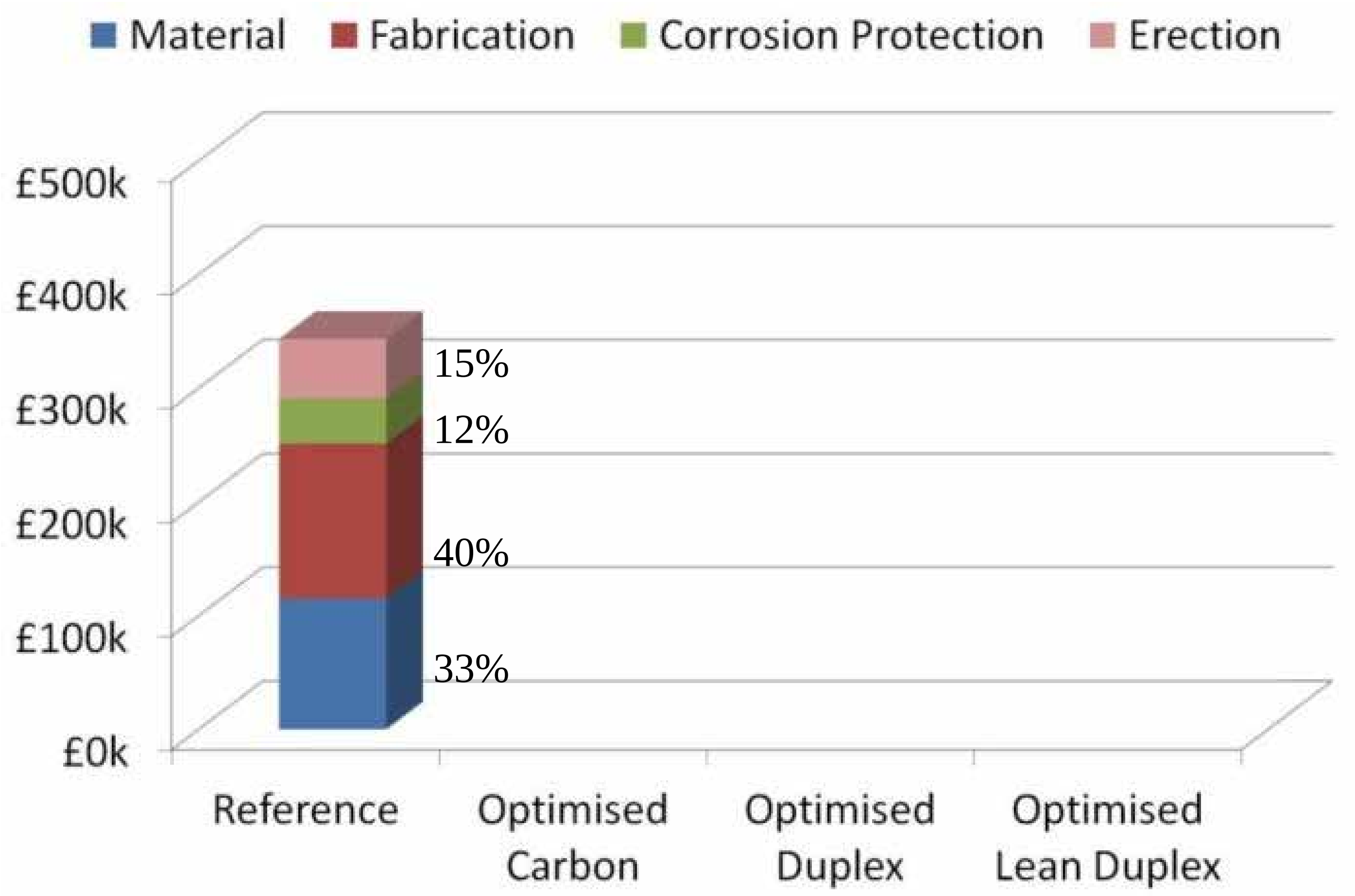
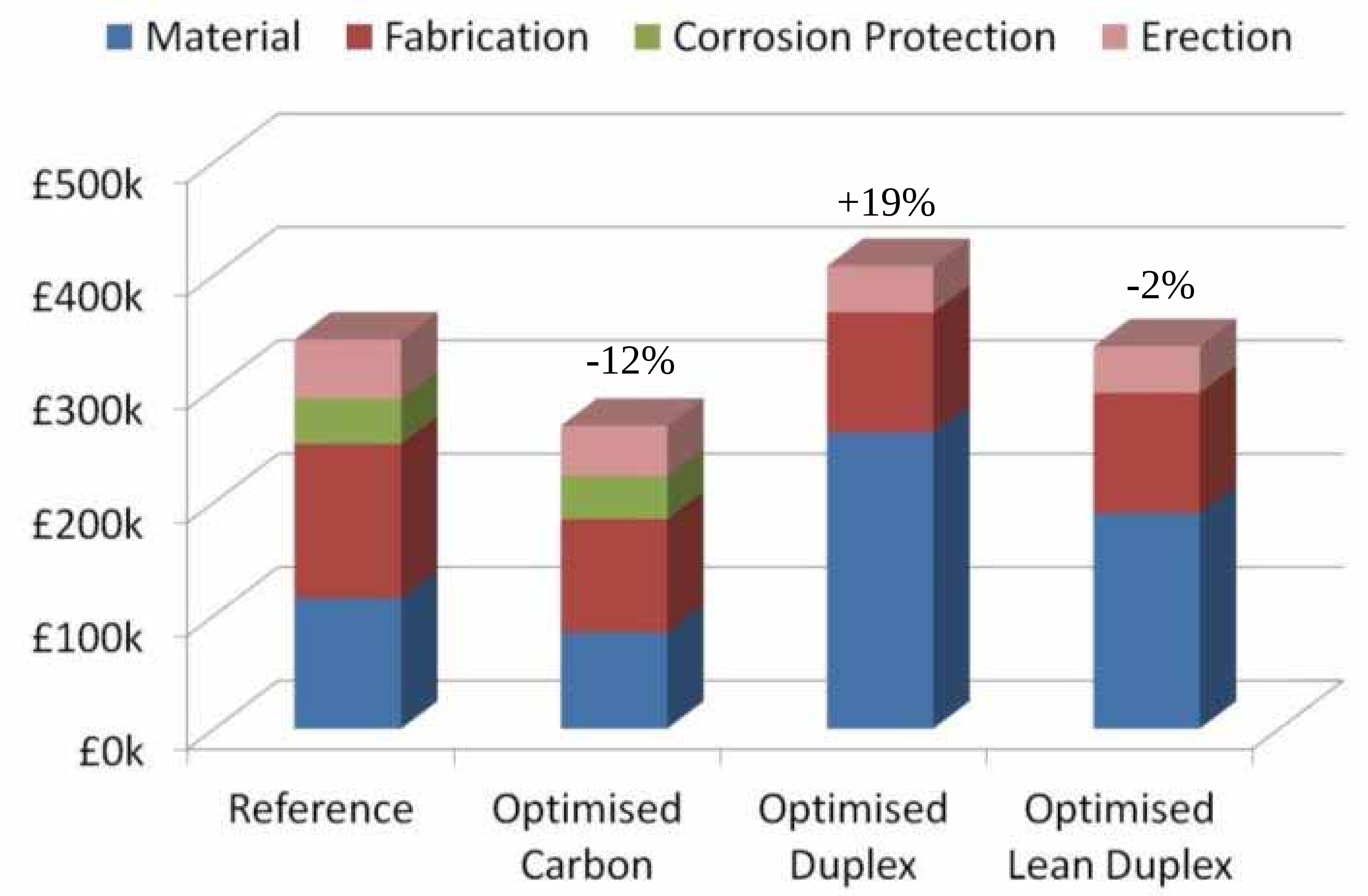
Steelwork Cost



Steelwork Cost



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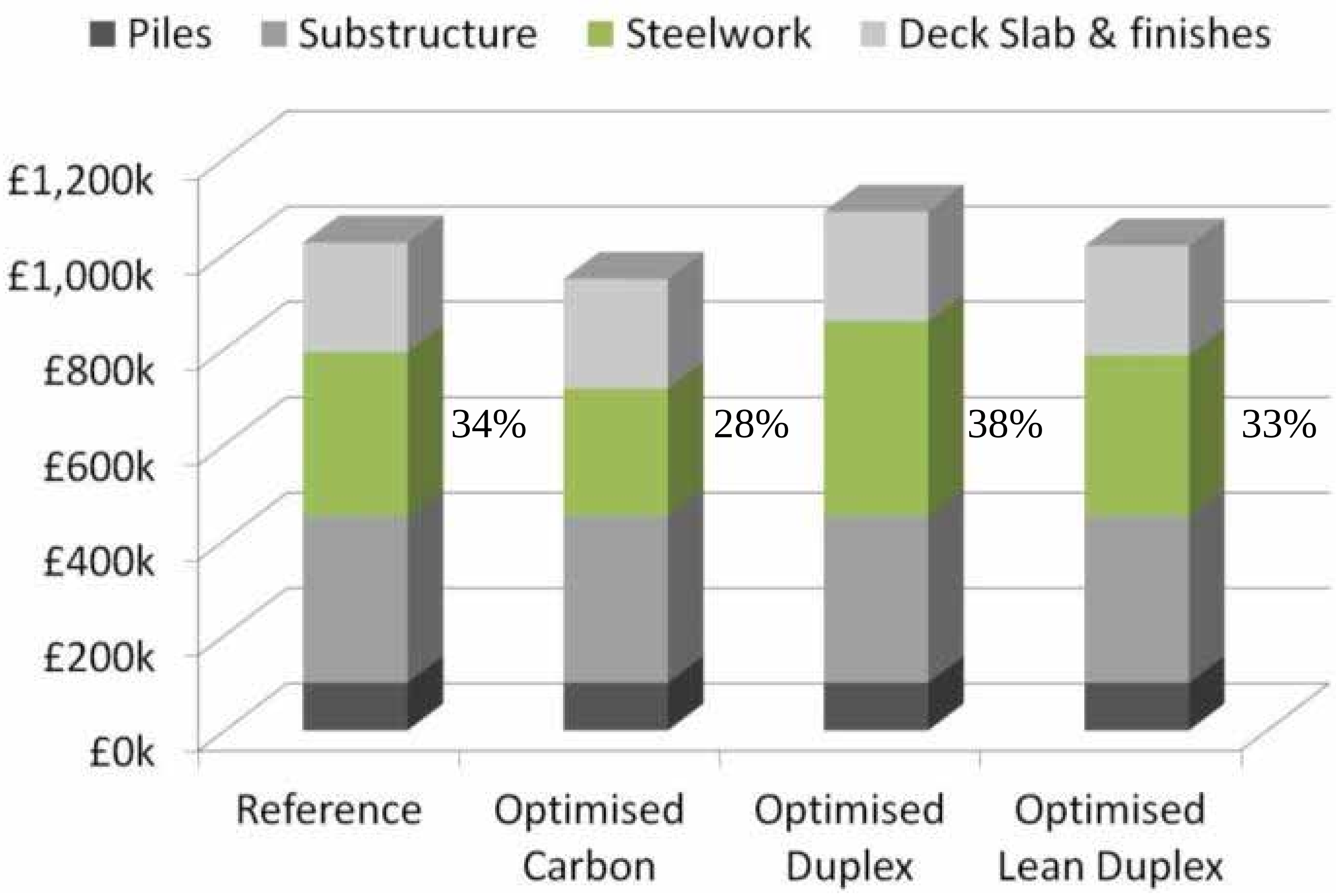
Construction Cost



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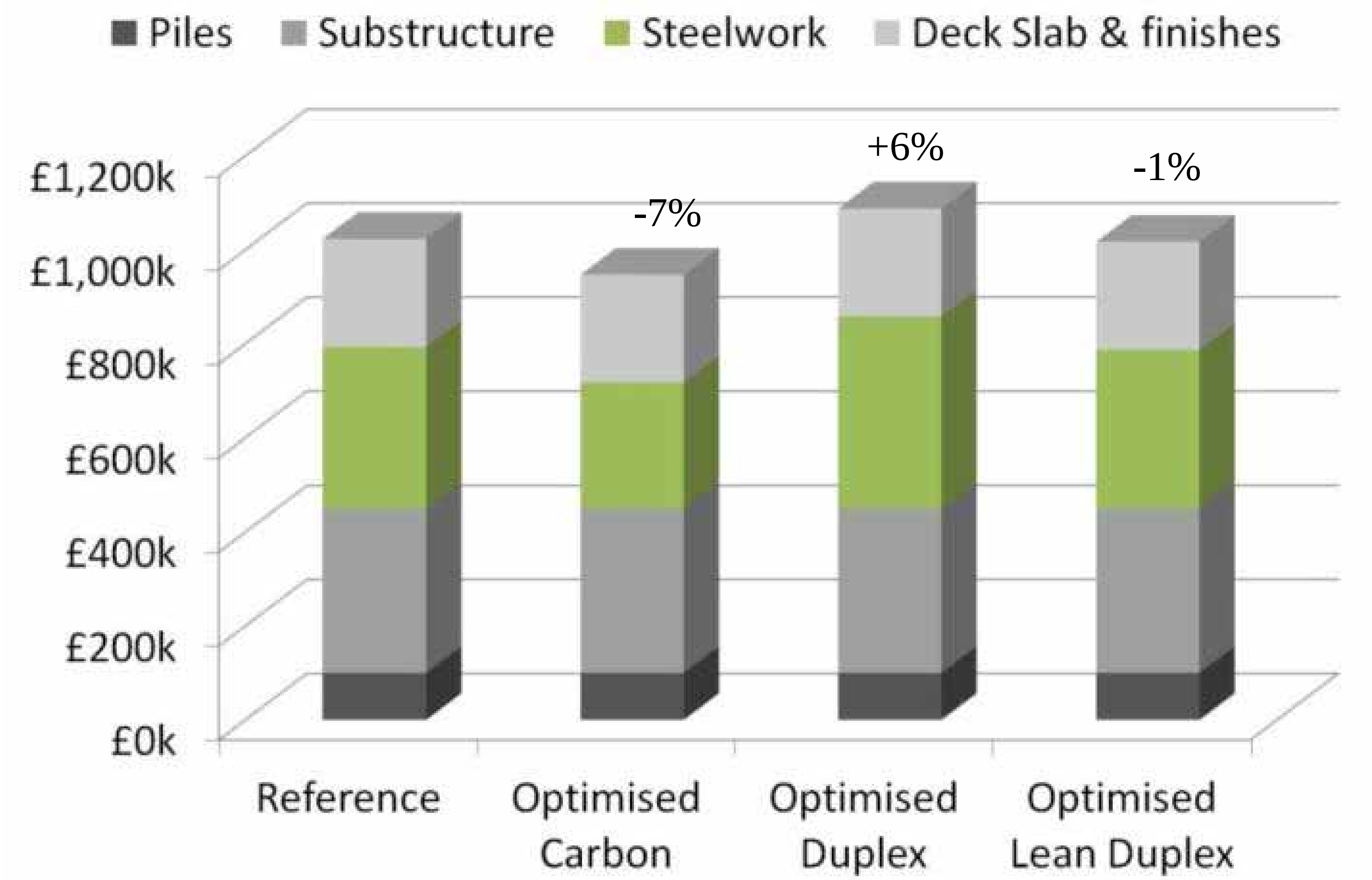
Construction Cost



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Life Cycle Cost – Model

- **Lifecycle Planner for Structures**
  - London Bridges Engineering Group (LoBEG)
  - Developed by LoBEG and Atkins
  - Publicly available resource
  - Models structure deterioration
- **Maintenance regime**
  - Maintenance interventions
  - Rates from database
- **Supplemented with Arup experience**

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Life Cycle Cost – Parameters

- **Consistently applied across all scenarios**
  - 60 year service life
- **All maintenance and inspection costs**
- **Repainting of carbon steel**
- **Neutral / conservative assumptions**
- **Discount rates from UK government guidance**

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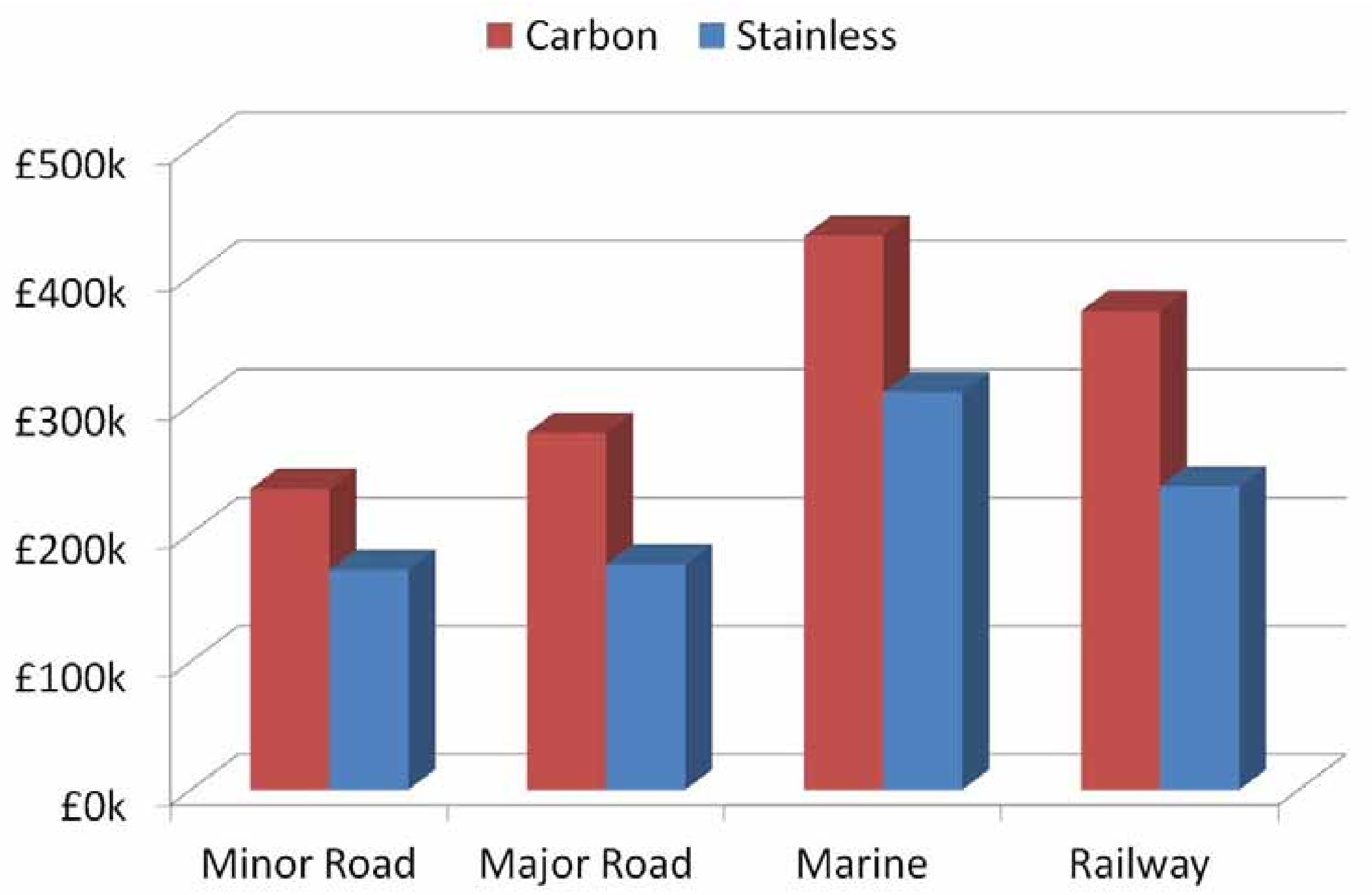
Life Cycle Cost - Results

- **Environment did not govern costs**
- **Costs dominated by access costs**
- **Fewer interventions over railway...**

  ...but more costly due to access
- **Significant savings with stainless steel**

Life Cycle Costs - summary



Cost Study Conclusions

- **Design for stainless steel NOT carbon steel**
- **It can be possible to design a cost neutral structure in stainless**
- **Modern duplex alloys offer potential for cost effective design**
- **In some cases stainless may be a viable option**